Anglia Ruskin University

Faculty of Science and Engineering

The Effect of Hippotherapy on Physical Function and Balance of Children with Cerebral Palsy

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A thesis in partial fulfilment of the requirements of Anglia Ruskin University for the degree of **Doctor of Philosophy**

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Dedications

To my Princess Letícia (in Memory)

To Mum and Dad

To my younger-self

To my dearest love Ana Paula

To all the Women that before me would not dream of achieving something like this

To all the Women who sacrifices helped women like me to have a choice and a chance of an education

To all little girls who are curious and to all the women who fight to find new answers

To all researchers and healthcare professionals

Rise
Said the moon
And the new day came
The show must go on said the sun
Life does not stop for anybody
It drags you by the legs
Whether you want to move forward or not
That is the gift
Life will force you to forget how you long for them
Your skin will shed till there is not
A single part of you left they've touched
Your eyes finally just your eyes
Not the eyes which held them
You will make it to the end
Of what is only the beginning
Go on
Open the door to the rest of it

Time – rupi kaur

Anglia Ruskin University

Abstract

FACULTY OF SCIENCE AND TECHNOLOGY

DOCTOR OF PHILOSOPHY

THE EFFECT OF HIPPOTHERAPY IN PHYSICAL FUNCTION AND BALANCE OF CHILDREN WITH CEREBRAL PALSY

FLAVIA REGINA BUENO

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Children with cerebral palsy (CP) experience deficits of fine and gross motor control and balance. Long-term physiotherapy helps decrease the impact of these multiple impairments improving their motor control, balance and postural alignment. Hippotherapy (HPOT) is a technique that uses the movement of the horse to translate sensory inputs to the human pelvis while mounted on the horse. This technique may improve motor impairments and balance in children with cerebral palsy after short- and long-term treatment. A systematic literature review identified the limitations of the current research evidence for the effectiveness of HPOT in those physical outcomes. A semi-structured survey guided the development of a research protocol development which reflected typical clinical perspectives and practice of HPOT treatment for children with CP. A study design was developed to evaluate HPOT efficacy on motor function, quality of life, spasticity and balance, recruiting a sample of 10 children with CP. Children with CP undertook 12 weeks of HPOT sessions (30 minutes, once a week) and were evaluated 3 times, prior to the treatment, after 6 weeks and after 12 weeks. Friedman's test was used in the analysis of all outcomes, as that was found to be non-parametric. Results indicated that HPO treatment is able to improve significantly gross motor function, spasticity and quality of life of children with CP across all GMFCS levels. It also demonstrated the positive effect of spasticity on balance outcomes, indicating the therapy may be useful in training balance of children with CP. Finally, it is concluded that HPOT may be indicated as an alternative therapy to physiotherapy to improve physical outcomes of children with CP. Cohort studies with bigger samples are recommended to establish this results.

Key Words: Hippotherapy, Cerebral Palsy, Balance, Gross Motor Function

Table of Contents

List of Tables

List of Figures

List of Equations

Notation

1. N = Newton
2. mm = Millimetres
3. mm/s^2 = Millimetres per second squared
4. hh= Hands High
5. m= metre
6. Hz = Hertz
7. min = Minutes
8. s = Seconds
9. cm= Centimetres

List of Abbreviations

1. AHA - American Hippotherapy Association
2. ANDE - National Association of Hippotherapy – Brazil
3. BR - Brazil
4. CNS - Central Nervous System
5. CoG - Centre of Gravity
6. CoM - Centre of Mass
7. CoP - Centre of Pressure
8. CP - Cerebral Palsy
9. CPT - Conventional Physiotherapy
10. CPTRH - Chartered Physiotherapists in Therapeutic Riding and Hippotherapy
11. CSP - Chattered Society of Physiotherapy
12. EAT - Equine Assisted Therapy
13. GMFCS - Gross Motor Function Classification System
14. GMFM - Gross Motor Function Measure
15. HBR - Horseback Riding
16. HPOT - Hippotherapy
17. ICF - International Classification of Functioning
18. ICF-DH - International Classification of Functioning Disability and Health
19. ICIDH - International Classification of Impairments, Disabilities and Handicaps
20. MAS - Modified Ashworth Scale
21. MN - Motor Neurons
22. NHS - National Health System
23. NICE - National Institute for Health Care and Excellence
24. PIS - Participant Information Sheet
25. PTs - Physiotherapists
26. QoL - Quality of Life
27. RDA - Riding for Disabled Association
28. THR - Therapeutic Horse Riding
29. UK - United Kingdom
30. USA - United States of America
31. WHO - World Health Organization

Copyright Declaration

Personal Statement

My journey to become a physiotherapist started in 2007 when I started my bachelor in Physiotherapy, at one of the most important Brazilian Universities, the Federal University of Sao Paulo (UNIFESP), in Santos, SP – Brazil. I have decided to pursue this course as I wanted to work with people and health sciences, and I found physiotherapy to be a great match for my aims.

During University I was awarded two research scholarships and one mentorship scholarship, I have done placement in HPOT for 6 months, have published two papers and have had the chance to present my research in national and international conferences.

In 2011, I was accepted to do a master's in health science and innovation in the University of Cadiz in Spain. There, I have investigated the effects of a drug in rats with induced amyotrophic lateral sclerosis.

The masters finished in 2012, and in 2013 I was awarded a research scholarship to fully fund my PhD in Biology at Anglia Ruskin University, in Chelmsford. My first year was somewhat turbulent, as due to University issues I was unable to develop the project I first proposed, which aimed to work with EEG, prosthesis and people with spinal cord injury.

After writing 6 different PhDs proposals and a lot of discussion, the proposal that originated the thesis here presented was accepted and started only in June of 2014, with first the development of aims, questions and research design, followed by the literature search and identification of gap in knowledge. To develop this, I moved departments, cities, and my supervisory team also changed.

The systematic review (the first study) was really only started in the end of 2014. This have caused some delays in the development of the thesis, in data collection, in University evaluation and in the writing up stage of the thesis, which affected the funding and submission dates in 2017/2018, as I was expected to graduate in October 2017, when my funding officially finished.

The thesis was then first submitted in January 2018, and I had to request the University to cover my writing up stage fees, also in consideration of the time lost due to

University irregularities in the first year. The first VIVA VOCE evaluation was scheduled for the 16th of March 2018, one month and half later of the thesis submission.

The VIVA outcome was re-submission with re-VIVA. I would then have a year to correct the thesis following the examiners recommendations and to defend again. The deadline for re-submission was April 2019. This deadline is two months after the expiration of my visa to stay in the UK as a student.

Once I have received the examiners forms, I noticed three issues with the examination process I) one of my external examiners declared she did not read the thesis entirely prior to finish the pre-VIVA report; ii) the biggest corrections (which were one of the main reasons for the re-submission request were on the bit that the examiner told she did not read; iii) the corrections they have requested were unclear and some were not possible to be addressed.

Immediately (in April 2018) I have asked my supervisory team to appeal, not the academic decision, but the conduct of the examiners. This requested was denied and then we tried to follow the very unclear directions given by the examiners. Months later, I still did not have a clarity of how to address many of the comments the examiners requested, and although I have asked to meet with the examiners to sought clarifications, this was also denied by my supervisory. The biggest issue to be corrected was the results of the experimental chapters (here presented from Chapter 5 to 8). Different guidance was given, and in a meeting with one of my annual reviewers, which is also a statistician, it was discussed that there was nothing wrong with my data and the methods of evaluations I have chosen in the past.

In spite of that, my supervisors seen to not know how to best approach this issue, if I should keep the analysis as it was and learn how to better defend it or if I should try to do what the examiners asked (which, later I have found out I could not). I have then contacted the head of department of Biology, and he dismissed my case.

In the end of July 2018 I have contacted the Student Union, which based on the regulations have told me that I did have the ground to appeal as there were three things that happened wrongly during my VIVA: i) the examiner did not read the entire thesis; ii) the faculty should have post-poned the VIVA till they were sure all examiners have read the thesis and iii) my supervisors should not have told me I did not have the permission to appeal. This, obviously, made me waste a lot of time. The appeal process was submitted in August, and after going back and forth with the Doctoral School the grant the appeal on the basis the examiner did not read the entire thesis. As a resolution I would be allowed to have a first attempt at the VIVA, with a completely new panel and to re-submitted a corrected version of the thesis, which is the one you are now receiving. The corrections were based on most of the comments given by the first examiners and supervisory team guidance.

If the appeal was applied when I wanted (back in April 2018) this submission would, most likely, has happened earlier. Now, you are receiving the thesis in April 2019 and the VIVA shall be held till three months after that. As I have previously mentioned, I no longer will have visa permission to be in the UK and I have requested for the VIVA to be held via videoconference.

Now, I am going through a complaint investigation with the University to tackle all the delays and the poor student experience I have had throughout this PhD that was meant to take 4 years, but it is taking almost 6 instead, mostly because of University poor administration.

There were challenges I have never though facing while being a PhD student, during the journey, I had to change projects a lot of times, which risked my scholarship, I did not approve the first evaluation, due to the delays caused in the first year, that caused further delays, I had to change departments three times, University location and city as well. I had to adapt and re-adapt, and to endure things that were beyond expected by anyone. I have had so many delays I had to do my final year without any funding whatsoever, which risked my financial situation and my visa stability in the UK. All of this made the PhD was the hardest experience of my life, and as for now, I can only hope, if I dare, that it will be somewhat worthwhile. Blame was given to my English, to my culture, to my background, while I worked day and night and while my country and my government was fully paying this University for a PhD course.

All this hardship, if did something, it taught me how to be resilient, how to critically think and how to critically approach the literature (after writing 6 different proposals, four annual reports and the thesis itself), it has taught me to be independent and proactive regard my research, to seek partnership when needed and to fight for directions throughout the development of this thesis.

Finally, I would like to say to all of you, supervisors, examiners, students and academics that came across this personal statement, that this is also a little protest. A very small protest of how things have been carried out during my PhD and of how things are done in higher education as whole. Perhaps this will not change how higher education happens, nor University policies, but if at least make one of you think how to best supervise or examine your students, or if at least help one student to know they have rights, and voice, and that they do not deserve to be dismissed or mistreated just because they are on the bottom of the academic food chain.

Higher education needs to change. I do not have all the answers, but PhD students have 6 times more chances to develop mental health issues and this is not okay. International PhD students having to leave their country to pursue a better education and go back home without a diploma because of Universities issues is not okay. International students being blamed that something went wrong because of their English, their culture, their background is not okay, we spend our lives learning a new language, and fighting hard to be able to get where we get.

Universities are claiming, they have received this award or that award by "listening to their students" but not actually doing so and with employees in high positions dismissing student issues is not okay. PhD student losing their lives because they spend hours in the office and laboratories or having to get a job while doing a full-time PhD just so they can afford rent, without no University support is not okay. Students going to the hospital because of panic attacks caused by the PhD is not okay. It is not okay a student needs to spend hours and hours of unpaid PhD work proving they are right and that some things did not happened as they should have, nor should anyone have to teach the University how to comply to their own regulations. The stress, and the emotional hardship that surrounded me and the need to re-live an experience just to proof to others that you are okay, others that are away above you on the food chain. Do that alone was probably one of the hardest things I have to go through during this course. This cannot keep happening. Supervisors and Examiners need better and more specific training and support so do the PhD students. Universities need to do better, by the students and by their staff too.

I am not telling you all of this so you would pity me, or because I want to play the victim. I am no victim. I am actually very privileged, as I came to do research, with a full scholarship in a first World country, and only less than 1% of people in my country are able to achieve a higher education degree or any degree for that matter. My gramma passed way knowing only how to write her name, my mother had to copy the school books, by hand, and to babysit by the age of 8 so she could afford to get the bus to school, being here is a privileged, but it also a result of a fight of many women before me. Have a PhD is really hard work, but for me is a privileged too. Nevertheless, that does not mean this experience was what it should have been. I was not treated well, I was not heard, I was often dismissed and disrespected.

Many thanks for reading this. I am no victim, I am a fighter, and I will keep fighting for this and for what it is my right. I do hope in the future things get better and the students no longer must go through what I did to become a doctor. It is only a diploma, and people should not have to be sick and lose everything for it.

1. Chapter 1: Introduction

This chapter highlights the research context and it includes an overview of the subsequent chapters.

1.1. Context for the Research

Cerebral Palsy (CP) is the most common non-progressive condition caused by an insult in the CNS that generates physical impairments in children, which can generate a significant loss or interfere in the individual's participation (involvement in a life situation) or create activity limitations (difficulties in executing a task or activity) (WHO, 2001). Long-term physiotherapy helps decrease the impact of these multiple impairments, by helping a child with CP retain or improve their motor control, postural alignment, pain-free movement and dependence. Although it is known that participating in physiotherapy sessions can help the children to overcome these impairments and gain more function, often it can be painful, challenging and hard to keep the interest and enthusiasm of the person, with studies reporting that only 31% of people with motor disabilities do the exercises as recommended (Benda, McGibbon and Grant, 2003; Rimmer, 2006; Chang, *et al.*, 2011). In order to maintain engagement with therapy, it is important for doctors, physical and occupational therapists to develop new strategies for improving patient motivation.

Following recommendations of ICF and considering the concepts of participation and function, any physical therapy should include consider the level of functioning of the patient, the environment and community this patient is part of, provision of variety in the exercises a patient is asked to do whilst maintaining a clear focus on enhancing functionality, strength, balance, cardiovascular and respiratory outcomes, mobility and autonomy (Benda, McGibbon and Grant, 2003; Rimmer, 2006; Diniz, Medeiros and Squinca, 2007; WHO, 2011; Bodkin, *et al.*, 2016).

Hippotherapy (HPOT) is a technique that it is designed to enhance functionality, balance, strength, gross motor function and gait outcomes, as therapists that use HPOT advocate that the horse's gait promotes movement patterns similar to human gait and that the horse's rhythmic movement is able to stimulate motor, vestibular and sensory systems and to require muscle activation and learn to anticipate movement (Benda, McGibbon and Grant, 2003; Sterba, *et al.*, 2007; Diwan, *et al.*, 2014; Morgan, *et al.,* 2016). Combined with additional therapist intervention, this could alleviate symptoms, lead to improvements in functional ability by enhancing postural control and consequently may delay degeneration and maintain QoL when compared with patient's physical abilities before starting the therapy (Benda, McGibbon and Grant, 2003; Sterba, *et al.,* 2007; Tseng, Chen and Tam, 2013). The American Hippotherapy Association (AHA) defines HPOT as:

"Hippotherapy refers to the incorporation of equine movement by physical therapy professionals. These professionals use the equine movement within their evidence-based practice and clinical reasoning to engage the sensorimotor and neuromotor systems of their patients to create functional change. Used with other neuromotor and sensorimotor techniques, hippotherapy is part of a patient's integrated plan of care"(Modified definition based on the (American Hippotherapy Association, 2015a).

Whilst a range of research papers and professional publications advocate these hypotheses, recent literature reviews and meta-analyses have criticised the quality of a large proportion of the published studies on HPOT for participants with CP (Benda, McGibbon and Grant, 2003; Sterba, *et al.*, 2007; Tseng, Chen and Tam, 2013).

The primary aim of this research was to analyse the effects of HPOT on gross motor function, balance, quality of life and spasticity of children with spastic CP. To address this objective, five main research questions were created, and the chapters were developed in order to address such questions. The first study is a systematic review, which was followed by a survey with physiotherapists. Both studies provided evidence and guidance for the development of the experimental study that was carried out with pre/post-prospective design. The methodology of experimental study is presented in chapter 6, its results on chapter 7 and its discussion on chapter 8. The same type of evaluations was taken at three points in the study: prior to the treatment starts, after 6 weeks and after 12 weeks. The outline of which aspects are addressed in which the chapters is outline in the subsequent subsections.

1.2. Outline of Chapter 2

This chapter outlines the definitions, classifications, physiopathology and physical evaluations that can be made of children with CP.

1.3. Outline of Chapter 3

This chapter will discuss the definition of HPOT, and it brings an outline of the interaction between the horse and the person on the horse and a brief overview of how children with CP may benefit from this treatment.

1.4. Outline of Chapter 4

A systematic literature review was the first study of the thesis and is fully presented in chapter 4. The aim of this systematic literature review was to investigate the effects of HPOT on physical outcomes of children with CP. The physical outcomes investigated were gross motor function, balance, posture, gait, spasticity and muscle activity, kinematics and functional performance. The systematic review follows the Prisma® guidelines for systematic review and the Prisma® checklist to screen papers. The criteria proposed by Law *et al*., (1998) to analyse the quality of quantitative studies is used, as in previous literature reviews on this theme (Sterba, *et al.*, 2007; Tseng, Chen and Tam, 2013).

The systematic review was updated throughout the development of the project and provided the most recent evidence in the literature about HPOT effects in children with CP. It was the basis for the development of the experimental studies, as methodological decisions on the duration and frequency of therapy and the evaluation measurements were based on the evidence provided by this systematic review and the findings of the study presented in the chapter 4.

As a result, of keeping the systematic review up to date prior to the submission of the thesis, some of the most recent papers (published in 2018) will have similar aims to one of the experimental chapters presented in the thesis. The student is aware and will discuss such papers, comparing them to the results gathered in the experimental chapters and in the systematic review itself.

1.5. Outline of Chapter 5

Preliminary results obtained from the systematic review up to 2015 evidenced an inconsistency between the approach taken by a variety of researchers, in agreement with what was described previously by Tseng, Chen and Tam (2013). The studies investigating the physical effects of HPOT in children with CP varied in frequency and duration. Further differences were also found in method of evaluations across studies, as a variety of validated measurements to evaluate a single outcome was used (Benda, McGibbon and Grant, 2003; Debuse, 2005; Sterba, *et al.*, 2007; Tseng, Chen and Tam, 2013).

Due to the variation of methods used in research studies gathered in the literature review it seemed appropriate to examine whether practitioners also differ in their practice. The survey was developed with close-ended questions. The choice options given to answer each question were given based on the evidence gathered from the systematic review, such as the options for the duration of sessions or treatment, validated measurements used to a specific outcome and the outcomes that were expected to improve. Physiotherapists were given a chance to choose "order" and state their answers if none of the pre-coded answers matched their practice.

The two main aims of the survey were to increase knowledge and understanding about HPOT practice among practitioners, investigating if there was a consensus regard HPOT practices within and between different countries/HPOT schools and to increase knowledge about how HPOT was carried out in the UK by physiotherapists working with children with CP.

To investigate if practitioners in different countries differ in the way they conduct HPOT, as research studies conducted in different countries do, a choice of two countries was made. Firstly, the UK was chosen, following a similar population investigated by Debuse, (2005) as the experimental studies would be carried out in the UK, there was a clear need to understand how practitioners carried out the therapy, not only to the design of the studies themselves but also to fill up a gap in knowledge about HPOT practice in the UK.

The second country chosen for comparison was Brazil, for three reasons: i) HPOT research in Brazil has been growing substantially throughout the years (Antunes, *et al.*, 2016 and Moraes, *et al.*, 2016); ii): the lead researcher is a Portuguese speaker and qualified as a physiotherapist in Brazil; iii) this research was supported and funded by a research program from the Brazilian Government in attempt to increase research partnership between the two countries, and this work was a great opportunity to contribute to this aim.

The main research questions for the survey were as followed:

1. What are the general characteristics of HPOT Sessions?
2. How are professionals evaluating the physical outcomes of the CP patients?
3. What are the targets and outcomes expected from HPOT in the CP population?
4. What are the differences and similarities among HPOT practice in Brazil and in the UK?

The findings of the survey together with the findings of the literature review were then used to design the subsequent parts of the project.

1.6. Outline of Chapters 6

This chapter will discuss the methodology used to evaluate the gross motor function, the balance, the spasticity and the quality of life of children with CP that have undertaken HPOT treatment.

1.7. Outline of Chapter 7

The evidence gathered from the systematic review by analyzing papers published up to 2015 combined with the results obtained in the survey, highlighted the following key points about HPOT and the gap in knowledge in the literature:

- There is limited evidence of the effect of HPOT on gross motor function measure (GMFM) – 88 scores across different levels of gross motor function classification system (GMFCS);
- There is limited evidence of HPOT effect on dynamic balance of children with spastic CP across different levels of GMFCS;
- There is limited evidence on effects of HPOT on spasticity in the lower limb and absent evidence of its effects on the upper limb;
- There is limited evidence that QoL may be affected by gross motor function and about the effect of HPOT on these two outcomes together.

Question 1: Gross Motor Function Evaluation

The main question designed to address this gap in knowledge was: What is the effect of HPOT on the GMFM-88 scores?

Children with spastic CP were recruited and evaluated with the GMFCS. Children classified at levels I and II were allocated in the GMFCS 1 group and children classified on levels III, IV and V on the GMFCS 2 group. GMFM-88 data was collected at baseline, after 6 and 12 weeks of treatment.

Motor function reflects the body's capacity to produce movement (Enoka, 2008; Bower, 2009; Nicholls, *et al.*, 2012). In childhood, the development of gross motor skills are characterized by the acquisition of motor function that involves the development of postural control, the ability to move the body (e.g. rolling, crawling, kneeling, walking) and the ability to manipulate different objects (Newell, 1991; Santos, Dantas and Oliveira, 2004). To evaluate the participants' functional ability, the Gross Motor Function Measure and the Gross Motor Function Classification System were used.

The GMFM-88 evaluates the ability of a child with CP to attempt and/or complete a pre-determined motor activity. The level of GMFCS, as well the clinical and topographic classification of the condition will play a direct role on how the child will perform in the GMFM-88 and as mentioned previously is used in this chapter to classify and allocate the children in two different groups: GMFCS 1 (levels I and II) and GMFCS 2 (levels III, IV and V).

Question 2: Balance Components Evaluation

The main research question to address this gap in knowledge was: What is the effect of HPOT treatment displacement of the CoP of children with CP while statically sitting and when passively mounted on the horse passively?

Eleven studies identified in the systematic review investigated the effects of HPOT in dynamic and static balance, using a variety of tools that do not necessarily compared to each other, as they vary between clinical scales that are only suitable for mild classification of CP, as the Berg balance Scale and force plates.

Furthermore, there is not to date any study investigating the effects of HPOT on the dynamic balance of the child with CP while mounting passively the horse. This is a very important outcome to support the HPOT theory of movement and improvement of balance, which lies around the decreasing of CoP displacement, or increase of balance (McGibbon, *et al.*, 2009; Diwan, *et al.*, 2014; Antunes, *et al.*, 2016; Lucena-Antón, Rosety-Rodríguez and Moral-Munoz, 2018).

Children with CP were recruited and had their static sitting balance and their dynamic sitting balance while mounted passively on the horse evaluated. This was a pre/post-prospective design study and the displacement of CoP will be shown, comparing data obtained after 6 and 12 weeks of treatment with baseline values.

Question 3: Spasticity Evaluation

The main question of this study was: What is the effect of HPOT on spasticity of children with spastic CP?

To answer this question, the modified Ashworth scale was used, and spasticity was evaluated after short-term mounting passively on the horse and after 6 and 12 weeks of therapy.

Spasticity occurs due to a lesion on the motor cortex, which causes hyper-excitability of the α motorneuron (Guyton and Hall, 2011). There is some evidence about the effect of HPOT on decreasing spasticity on hip adductors, mainly due to the passive sustained stretch of these muscle group when the child is mounting the horse passively (Benda, McGibbon and Grant, 2003; McGibbon, *et al.*, 2009; Antunes, *et al.*, 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munhoz, 2018). Nevertheless, no study has investigated the other muscle groups of the lower limb, such as quadriceps or gastrocnemius, neither if HPOT may have some effect on spasticity of the upper limb.

Question 4: Quality of Life Evaluation

The main question of this study was: What is the effect of HPOT in quality of life (QoL)?

To evaluate QoL the parent proxy report of PedsQL® was used. The scores of these scales were them compared to the GMFM-88 to investigate if there was a relationship between both.

QoL is defined by the World Health Organization (WHO) as “an individuals’ perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns.” (Whoqol Group, 1995).

A successful therapy should be able to generate a positive change in a patient’s physical function, on their motor control and quality of life (Holt, Obusek and Fonseca, 1996; Holt, Fonseca and LaFiandra, 2000; World Health Organization, 2011; Chen, *et al.*, 2013a). Although there is some evidence of the positive effects of HPOT on gross motor function, balance and spasticity. There remains a need to explain if these positive effects of HPOT would be translated to an improvement on the quality of life of those children. To date, there is no evidence of a study investigating the effects of HPOT in QoL using PedsQL® in children with CP.

1.8. Outline of Chapter 8

Chapter 8 will discuss the findings of the experimental chapter.

1.9. Outline of Chapter 9

Chapter 9 will conclude the experimental chapter and the thesis itself by summarizing the main findings, discussing the contribution to knowledge made and providing recommendations for future work.

2. Chapter 2: The Pathophysiology, Classification and Assessment of Cerebral Palsy

This chapter describes i) key aspects of the pathophysiology of CP that are relevant to the purpose of this thesis, ii) the key aspects of the outcomes being evaluated in this thesis, englobing four aspects of functional ability of children with CP: gross motor function, balance, spasticity and quality of life and iii) the tools used by practitioners to assess the current functional ability and/or potential of their patients. The rationale behind selection of the tools used to categorize the subjects with CP that participated in this study is given is given. Further, an explanation is given for the choice of validated tools and scientific measurements used to evaluate the potential benefit of HPOT in further chapters in this thesis.

2.1. Cerebral Palsy – Aetiology and Classification

Prevalence and Aetiology of Cerebral Palsy

CP is a non-progressive neurodevelopmental disability which can occur during infancy and the early stages of childhood (Jones, *et al.*, 2007; Himpens, *et al.*, 2008; Oskoui, *et al.*, 2013). It is a permanent disorder; however physical symptoms can be alleviated with physiotherapy.

According to Glinianaia, *et al.*, (2017) the prevalence of CP ranges from 2 to 3.5 cases per 1000 live births in developed countries and their results anticipated that by 2020 there will be over 22 thousand children aged between 3 and 15 years living with CP in England and Wales.

Causal factors that can lead to CP that can be divided into three categories, grouped according to when the insult occurs: i) prenatal: maternal conditions (e.g. bleeding, toxaemia, twins or multiple births, metabolic diseases), prematurity, genetic factors (e.g. absence of corpus callosum); ii) perinatal: anaesthesia, mechanical trauma, immaturity at birth; and iii) postnatal-infancy: trauma, infection, anoxia, vascular accidents (Brashers and Rote, 2014; Kolb and Whishaw, 2015; Glinianaia, *et al.*, 2017).

With respect to the region in the body that is damaged or has developed abnormally, CP may be a result of a lesion on the pyramidal system (corticospinal pathways). This can result in spasticity, increased muscle tone and an exacerbated reflex action. CP may arise as a result of a lesion on the extrapyramidal area of the brain (basal ganglia, thalamus or cerebellum), causing difficulties on fine motor control coordination (dyskinetic CP) or gait disturbances and instability (ataxic CP) (Brashers and Rote, 2014). The classification of CP classification will be discussed further in section 2.1.

The severity of CP has an inversely proportional relationship with gestational age. The severity of the lesion typically decreases if it occurs later on the gestation period (Kerr Graham and Selber, 2003; Krigger, 2006; Bax, Tydeman and Flodmark, 2006; Himpens, *et al.*, 2008; Zarrinkalam, *et al.*, 2010). This occurs because the development of the CNS starts as early as 4 weeks into pregnancy with the closure of the neural tube (Nicholls, *et al.*, 2012). In the second half of pregnancy the complex events of differentiation (axonal and dendrite growth, synapse formation and myelination) and of stabilization (neural cell apoptosis, redundant synapse elimination) occur and the first neuronal chain of the motor cortex can be found in a foetus of 5 months' gestation. This is formed by Cajal-Retszius cells and fibres from older structures of the CNS that migrate from earlier developed cortical grey matter (Marin-Padilla, 1970; Nicholls, *et al.*, 2012) . These developmental events are followed by the specialization of neural circuitry, which continues into the post-natal period, reaching the maximal rate during the first 2 years of the infant's life (Marret, Vanhulle and Laquerriere, 2013).

Lesions caused during pregnancy until 2 years of age determine the extent of injuries in the white matter of preterm infants and in the grey matter and brainstem of full-term new-borns (Bax, Tydeman and Flodmark, 2006; Jones, *et al.*, 2007; Marret, Vanhulle and Laquerriere, 2013) .

The European CP Study investigated the relationship between the information available from magnetic resonance imaging and clinical findings in persons with CP. White matter damage was reported in more than 70% of children with diplegia, but also in 34% of those with hemiplegia and 35% in those with quadriplegia, and generally occurs before 34 weeks of gestation. Lesions on the basal ganglia and thalamic damage were mainly connected with dystonic CP, while focal infarct was almost exclusively connected to diagnosis of hemiplegia.

Their findings suggest that the severity and type of CP is influenced by when and where the insult has happened as well which type of the damage it has caused (Bax, Tydeman and Flodmark, 2006).

Classification of Cerebral Palsy

This following section describes pathophysiological characteristics of spastic CP that were seen in participants in the study presented within the experimental chapters of the thesis. The potential efficacy of HPOT in managing these aspects of their condition is presented in later chapters. The objective here is to explain how the type of insult they possess translates into their musculoskeletal impairments that the HPOT treatment is intended to address.

How CP manifests in each individual is influenced by factors such as the history of the condition and the type of motor impairment or functional disability they have (Gorter, *et al.*, 2004; Rosenbaum, *et al.*, 2007; Pakula, Braun and Yeargin-Allsopp, 2009).

Research studies and practitioners generally focus on the physical characteristics of the motor disorder, its anatomical distribution and/or against surveillance scales that evaluate functional ability (Rosenbaum, *et al.*, 2007; Jones, *et al.*, 2007; Pakula, Braun and Yeargin-Allsopp, 2009; Herrero, *et al.*, 2012b). Components of CP classification based on the motor disorder and anatomic distribution are described in Table 2.1.

According with the National Institute for Health and Care Excellence guidelines, 45% of CP cases originate from lesions in white matter. This type of insult is highly associated with spastic CP (Jones, *et al.*, 2007; Marret, Vanhulle and Laquerriere, 2013; NICE, 2017b). Spastic CP, also known as pyramidal CP, results from insults that have caused damage to the brain’s corticospinal pathways which are broadly responsible for the accomplishment of movement through the activity of the motor neurons (Kerr Graham and Selber, 2003; Jones, *et al.*, 2007; Enoka, 2008).

The motorneurons are specialized neurons that represent the pathway by which the commands of the CNS are sent to the muscle. These specialized cells are responsible for producing voluntary contractions, as they receive inputs from descending systems (stimuli coming from CNS) and from afferent pathways (impulses that come from the muscle itself). Afferent pathways can provide excitatory and inhibitory input to the motoneuron, and the descending systems supress the inhibitory inputs, whilst they facilitate the excitatory ones to execute a movement (Enoka, 2008).

The muscle synergy is directly controlled by the physiological function of this system, by promoting an excitation of the agonist muscle (the one that will be responsible to conduct the action) and the inhibition of an antagonist muscle (the one opposed to the action) (e.g. flexor/extensor) or even the co-activation of both (Enoka, 2008; Nicholls, *et al.*, 2012).

In children with spastic CP, it is described that the insult will generates damage in the upper motor neurons (Kerr Graham and Selber, 2003) which are specific types of motoneurons that are located in the pre-motor and primary motor region of the cortex and connect with the lower motor neurons. This damage will generate, grossly, two different features that are translated in the clinical findings of these individuals, which are a result of the loss of inhibition to the lower motor neurons but also the loss of connections with them, as shown one figure 2.1 (Kerr Graham and Selber, 2003; Stifani, 2014).

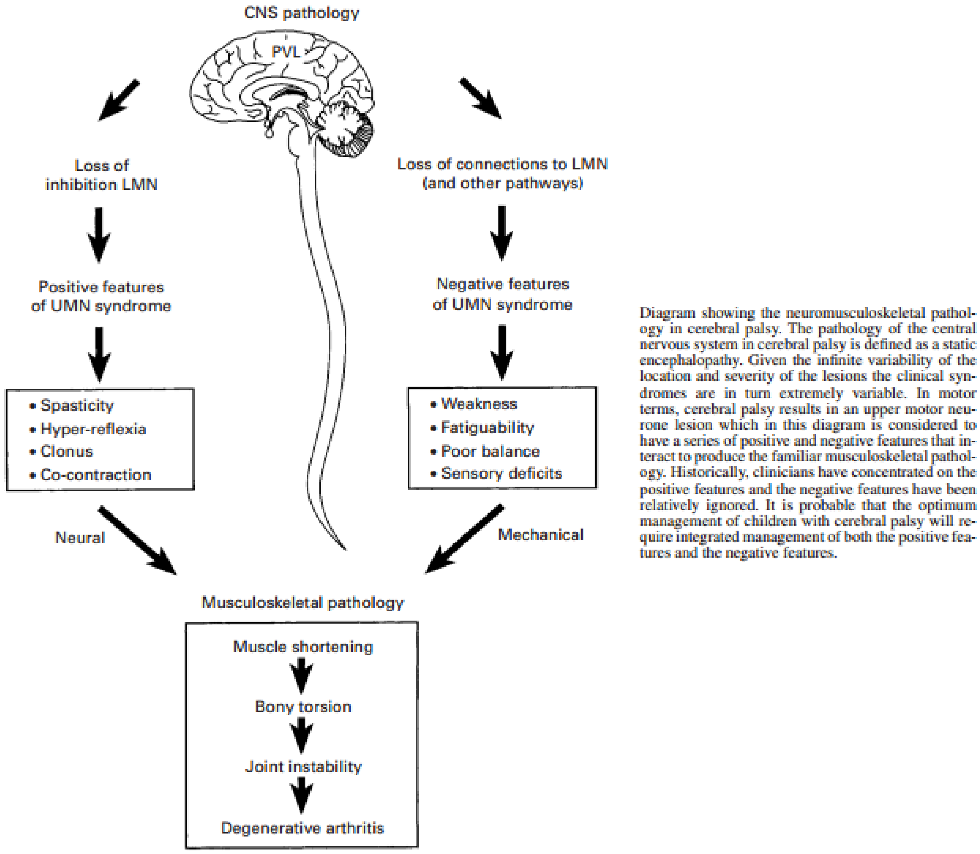

Figure 2.1 Diagram Representation of the Lesion in UMN and its Consequences.

CNS: central nervous system; UMN: upper motor neuron; LMN: lower motor neuron. Source: Nicholls, et al., (2012).

These impairments will have an impact on the child's motor function, by the delay in achieving motor milestones and the presence of abnormal posture patterns (Beckung and Hagberg, 2002; Kerr Graham and Selber, 2003). The variations of these impairments are what is used to build the clinical classification of CP.

Table 2.1. Components of CP Classification: Motor Disorder and Anatomic Distribution.

Motor Disorder			**Anatomic Distribution**	**Characteristics**	**Clinical Findings**
Spastic: damage to cerebral cortex often due to periventricular leukomalacia.			Diplegia	-~40% of Spastic CP; - Associated with preterm;	- ~80% may ambulate independently; - Independent in self-care; - Spasticity in the lower limbs.
			Hemiplegia	- ~30% of Spastic CP; - Associated with strokes and malformations;	- May ambulate with or without aid; - One side of the body is affected.
			Quadriplegia	- ~15% of spastic CP; - Associated with severe asphyxia.	- All limbs impaired; - May achieve some ambulation with assistance; - 25% non-ambulatory; -Communication and self-care limitations; - Muscles of the head and trunk may also be affected; - Higher risk of epilepsy and mental retardation.
Motor Disorder			**Anatomic Distribution**	**Characteristics**	**Clinical Findings**
Non-Spastic	**Dyskinetic: damage to basal ganglia or thalamus**	Athetosis	Entire body	- Hypotonic;	- Lack of proximal stability; - slow movement pattern;
		Chorea-athetosis		- Hypotonic; - Lack of control.	- Random movement patterns; - May achieve some ambulation
		Dystonic		- Rigid posture in flexion or extension.	- Involuntary muscle contraction; - Variated muscle tonus.
	Ataxic: damage to neurons in the cerebellum		Entire body	- Most rare type of CP; - Problems with voluntary movement and balance	- Common oral difficulties; - Tremors; - Poor head control and coordination

Source: (Jones, *et al.*, 2007; Rosenbaum, *et al.*, 2007; Bialik and Givon, 2009; Bower, 2009)

Classification based on function limitation/ability is defined by various clinical scales and questionnaires that evaluate the extent of the limitation on the individuals' motor function (Gorter, *et al.,* 2004; Rosenbaum, *et al.,* 2008). The most common classification system based on motor ability is the Gross Motor Function Classification System (GMFCS), which defines five levels for four age groups (Chagas, *et al.,* 2008; Bialik and Givon, 2009; Oliveira, Golina and Cunha, 2010). In addition to the GMFCS, there other scales to evaluate function, such as the International Classification of Functioning, Disability and Health, the Paediatric Evaluation of Disability Inventor and the Gross Motor Function Measure (GMFM) (Krigger, 2006; Rosenbaum, *et al.,* 2007).

Classifying a child with CP as "mild" or "severe" does not comply with the WHO International Classification of Impairments, Activity and Participation. This is because it does not effectively describe the child's current physical function and ability, nor the potential function that the child could achieve, making it challenging to track participant improvement and/or set rehabilitation goals (WHO, 2001; Barlett, 2006; Chagas, *et al.,* 2008; Bower, 2009, Barlett, *et al.,* 2014). Therefore, such terminology is not used in this thesis.

In this study, the GMFCS it is not used to investigate the effect of HPOT, but instead it will be used as a reliable and standardized way to describe the children's motor ability and to support the results that will be extracted from the gross motor function measure evaluations.

Created at *CanChild* Centre for Childhood Disability Research at McMaster University in Canada, the GMFCS (Appendix 6) is a reliable method that helps classify children with CP into categories, according to their motor abilities (Barlett, 2006; Bower, 2009). This standardized system classifies gross motor function in children with CP aged between 12 months to 12 years based on qualified practitioner observation of the child's motor ability to initiate or complete a pre-determined activity (Barlett, 2006; Bower, 2009; Oliveira, Golina and Cunha, 2010; Barlett, *et al.,* 2014).

The GMFCS is strongly correlated with the WHO International Classification of Impairments, Activity and Participation, as it not only looks into the physical impairment of the person, but also how it affects the execution and/or participation in a pre-determined activity (WHO, 2001; Bialik and Givon, 2009). The classification is done according to the age of the individual and has five different categories, levels I to V. In general terms, a child classified as level I would indicate that the child is considered likely to develop the ability to walk by themselves with or without a mobility aid. A child classified as level V will have limited functional mobility and will most likely continue to struggle to achieve standing and walking without whole body support.

The GMFCS is considered to be the most established and recognized type of functional classification, with moderate agreement in children <2 years of age (kappa of 0.55) and excellent in children 2-12 years of age (kappa 0.75) (Paulson and Vargus-Adams, 2017). Wood and Rosenbaum (2000) have also examined the interrater reliability of GMFCS in predicting development of the ability to walk and in addition they evaluated how reliable the scale was in predicting the child's motor development according to the child's age (positive stability of age). The authors reported an interrater reliability of 0.93, a positive stability of age (kappa 0.84) for children under 6 years old and kappa of 0.89 for those older than 6 years of age, indicating that the child would have similar levels on the GMFCS growing up.

This also led to their investigation on predicting a child's ability to walk. A child at level III, before two years of age, would be expected to roll and creep on their stomach. Before four years of age the child would be expected to start developing gait abilities and walk indoors with assistance and aids and at 12 years the child would be expected to walk indoors and outdoors with assistive mobile device for short/medium distance on level surface terrain. They reported that the positive prediction before 2 years to be walking at 12 years old was 0.74 and the negative (to not be walking) was 0.90 (Palisano, *et al.,* 2000).

In addition, a study conducted at the University of Sao Paulo (Pfeifer, *et al.*, 2009) investigated if there was an association between the GMFCS and age, gender, motor type disorder, topography (anatomic distribution) and gross motor function. They reported an association with age, agreeing with the findings reported by Wood and Rosenbaum (2000). Moreover, most children classified with hemiplegia were predominantly level I, diplegic individuals were typically among the first four levels and majority of the quadriplegic were classified as level V. In addition, they have also reported an association with age, agreeing with the findings reported by (Wood and Rosenbaum, 2000; Beckung and Hagberg, 2002; Howard, *et al.*, 2005; Himmelmann, *et al.*, 2006). These studies support the use of GMFCS to classify the gross motor function ability of children with CP and adds to the body of the literature, discussing the validity of this scale.

2.2. The Impact of Spastic Cerebral Palsy on the Motor Function

Motor skills reflect the body's capacity to produce movement, which is accomplished through the interaction and coordination of the CNS with the musculoskeletal system (Enoka, 2008; Bower, 2009; Nicholls, *et al.*, 2012). In childhood, the development of motor skills are characterized by acquisition of gross motor function, or basic motor skills, which involve the development of postural control, the ability to move the body (e.g. rolling, crawling, kneeling, walking) and the ability to manipulate different objects (Newell, 1991; Santos, Dantas and Oliveira, 2004).

The ability to develop motor skills is strongly connected with the capability of the CNS to plan and execute voluntary movements (Enoka, 2008; Li, *et al.*, 2015). Furthermore, this ability is modulated by a series of factors, such as the physiological interaction of motor neurons and the musculature, the environment, stimuli and the learning process (Santos, Dantas and Oliveira, 2004; Enoka, 2008). Therefore, an insult to the CNS during development would affect an individual's ability to regulate muscle activation, cause alterations on muscle tone and weakness and minimize their capability to regulate processes necessary to plan and execute movements (Kurz, *et al.*, 2014; Li, *et al.*, 2015).

Moreover, it is important to highlight that an impaired gross motor function interferes directly on the individual's function, participation and QoL. The abnormal movement patterns exhibited within the CP population can affect the execution of movement needed to engage in daily life activities, the interaction of the environment and the independence of the individual Beckung and Hagberg, 2002; Kerr Graham and Selber, 2003; Santos, Dantas and Oliveira, 2004; Himpens, *et al.*, 2008; Bower, 2009; Prado, *et al.*, 2013).

It is agreed among researchers that children with CP will present an impaired gross motor function, which will vary according to when the insult to CNS occurs, which area has been affected and the magnitude of the injury (Bower, 2009; Pakula, Braun and Yeargin-Allsopp, 2009). For years, the prognosis of the gross motor function development in children with CP has been a subject of research and discussion among academics and practitioners. As one of the results of this discussion, a validated and feasible measurement was developed to evaluate the gross motor function across a set of pre-determined activities. Called the gross motor function measure, this scale is widely used in the literature to investigate the effects of different rehabilitation on their impact on motor function of children with CP, including HPOT studies (Russell, *et al.*, 1989a; Herrero, *et al.*, 2012b; Champagne, Corriveau and Dugas, 2016; El-hakiem and Agha, 2017; Mäenpää, *et al.*, 2017; Park, 2017).

Gross Motor Function Measure - 88

The GMFM-88 is used to evaluate the effects of HPOT on children with CP after 6 and 12 weeks and the scores were used to evaluate if HPOT would interfere on the overall gross motor function of children with CP, comparing before, middle-treatment and after treatment.

The prognosis of gross motor function development in children with CP has long been a subject of research and discussion among academics and practitioners. As one of the results of this discussion, a validated and feasible measurement, the GMFM was developed to be used by practitioners (physiotherapists and doctors) to readily evaluate the gross motor function across a set of pre-determined activities (Palisano and Rosenbaum, 1997; Queiroz, 2016).

The purpose of the gross motor function measure (GMFM - 88) (Appendix 7) is to help health professionals to quantify gross motor function changes over time by evaluating the functional capability of the child in five different categories: lying and rolling (A); sitting (B); crawling and kneeling (C); standing (D); and walking, running and jumping (E) (Palisano and Rosenbaum, 1997; Queiroz, 2016). This scale is considered by most to be the best standardized clinical tool for measuring motor changes in children with CP (Moraes, *et al.,* 2016; Harvey, 2017).

The same group has also developed a shorter version of the GMFM-88, the GMFM-66. This version is only valid for children with CP. Despite its advantages with regards to the time it takes to be administrated and the algorithm type of scoring, the GMFM-66 requires the use of a specific piece of software, a computer and the purchase of a manual. Furthermore, because it has less items, it detects less changes in the older children with CP (>5 years old) regardless severity (Russell, *et al.*, 2000; Alotaibi, *et al.*, 2013; Harvey, 2017). In the experimental chapters of this thesis, some of the children recruited were above 5 years of age and have also presented a more severe type of CP (GMFCS levels IV and V for seven of the ten children recruited) a decision to use the GMFM-88 was taken, as observed in chapter 5. These reasons, combined with the fact that most of the studies investigating the effect of HPOT on gross motor function in children with CP used the same version make it appropriate for this study to use GMFM-88 instead of GMFM-66, despite its advantages.

How does the Gross Motor Function Classification System Relate to the Gross Motor Function Ability of Child with Spastic Cerebral Palsy?

As previously discussed, the GMFCS is a scale used to classify the child's gross motor function ability, and the GMFM is an away of evaluating this ability giving scores for pre-coded motor function activities. In this study, the GMFCS is used to categorise children with CP for the purpose of analysis. Children classified as GMFCS level I and II will be in the GMFCS group 1 and children III, IV and V in the GMFCS group 2.

The GMFCS presumes that a child with CP that is over 2 years of age and classified at level I would be able to complete a specific task or at least initiate the task in all 5 categories of the GMFM. Likewise, a child that is level V, regardless of their age, would not be expected to complete or initiate any task within category E (walking, running and jumping) as children under this classification have no means to achieve independent mobility, as all areas of motor function are impaired (Rosenbaum, *et al.*, 2008).

Therefore, it would be expected that a child classified as level IV would perform more poorly on the GMFM than the child classified as level I (considering the

GMFCS), as this child is more severely impaired and have further limitations in activity and participation.

It is key to understand that although children may have the same condition, according to the topography and motor disorder, they may have a variable set of motor limitations and motor abilities. This needs to be taken into consideration when investigating the effect of any type of physiotherapy in the GMFM scores of children with CP. Most studies evaluating the effect of HPOT in children with CP (Sterba, *et al.*, 2007; Zadnikar, *et al.*, 2011; Tseng, Chen and Tam, 2013) did not take this into consideration when looking into the variability of motor ability in children across all the GMFCS. This is a potential issue when considering how one can spread the results presented to general population, as it can be quite challenging to ensure that a type therapy is effective in improving a determined motor outcome without knowing the motor ability of the children recruited to begin with. In addition, it is quite obvious that a child with CP classify as GMFCS I (able to walk with or without aid) and a child with CP classify as GMFCS V (not able to walk, independently of aid or stage of motor development) will not perform a determined motor activity in the same way, as the first will be able to perform things such as walking, or even jumping or running with assistance and the last will, most likely not be able to even achieve the standing position without assistant.

Gross Motor Function, Cerebral Palsy and Hippotherapy

CP is a complex neurologic disorder which is not progressive, however the musculoskeletal impairments that results from the insult in the brain can deteriorate even more without treatment (Chang, *et al.*, 2017). The spasticity, the muscle weakness, the affected motor control and the abnormal muscle tone will together contribute to an abnormal development of the gross motor function, affecting the child’s ability to crawl, sit, kneel, reach for objects, stand, walk and run (Park and Kin, 2017; Chang, *et al.*, 2017; Prieto, *et al.*, 2018).

The development of motor skills is directly related to functional, social and play activities during childhood and play an important role in the acquisition of fine motor function and complex movement skills (Toovey, *et al.*, 2017). For children with CP, it is important that interventions aim to improve the child’s motor skill, to avoid the progression of abnormal patterns of movement but also to enhance the acquisition of new movement patterns in order to improve child's functional participation and quality of life (Toovey, *et al.*, 2017; Sun, *et al.*, 2017; Chang, *et al.*, 2017; Prieto, *et al.*, 2018).

For that reason, children with CP may benefit from a variety of complementary therapies, like task-specific training, Bobath® or HPOT (Chang, et al., 2012; Chang, *et al.*, 2017; Toovey, *et al.*, 2017; Prieto, *et al.*, 2018). In order to understand how beneficial a therapy may be and/or how the child is progressing regarding their motor capacity, many therapists and researchers rely on scales that can classify the motor ability of the child. Scales like the GMFCS can evaluate the capacity of the child to do a pre-determined motor activity, like the GMFM-88 (Russel, *et al.*, 1999; Oliveira, Golina and Cunha, 2010; Park, *et al.*, 2014; Toovet, *et al.*, 2017; Prieto, *et al.*, 2018).

A recent systematic review (Prieto, *et al.*, 2018), focused on evaluating the effect of HPOT on the gross motor function of children with CP. The review included 12 studies, published between 2003 and 2016. The authors reported that the GMFM scale was the most used scale among the studies included and, in spite of the divergence in study protocols, most of the studies reported that HPOT appeared to the improve gross motor function of children with CP (Benda, McGibbon and Grant, 2003; McGbibbon, *et al.*, 2009; Shurtleff, Standeven and Engsberg, 2009; Shurtleff and Engsberg, 2010; Kwon, *et al.*, 2011; Park, *et al.*, 2014; Kwon, *et al.*, 2015). These results corroborate with what was presented in Chapter 3 of this thesis.

However, other systematic reviews and meta-analysis diverge on their conclusions about the effect of HPOT in improving GMFM scores. Sterba, *et al.*, (2007) and reported that HPOT appears to have positive effects on GMFM score, but they highlighted that large and more rigorous studies are needed to strengthen this evidence. Other studies (Herrero, *et al.*, 2012a; Tseng, Chen and Tam, 2013) reported that there was not enough evidence to conclude that HPOT has significant positive effects on GMFM scores, in spite of the studies been reporting significant effects. Zadnikar and Kastrin (2011) did not discuss GMFM specifically, however they concluded that HPOT seems to be effective in improving balance and posture, two components that are relevant to the ability to stand, walk, jump and run.

Despite the different conclusions, every single literature review has criticized the allocation of subjects without considering the GMFCS level, the difference among the motor disorder in their samples, as well the differences on frequency and duration of the treatment. They have suggested a need for more studies due to limited evidence of HPOT effectiveness as these methodological issues impact directly on the analysis of the effect of HPOT when looking across studies, as different scales and different treatment protocols cannot be compared directly.

These concerns do not necessarily indicate that HPOT is not effective, but it makes it challenging to draw consistent conclusions about its effects. In this study, the approach adopted was to replicate common features of HPOT sessions in practice, following the results reported on Chapter 4 of this thesis. In this study the typically adopted protocols recommended by PTs (as per discussed in chapter 4) and the most used scale to evaluate gross motor function (as per discussed in chapter 3) were chosen.

It is known that gross motor function is often evaluated with the GMFM (Marois, *et al.,* 2016; Vos, *et al.,* 2016; Arı and Günel, 2017; Diwan, *et al.,* 2017). This scale has 5 categories to investigate the child's motor ability while lying and rolling (A), sitting (B), crawling and kneeling (C), standing (D) and walking, running, jumping (E). Taking that in consideration and knowing that the level of GMFCS also defines some of these abilities, it is presumed that a child over 2 years of age that is classified at level I would be able to complete a specific task or at least initiate the task in 5 categories of the GMFM. Likewise, a child that is level V, regardless of their age, will not be expected to complete or initiate any task on the category E, as children under this classification have no means to achieve independent mobility as all areas of motor function are impaired.

In the GMFM, each task is graduated from 1 (can initiate the task) to 3 (complete the task independently). To evaluate how well a child performs in each category, the sum of the grades given to each task within a category is totalled. Once there is a score for each of the categories, the sum of those scores give the total GMFM-88 score (Russell, *et al.,* 1989a). Bearing that in mind, and considering a child with spastic diplegia level I and a child with the same condition and age but with level IV, it would be expected that the child level IV will perform more poorly on the GMFM than the child level I, as this child has more motor impairment and limitations, therefore it would be more challenging to attain or complete a task, especially on GMFM D and E. It is key to understand that although children may have the same condition, according to the topography and motor disorder, they may have a variable set of motor limitations and motor abilities. This needs to be taken into consideration when investigating the effect of any type of physical therapy in the GMFM scores of children with CP. This study aims to increase knowledge and understanding about the effects of HPOT on GMFM-88 scores of children with CP after 6 and 12 weeks of typically HPOT treatment (Damiano, *et al.*, 2006).

2.3. The Impact of Spastic Cerebral Palsy in Balance: Outcomes and Methods of Evaluation – Pliance® and Force Plate

What is Balance?

In mechanics the term balance is defined as the state of a body when the resultant forces acting on it equals zero and it is directly dependent on the centre of gravity (CoG) and the base of support, so if the CoG is displaced outside out of the base of support balance will be disturbed and unless another force acts to control it the unbalanced body will fall (Durward, *et al.*, 2000). In the literature and in clinical practice, balance is evaluated throughout its components, defined on table 2.2 (Clayton, *et al.*, 2011; Kang, Jung and Yu, 2012; Gregório and Krueger, 2013; Lemay, *et al.*, 2014; Bonnechère, *et al.*, 2015; Champagne, Corriveau and Dugas, 2016).

Table 2.2. Components of Balance

Concepts	***Definitions***
Stability	Is a resistance to both linear and angular acceleration (Hamill, 2015)
Body Sway	Body sway is how much the body will move on the anterior-posterior (AP) and mediolateral (ML) plans during a determined duration of time. It can be described by series of parameters such as centre of pressure displacement and velocity (Pollock, *et al.*, 2000b; Raymakers, *et al.*, 2005; Hamill, 2015). There always will be a minimum amount of sway, due to small perturbations such as breathing, or shifting body weight from one foot to the other, dislocation of centre of mass or posture weakness (Pollock, *et al.*, 2000b; Raymakers, *et al.*, 2005; Hamill, 2015).
Centre of pressure	The centre of pressure is a type of measurement that indicates the path of the resultant of the ground reaction force. It can be obtained by using a force plate or a pressure mat. The trajectory of the CoP is independent of the CoM and it will represent the location of the ground reaction force vector from a single force platform assuming all body contact points are on the platform. The CoP

	is indicative of a neuromuscular response to the imbalance of the body's CoM. In quiet standing the AP direction of CoP is controlled by ankle dorsi/plantar flexors, and the ML by the hip adductors/abductors (Enoka 2008; Winter, 2009; Robertson, 2014).
Centre of mass	The centre of mass of a body is the point where the body's mass is equally distributed in all directions. If the body is supported at its CoM there is no net force so the body will remain in static equilibrium. This point is variable, as it moves according to relative movement of body parts and it is dependent of anthropometric measurements (Enoka, 2008; Robertson, 2014).
Posture control	Postural Control is defined by the act of maintaining, achieving or restoring a state of balance during a posture or activity. (Pollock, *et al.*, 2000)
Static Balance	Is the condition when the body is stable in a determined position, it is *per se* when the body is not moving (e.g. standing, sitting). When the body is in static balance and is disrupted by a force, acceleration or a condition (e.g. alcohol, eyes closed) this balance may be then instable and the body shall answer in two different ways: "Compensatory", when posture strategies will get in coordination to keep the body stable or "Predictive", which will involve a voluntary movement or muscle activation in anticipation of the disturbance. Both postural control reactions can happen as well combined (Pollock, *et al.*, 2000b; Rebelatto, *et al.*, 2008; Robertson, 2014; Hamill, 2015).
Dynamic Balance	The position of the body when the body acceleration is greater than zero but the body is still stable (e.g. walking, jumping, dancing, running and riding). Postural control in this condition will be defined as the ability of the body to keep the balance during a moving action (Pollock, *et al.*, 2000b; Rebelatto, *et al.*, 2008; Hamill, 2015).

In the human body, the ability to maintain balance depends on three major systems: i) the sensory and vestibular; ii) CNS and iii) musculoskeletal system. The vestibular system processes stimuli that relate to the head position, with information brought directly from the vestibular apparatus (Horak, 1997; Horak, 2006; Enoka, 2008). Sensory information will come through proprioceptors presented at joints, in the skin and from visual information of the verticality of the body and its spatial locations relatively to objects and base of support. Muscles, bones, joints will be responsible to maintain the body in a determined position to keep the equilibrium between the CoG and base of support. The CNS will coordinate, process and ordinate all this information (Horak, 2006; Enoka, 2008; Nicholls, *et al.*, 2012).

The research literature reports that children with CP have a poor ability to engage sensory and motor components to adopt satisfactory postural control strategies. Therefore a variety of research studies have focussed on evaluating intervention programs to improve postural control and balance in these populations (Goldie, Bach and Evans, 1989; Kernozek and Lewin, 1998; Shumway-Cook, *et al., 2*003; Gribble and Hertel, 2004; Hamill, Washington and White, 2007; Hochmuller, *et al.,* 2007;

Duarte and Freitas, 2010; Clayton, *et al.*, 2011; Kang, Jung and Yu, 2012; Gregório and Krueger, 2013; Lemay, *et al.*, 2014; Bonnechère, *et al.*, 2015; Champagne, Corriveau and Dugas, 2016).

Balance Components and Maintenance of Postural Equilibrium

Postural equilibrium during static tasks can be characterized by the maintenance of the CoM within the BoS (Hamill, 2015; Robertson, 2014; Winter, 2009; Horak, 2006; Palmieri, *et al.*, 2002; Karlsson and Frykberg, 2000; Massion, 1992). Characteristics of CoM and CoP movement are used to evaluate balance and balance disturbances (Massion, 1992; Horak, 2006; Mackow, *et al.*, 2014), however CoP is more commonly reported as it is easier to capture and is highly correlated with the CoM (Karlsson and Frykberg, 2000).

In maintaining postural equilibrium, sensorimotor information will be integrated with previous experiences to inform the neuromuscular strategies to control the body's CoM (Horak, 2006). Although human beings are not conscious of the exact location of the CoP or the CoM, they are aware of its limits. This awareness happens when the limits exceed postural reactions, which is followed by a voluntary reaction to restore stability (Palmieri, *et al.*, 2002; Enoka, 2008; Horak, 2006; Callahan, 2017). The CNS will detect a shift in the CoM, and postural contractions will occur, moving the CoP somewhat further to the CoM in the attempt to regain balance. If for any reason, this reaction is not enough, the individual will fall (Pollock, *et al.*, 2000a; Palmieri, *et al.*, 2002; Teixeira, 2013; Zolnerkevic, 2015).

Disorders such as CP, will often present an impaired postural stability due to poor interactions between musculoskeletal, sensorimotor and central nervous systems. For example, children with CP will present an inability to coordinate the following: activation of postural muscles in the right sequence; a velocity dependent increase tone (spasticity); muscle weakness; and excessive co-activation of antagonist muscles (Burtner, Qualls and Woollacott, 1998; Pavão, *et al.*, 2013). Moreover, children with CP tend to increase the recruitment of antagonists and decrease trunk muscle activation, as it is hypothesised that this recruitment assists in joint stabilization and improved postural control (Burtner, Qualls and Woollacott, 1998).

The deficient postural control of children with CP has been suggested to be one of the most influential factors to abnormal gait and motor skill acquisition and development (Burtner, Qualls and Woollacott, 1998; Rose, *et al.*, 2002; Shumway-Cook, *et al.*, 2003; Woollacott, *et al.*, 2005; Donker, *et al.*, 2008; Bower, 2009; Pavão, *et al.*, 2013; Burtner, *et al.*, 2014). In order to tackle this issue researchers and therapists have been using and evaluating a variety of rehabilitation techniques to tackle postural abnormalities and improve motor skills. Some research has shown improvement in manipulation skills when postural support is provided, and that crouched posture and gait increase the sway of CoP and that there is a relationship between the reduction of these balance impairments and the improvement in gross motor skills and abilities of children with CP (Rose, *et al.*, 2002; Shumway-Cook, *et al.*, 2003; Pavão, *et al.*, 2013; Pavão, *et al.*, 2014; Verbecque, *et al.*, 2016).

HPOT is one of the techniques used to improve postural control. For example, Zadnikar and Kastrin, (2011) found that during riding, a non-disabled subject would rely on the activation of core muscles to control body movements relative to a moving surface to maintain balance (Terada, *et al.*, 2004; Pantal, *et al.*, 2009; Clayton, *et al.*, 2011). However, individuals with CP may lack control of these core muscles, resulting in an inability to stabilize in the light of perturbation which could lead to larger amplitudes of CoP responses, with lower frequencies of response, if compared to non-disabled children (Clayton, *et al.*, 2011).

Therefore, the CoP sway path (how much the body moves during an action of stance balance) and velocity (how quick it moves) can be an indicative measurement to evaluate reactive balance response, with studies showing that children with CP have a larger range of CoP movement on a movement platform, or in the moving horse, when compared to non-disable children (Woollacott and Cook, 2005; Clayton, *et al.*, 2011).

Balance and Cerebral Palsy

According to Bower, (2009) a child with CP is motor limited by the impairments caused by the disorder, which can lead to the adoption of poor postures. These movements become stereotyped and the current adoption of asymmetric postures and movements may lead to deformation. Figure 2.2 makes a comparison of normal muscle tone to abnormal muscle tone and its relationship with postural reactions and movement (Bower, 2009). Postural and balance control are vital to a child's physical and cognitive development as the need to achieve new postures and complex motor skills will have an important impact on the child's motor ability acquisition and learning (Bower, 2009; Verbecque, *et al.,* 2016).

In children with CP, the interactions between musculoskeletal, sensorimotor and CNS are affected, as these children will present an inability to coordinate the activation of postural muscles in the right sequence. This is a result of a series of contributing factors, such as a velocity dependent increase tone (spasticity); muscle weakness; and excessive co-activation of antagonist muscles (Burtner, Qualls and Woollacott, 1998; Pavão, *et al.,* 2013). Moreover, children with CP, tend to create compensatory postures to achieve a determine position of movement, which is often a consequence of increasing recruitment of antagonists and decrease trunk muscle activation. It is considered that this recruitment assists in joint stabilization and improve postural control (Burtner, Qualls and Woollacott, 1998; Beckung, *et al.,* 2007).

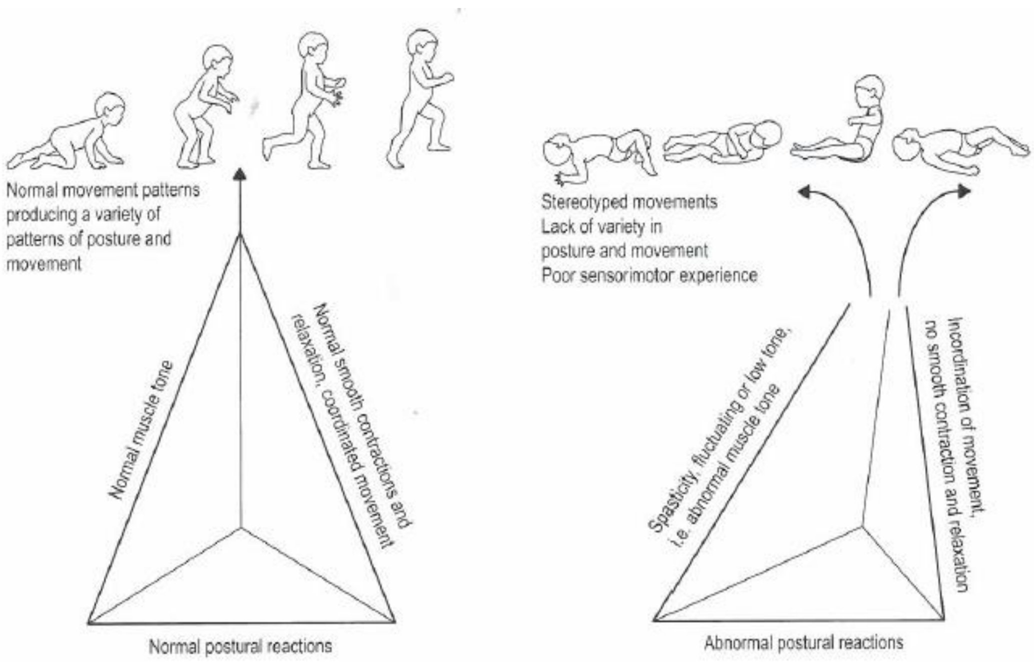

Figure 2.2. Comparison of Muscle Tone, Posture Reaction and Movement.

Source: Bower, (2009).

The motor development of a child with CP is affected by a cycled relationship between the neuromuscular deficits, the impairments on CNS and motor acquisition. The insult to the immature brain results in musculoskeletal and sensorimotor impairments (spasticity, fluctuating tone, muscle weakness, contractures), that affect the child's ability to adopt normal postural reaction and orientation and to learn a motor skill. Thus can lead to motor limitation, acquisition of "crouch"[1] posture and deformities that will finally lead to further motor impairments and the inability to learn new motor skills (Burtner, Qualls and Woollacott, 1998; Shumway-Cook, *et al.*, 2003; Woollacott, *et al.*, 2005; Bower, 2009; Pavão, *et al.*, 2013; Burtner, *et al.*, 2014).

The deficiency in postural control of children with CP is considered to be one of the known factors in abnormal gait and motor skill acquisition and development (Burtner, Qualls and Woollacott, 1998; Rose, *et al.*, 2002; Shumway-Cook, *et al.*, 2003; Woollacott, *et al.*, 2005; Donker, *et al.*, 2008; Bower, 2009; Pavão, *et al.*, 2013).

A study published by Donker, *et al.*, (2008) investigated CoP sway path of children with CP in comparison with children that are typically developed, looking into the differences between both and how visual information would affect the postural sway in both populations. They evaluated 10 children with congenital hemiplegia or CP and 9 typically developed children. The experiment consisted in children standing on the force plate under three conditions: with eyes open with eyes closed and with visual feedback of the CoP. As previously hypothesised by the authors, children with CP exhibited larger and more regular sway than children that were typically developed. As for the comparisons among the different visual information, they have found that it affects children in both groups differently, with the sway being less regular with CoP feedback and with EC in children with CP.

In a more recent study, Mendoza, Gomez-Conesa and Montestinos (2015) investigated the association between gross motor function and postural control in sitting children with CP. The study involved 139 children with CP from 24 different centres, with 64 children being classified as Level I (GMFCS), 28 level V, 24 level II, 12 level IV and 11 level III. To evaluate sitting balance, they have used the Level

[1] "Crouch" stance/gait is a typical gait pathology adopted by children with diplegia, that is characterized by increase in knee flection during stance phase and frequent increased hip flexion and internal rotation that can lead to joint pain and degeneration (Hicks, e*t al.*, 2008, Pavão, *et al.*, 2013).

Sitting Scale and they analysed the relationship this scale would have with the GMFCS (Mendoza, Gomez-Conesa and Montestinos, 2015). A significant inverse relationship between both scales was found (r=-0.86, p=0.00). This means that children that were able to walk with or without a walking aid, performed better on the Level Sitting Scale, with 45.3% of the children capable of leaning in any directions of re-erecting the trunk (level VII of Level Sitting Scale) were classified as level I in the GMFCS (Mendoza, GomezConesa and Montestinos, 2015).

In order to break the cycle described in the Figure 2.3 researchers and therapists have been evaluating and using a variety of rehabilitation techniques to tackle postural abnormalities and improve motor skills. Some studies have shown improvement on manipulation skills when posture support is given, indicating that there is a relationship between balance impairments and the gross motor skills and abilities of children with CP (Rose, *et al.*, 2002; Shumway-Cook, *et al.*, 2003; Pavão, *et al.*, 2013; Pavao, *et al.*, 2014; Verbecque, *et al.*, 2016).

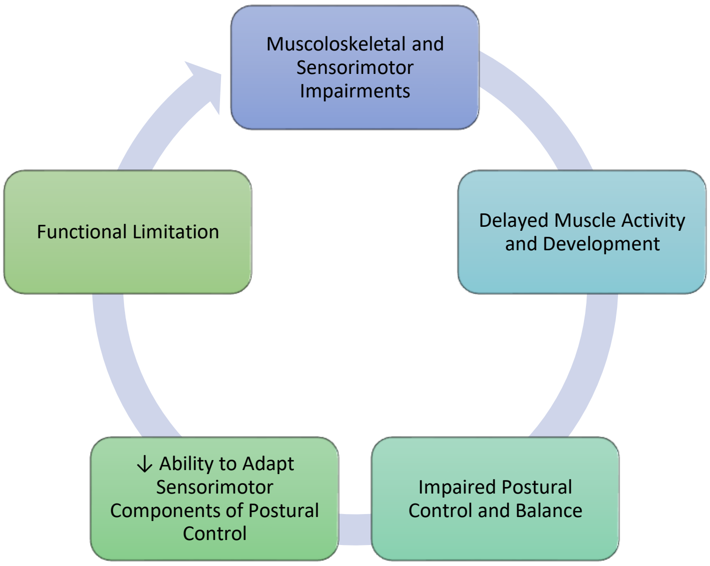

Figure 2.3. Cerebral Palsy Cycle of Motor Impairment.

Balance Training in Children with Cerebral Palsy

To comply with the aim of reducing impairments and increase postural and balance control, a variety of interventions, in addition to conventional physiotherapy may be used. These include constraint-induced therapies, training on a moving platform, electrical stimulation, HPOT and horse-back riding (Saether, *et al.*, 2013).

The evidence of the effectiveness and effectiveness of these therapies in improving functional reactive balance control is still limited (Shumway-Cook, *et al.,* 2003).

However, studies investigating these therapies investigate the hypothesis that balance training would generate a reduction on sway path of CoP and an increase of stability of children with CP (Shumway-Cook, *et al.,* 2003; Clayton, *et al.,* 2011; Mikołajczyk, Ligęza and Jankowicz-Szymańska, 2017). Balance training, as any rehabilitation treatment, should be patient-centred and tailored to the abilities and impairments of everyone. The treatment should comply all components of postural control, providing stimuli to all systems involved (vestibular, sensorimotor and neuro-musculoskeletal) and positive improvements to both dynamic and static balance components (Shumway-Cook, *et al.,* 2003; Woollacott, *et al.,* 2005; Gürkan, *et al.,* 2016; Mikołajczyk, Ligęza and Jankowicz-Szymańska, 2017).

Woollacott, *et al.,* (2005) investigated the neuro-mechanism of training-induced improvements in balance in children with CP. Using a force plate and a surface electromyogram they collected CoP variables and recorded the muscle activity of the gastrocnemius and tibialis anterior to investigate the neuromuscular responses that contribute to postural improvements as a result of training. The responses were acquired prior to training, after training and at 1 month follow up. They hypothesized that the changes on postural performance would be due to two factors: combinations of changes in directional and spatial and/or temporal domains. These factors would reduce agonist-antagonist activations and improvement in muscle response sequencing would be observed (Woollacott, *et al.,* 2005).

Results suggested that changes in these factors cited above contributed to improvements on postural performance. Each child showed a different combination of components contributing to the improvement, which was associated with the severity of the impairment (Woollacott, *et al.,* 2005). In summary, a child with hemiplegia may present modified temporal and amplitude characteristics, differently of a child with diplegia. Woollacott, *et al.,* (2005) provided some evidence of neural mechanism changes in children with CP. It highlights that these neural changes are highly dependent of the severity of the impairment and the variability among the children, even among those with same diagnosis. These reinforce the idea that training should be tailored and patient centred and that studies should consider the importance of individual analysis and the use of quantitative tools (Woollacott, *et al.*, 2005).

Hippotherapy and Balance

HPOT is one of the techniques that has been used to help improve balance in children with CP. Riding a horse requires constant adjustments in posture to maintain balance in a dynamic situation, and it has been suggested to lead to improved control of spasticity and increased muscle strength and importantly, improved balance (Clayton, *et al.*, 2011; Zadnikar and Kastrin, 2011).

Two meta-analysis (Zadnikar and Kastrin, 2011; Tseng, Chen and Tam, 2013) have assessed the quality and the results of studies investigating the effects of HPOT and/or THR on the balance and/or posture control of children with CP. Tseng, Chen and Tam (2013) have discussed the results reported in four studies (Hamill, *et al.*, 2007; Shurtleff, *et al.*, 2009; Shurtleff, 2010; Kwon, *et al.*, 2011) of which three reported significant and positive changes in either postural stability or balance after HPOT. These studies provide support that HPOT could be an effective intervention for improving functional movements of children with mild CP.

Zadnikar and Kastrin (2011) included 8 studies in their meta-analysis (MacKinnon, *et al.*, 1995; Bertoti, 1998; MacPhail, *et al.*, 1998; Quint and Toomey, 1998; Haehl, *et al.*, 1999; Kuczynski and Slonka, 1999; Benda, McGibbon and Grant, 2003; Shurtleff, *et al.*, 2009) concluding that of the combined 39 children with CP, a statistically significant improvement in posture and/or balance after HPOT or THR existed. The authors discussed that during HPOT or THR, changes in the horse's gait facilitate equilibrium responses that are linked to the positive effects, reporting that HPOT could be indicated as form of improving posture and balance.

During a horse's locomotion the subject is moved up and down, forwards and backwards. Furthermore, the movement of the participant varies depending on the horses' gait. For example, during the horse's walk the subject's pelvis pitches in the sagittal plane and yaw in the vertical axis. As for the horse, with the weight of the subject, it is observed an extension of the horse's thoracolumbar spine when the horse is standing or during locomotion is observed. The subject's movement will be driven by the horse; however, the subject can voluntarily influence the horse's pattern of walk (Gregorio and Krueger, 2013; Clayton and Hobbs, 2017).

According to Schusdziarra, Schusdziarra and Abelshauser (2004) a beginner rider would be trained to activate abdominal and back muscles, stretch and engage spinae, shifting the weight to keep balance using a method that elicits the pelvis will follow the horse's trunk movement. In the healthy motor control and learning, balance should improve, and this improvement may be found by looking into CoP range of motion (Schusdziarra, Schusdziarra and Abelshauser 2004; Clayton, *et al.*, 2011). However, a child with a motor impairment such as CP has abnormal motor control and the ability to adapt may be compromised due factors such as poor muscle synergy, inability to shift weight, overall muscle weakness and spasticity, and poor pelvic mobility, which leads all together to poor balance control and mobility (Benda, *et al.*, 2004; Casady, *et al.*, 2004; Schusdziarra, Schusdziarra and Abelshauser 2004).

Researchers and therapists advocate that different movements of the horse generate a variety of stimuli that challenge postural performance and responses, to maintain the stability of trunk, head and limbs (Zadnikar and Kastrin, 2011; Herrero, *et al.*, 2012; Tseng, Chen and Tam, 2013; Moraes, *et al.*, 2016; Koca and Atasaven, 2016; Clayton and Hobbs 2017; Mikołajczyk, Ligęza and Jankowicz-Szymańska, 2017). Recent literature reviews and research studies have discussed the reasons why the horse is used and how it may generate positive physical outcomes in children with motor impairments (Koca and Ataseven, 2016; Mikołajczyk, Ligęza and Jankowicz-Szymańska, 2017; Stergiou, *et al.*, 2017). Authors of these studies suggest that during ambulation the horse provides a rhythmic movement that can stimulate anterior-posterior (AP) and mediolateral (ML) swings in the participant's body. Furthermore, since the horse's back moves in a similar way as the human pelvis does during walking these weight shifts are highly relevant. Other factors including the position of rider's the legs and the horses' temperature may also help to normalize muscle tone. In addition, it has been noted that the variety of stimulation the child receives while riding ranges from sensory to vestibular, of which the benefit in effective therapy is reported in wider studies (Koca and Ataseven, 2016; Mikołajczyk, Ligęza and Jankowicz-Szymańska, 2017; Stergiou, *et al.*, 2017).

While previous research has suggested the benefits of HPOT for improving postural control of riders, and those with CP, there were some weaknesses in the research area to date. While these have been extensively discussed previously in the thesis, they are summarised below:

i) With a different treatment protocols, the conclusions of systematic reviews and meta-analysis can be often generalized and biased;

ii) Different methods for evaluations make it challenging to draw general conclusions regarding the effect of HPOT or any other therapeutic technique on functional ability in children with CP. Specifically, in this case, in the review presented by Zadnikar and Kastrin, (2011), none of the studies used balance outcomes, such as CoP or CoM, which indicates that they were not necessarily evaluating balance directly, but only postural alterations.

iii) The confusion between THR, HPOT and other EAT. Zadinkar and Kastrin (2011) as Tseng, Chen and Tam, (2013) included papers without defining or distinguishing each generating bias to their conclusions and limiting the ability to advocate any of these techniques based on the research performed to date.

While there is some evidence of the positive effect of HPOT on balance of children with CP, no study to date has evaluated the dynamic balance of children with CP during the time while they were sitting passively on the horse (with the horse moving), nor the effect of HPOT on balance of children with CP across all GMFCS levels (I-V). Therefore, the aim of this study was to evaluating CoP of children with CP GMFCS levels I-V while sitting passively on the horse and while sitting on the force plate pre and post a HOPT intervention.

Prior to the discussion of how HPOT could help to improve balance in children with CP, it is important to clarify few concepts involved in the evaluation and rehabilitation of balance, such as postural equilibrium and balance components.

Balance Evaluation: Static Position and While Riding

In order to understand how balance components and postural control affect motor skill acquisition in children CP, it is important to understand how balance can be evaluated in this population (Pavão, *et al.*, 2013). There is still no general consensus on how balance should be evaluated in clinical and research settings, where it is often challenging to have a scale, test or equipment that will provide reliable, cost-effective, user friendly data, and that provides a meaningful evaluation of children's balance in line with different motor skills and classification (Pavão, *et al.,* 2013; Saether, *et al.,* 2013).

Pliance – Dynamic Evaluation of Balance

The Pliance® (Novel, Germany) pressure mat can measure dynamic pressure distribution between the saddle and the horse. With this device the amount of pressure the horse is experiencing under the subject and the dislocation of the subject's CoP can be measured. Previous studies have shown that the mean force and pressure corresponds to the subject's weight (Fruehwirth, *et al.,* 2004; de Cocq, *et al.,* 2009; Janura, *et al.,* 2009; pliance®-s, n.d.).

A pressure mat is an arrangement of sensors that measures forces acting perpendicular to their surface and preliminary studies reported that there is a linear relationship between an individual's body weight and the total pressure measured by the mat (Jeffcott, *et al.,* 1999; de Cocq, Van Weeren and Back, 2006; de Cocq, *et al.,* 2009). Specifically, contains 224 individual sensors measuring 3.2 x 2.5 cm each and organized in 14 columns and 16 rows. With this device, the amount of pressure the horse is experiencing under the subject and the dislocation of the subject's centre of pressure can be measured. In validating the use of a pressure mat to measure CoP of a rider on a horse, preliminary studies have reported that there is a linear relationship between an individual's body weight and the total pressure measured by the mat (Jeffcott, *et al.,* 1999; de Cocq, Van Weeren and Back, 2006; de Cocq, *et al.,* 2009).

Greve, (2013) published a review on the evidence about the interaction between the horse and the rider, highlighting what has been done and what gaps in the literature exist. They reported the Pliance® pressure mat has capacitive sensing elements, and it should be positioned on the horse's back and the subject should mount from a high mounting block or stairs, with calibration happening daily prior to the measures. The pressure data can vary according to the horse's back shape, as the total force recorded in a horse with a narrow back may be smaller than the recordings on a horse with a flat back, nonetheless the authors of the review reported that the data provided is an objective measure of the force applied to the horse's back and the stability of the subject while on the horse.

A study carried out by Clayton, *et al.,* (2011) compared the AP and the ML RoM and velocity of the CoP in subject with CP to the same variables of subject without disabilities, using the Pliance® pressure mat. They reported that the balance components of children with CP were significantly more unstable than the balance components in the non-disable subject, except for the velocity of the CoP in the AP axis. Although Clayton, *et al.*, (2011) demonstrated that changes in the CoP could be evaluated while riding and that they are potentially useful to track changes in balance, although the study did not investigate the effect of any therapy on these outcomes.

An earlier study (Janura, *et al.*, 2009) investigated the changes in the magnitude and distribution of pressure between horse and subject during HPOT sessions, by using the Pliance® pressure mat. In this study the participants took 5 HPOT sessions for a period of 20 minutes, however, all the participants were healthy adult women without any riding experience. They have reported that the maximum pressure increased after the 5th session in comparison to the first one. Furthermore, the study reported that the pressure was significantly higher during the contact of hind limbs than on the fore limbs, and that CoP on the AP axis was significantly reduced after the 5 sessions. Their results suggest that, although with a small sample, the Pliance® can give information about the interaction of the subject with the horse.

Force Platform – Static Evaluation of Balance

The maintenance of balance is essential to the execution of daily upright living activities and as such many researchers have used CoP to evaluate balance considering that the body sway contains valid information about body stability (Duarte and Freitas, 2010; Karlsoon and Frykberg, 2000).

An impaired balance can lead to an impaired motor function and this would be reflected in an increase and/or altered movement strategy on the body sway (Karlsoon and Frykberg, 2000). Children with CP often make use of compensatory mechanisms to overcome gravity to keep upright, yet these compensations, in the long-term, can lead to muscle imbalance. For that reason, balance training is an important part of the rehabilitation process for these children (Bonnechere, *et al.* 2015).

Since 1970, force platforms (Figure 2.4) have been used to measure CoP movement to underpin quantitative measures of postural control (Palmieri, *et al.*, 2002). In summary, the force plate records ground reaction force (GRF), which allows the calculation of CoP that reflects the trajectory of the CoM, within a series of variables, such as sway path and sway velocity (Palmieri, *et al.*, 2002).

Figure 2.4. Force Platform.

A force plate measures force in 3 dimensions (3-D) – vertical (Z), along the length of the plate (Y) and along the width of the plate (X) and the three orthogonal components of the force are *Fx*, *Fy* and *Fz* (x, y and z are anterior-posterior, medial-lateral and vertical, respectively) (Karlsson, *et al.*, 2000; Winter, 2009; Duarte and Freitas, 2010; Robertson, 2014; Hamill, 2015). Since *Fx*, *Fy* consistently change and considering that the force vector is the resultant of a distribution of forces in an area of contact, the name given to this location is CoP (Winter, 2009; Timmis, 2010; Robertson, 2014). The X component is equivalent to the anterior-posterior measure and Y to the medial-lateral measure in this study. The range of motion of the CoP and its sway path will be present in millimetres (mm) and the sway path velocity in millimetres per second (mm/s) on the X and Y components (Figure 2.5).

The reason why X is anterior-posterior (although runs alongside the width of the platform) is because the children stand and sit on the plate looking towards the width of it, as it would give them as bigger base of support, making the Y medio-lateral (Figure 2.6).

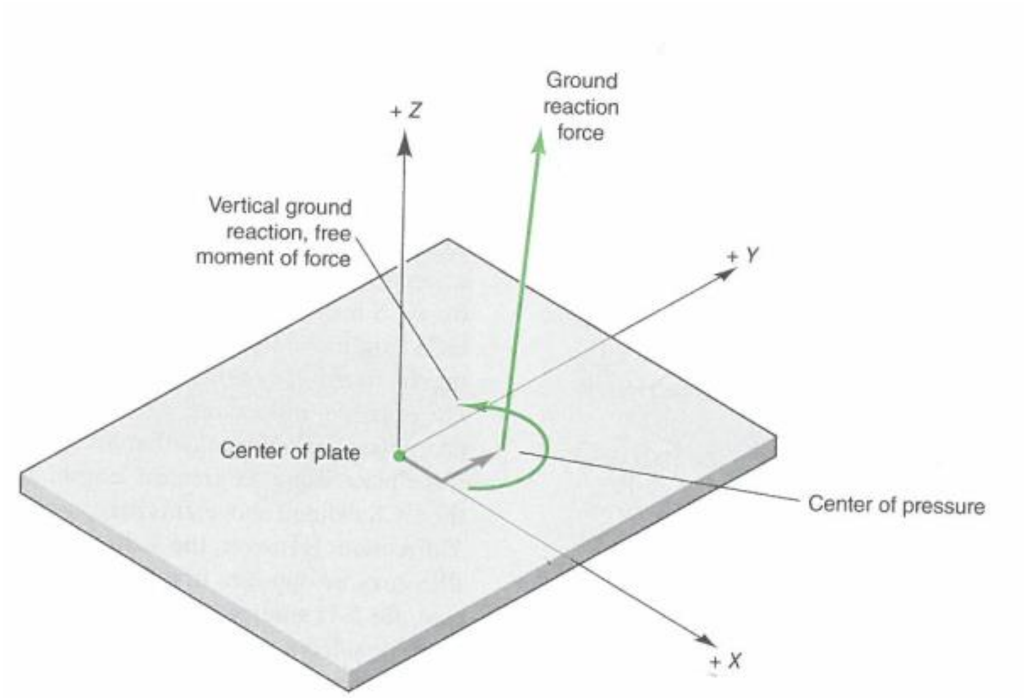

Figure 2.5. Force Plate with its Reaction to an Applied Force and Vertical Moment of Force.

Source: Robertson, (2014).

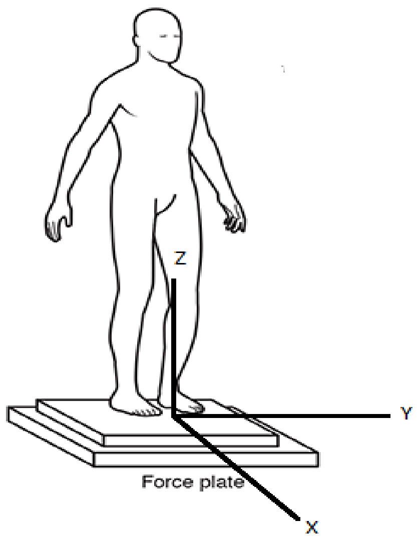

Figure 2.6. Schematic representation of how the children were standing in the Force Plate.

Adapted from (Herdman and Clendaniel, 2014).

At this study, the Kistler Force Plate (Figure 2.4) was used. It has 12 piezoelectric sensors, arranged in three orthogonal cylinders in each of the four pedestals. The sensors are horizontal and summed in pairs giving 8 output signals:

F_x^{1+2}, F_x^{3+4}, F_y^{1+4}, Fy^{2+3}, F_z^1, F_z^2, F_z^3 and F_z^4 (Robertson, 2014). The equations for computing the quantities of the ground reaction force (Equation 2.1). and the coordinates of CoP are below (Equation 2.2).

Equation 2.1. Calculation of Ground Reaction Force.

$$F_x' = (F_{x^{12}} + F_{x^{34}})f_{xy}$$

$$F_y' = \left(F_{y^{14}} + F_{y^{23}}\right)f_{xy}$$

$$F_z' = (F_{z^1} + F_{z^2} + F_{z^3} + F_{z^4})f_z$$

Where $F_x', F_{y,}' F_z'$ are the components of ground reaction force.

Equation 2.2. Coordinates of CoP.

$$x = \ [a(-F_{z^1} + F_{z^2} + \ F_{z^3} - \ F_{z^4})f_z - \ F_{x^z}']$$

$$y = \ \left[b(F_{z^1} + F_{z^2} - \ F_{z^3} - \ F_{z^4})f_z - \ F_{y^z}'\right]F_z'$$

Where, x, y and z are coordinates of CoP and f_{xy} and f_z are scale factors that convert the forces from voltages to newton, and *a* and *b* are the distance between the sensors and the centre of the force plate, in the X and Y direction, respectively (Robertson, 2014) (Figure 2.7).

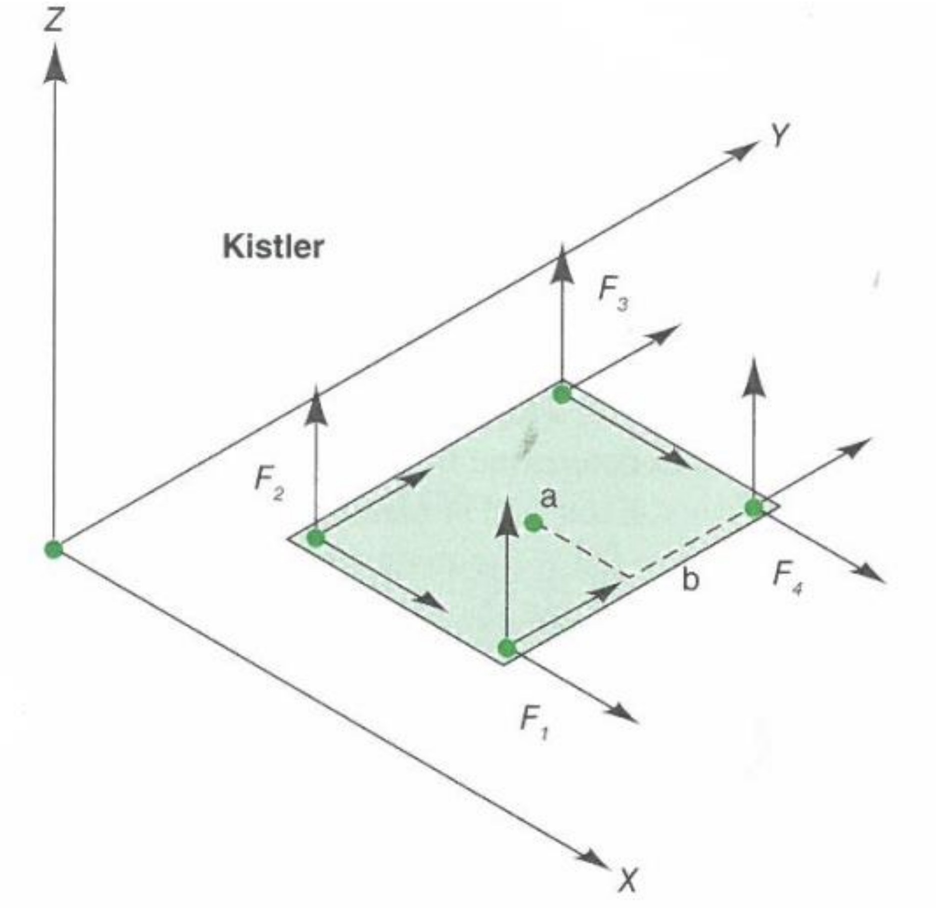

Figure 2.7. Four Piezoeletric Sensors in a Kistler Force Plate.

Adapted from Robertson, (2014).

The output signals that are captured by the platform are then fed to an amplifier that determine the exact values of each scale factors, these pre-determined equations are what determine the ground reaction force and CoP that are collected during the trials (Robertson, 2014).

A number of studies have evaluated the effect of HPOT on balance outcome in children with cerebral palsy (Kwon, *et al.,* 2011; Hyun Jung, *et al.,* 2012, Silkwood-Sherer, *et al.,* 2012; Lee, *et al.,* 2014; Kwon, *et al.,* 2015), with five of them using the paediatric berg scale to evaluate balance and only one (Kang, *et al.,* 2012) used a force plate to complete the sitting balance test. All studies that have used paediatric berg balance have shown significant improvement on the scale score after HPOT treatment and Kang, *et al.,* (2012) has shown that sway path and sway path velocity of the CoP significantly improved in the experimental group that were doing HPOT when compared to control and conventional physiotherapy.

Scales such paediatric berg balance scale and paediatric clinical test of sensory interaction for balance are reliable and widely used in the literature to assess dynamic and static balance (Saether, *et al.*, 2013). However, it is noted here that these scales cannot be used in children with GMFCS levels IV and V because they require the child to perform activities such as "standing to sitting", "standing in on foot", "sit unsupported" which are challenging or not possible (Pavão, *et al.*, 2013; Saether, *et al.*, 2013). In addition, validated clinical scales typically used with these populations do not quantify components of balance based on CoP or CoM.

For these reasons and considering that most of the recruited population for this experimental study were classified as GMFCS IV and V, CoP movement, captured via the force platform was chosen as the measure for balance, with the aim to quantify components of balance (sway path and velocity of CoP) of children with CP pre and post HPOT treatment.

2.4. The Impact of Spastic Cerebral Palsy in Spasticity and the use of the Modified Ashworth Scale

Pathophysiology of Spasticity

The first widely accepted spasticity definition, proposed by (Lance, 1980) was "*a motor disorder characterised by a velocity dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks*[2]*, resulting from hyper-excitability of the stretch reflex, as on component of the upper motor neurone syndrome*". However, a more recent study has suggested an updated definition, reflecting upon scientific evidence, proposing that spasticity is considered as "*disordered sensorimotor control, resulting from an upper motor neuron lesion, presenting as intermittent or sustained involuntary activation of muscles*" (Ashford, 2017).

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[2] Tendon or muscle jerks is a clinical method used to determine the sensitivity of stretch reflexes (e.g. the knee jerk is expressed by striking the patellar tendon with a reflex hammer, which results on a stretch of the quadriceps, causing the lower leg to "jerk" forward). The "jerks" are often used to assess the degree of facilitation of spinal cord centres that can be often exaggerated by a large number of facilitatory impulses (Hall, 2011).

Spasticity occurs due to a lesion on the motor cortex, which causes hyper-excitability of the α motorneuron (Ivanhoe and Reistetter, 2004; Guyton and Hall, 2011). This hyper-excitability means that the muscle will "over" contract, involuntarily, and that agonists and antagonists will not work in synchrony to generate an action (Bohannon and Smith, 1987; Ivanhoe and Reistetter, 2004; Bower, 2009; Theis, *et al*. 2015). The Ashworth Scale was used to evaluate spasticity.It is one of the features of upper motor neuron (UMN) syndrome – a very common syndrome in children with CP that affects anti-gravitational muscles, generally flexors on the upper limb and extensors on the lower limb, by the exaggeration of stretch reflexes[3].

It is velocity dependent, meaning that the resistance increases with the velocity of the stretch, which could result to a clinical sign, called "spastic catch" (Kerr Graham, 2003; Barnes, 2005; Johnson and Barnes, 2008). Generally speaking, spasticity has two main direct consequences: i) the muscle will have a tendency to stay in a shortened position, which may result in eventual contractures and in severe cases deformities and ii) it restricts movement (Barnes, 2005).

The pathophysiology of spasticity has been reported in the literature (Lance, 1980; Ivanhoe and Reistetter, 2004; Pandyan, *et al.*, 2005; Brashear, 2010; Hall, 2011; Trompetto, *et al.*, 2014; de Mello, 2016; Nonnekes, *et al.*, 2017; van den Noort, *et al.*, 2017) and it can be explained by two interconnected mechanisms: i) the spinal mechanism (motor-neurons activity) and ii) the supraspinal mechanism of descending pathways[4] in the CNS (Armutlu 2010; Martins 2016; van den Noort, *et al.*, 2017).

To understand the Supraspinal and Spinal mechanisms of spasticity, there is a need to discuss briefly how the muscle receive afferent and efferent inputs, considering that the UMN connect to the lower motor neurons, the α and γ motorneuron (Guyton and Hall, 2011; Nicholls, *et.al.*, 2012). In healthy subjects, the *α* motorneuron innervates the muscle fibres forming with them a motor unit, which means that when a α motorneuron discharges, a group of muscle fibres will contract. An average α

[3] Stretch reflexes is a rapid response given by the muscle to when it experiences a brief and unexpected increase in length (stretch). The stretch reflexes are evoked by monosynaptic fiber Ia excitation, which is influenced by the excitability of the motor neuron (Enoka, 2008).
[4] Pathways: the path of neuron connection/activity in the synapses. Inhibitory pathways: the pathway of the neuron activity that will inhibit the muscle action. Excitatory pathways: the pathway the neuron activity that excite the muscle action.

motorneuron receive thousands of synaptic inputs from higher centres and sensory receptors in the periphery that are transmitted throughout efferent axons to the extrafusal muscles fibres (Nicholls, *et.al*., 2012). The γ motorneuron are responsible to regulate the sensitivity of muscle spindles[5], as their afferent axons connect directly to the muscle spindle and intrafusal muscle fibre. When there is a muscle contraction generate by the activation of α motorneuron, the intrafusal muscle fibre will stretch sending sensory feedback through the afferent axons of the γ motorneurons back to the spinal cord and then to the motor cortex (Nicholls, *et.al*., 2012). The summary of the important points of healthy muscle activity can be found on table 2.3.

Table 2.3. Summary of Coordinated Muscle Activity in Healthy Individuals. Adapted from (Nicholls, *et.al*. 2012).

A motor unit consists of a single α MN and the muscle fibres that innervates it;
The stretch reflex excites agonist muscles and inhibit antagonist muscles through inhibitory interneurons
The muscle spindle sensitivity to stretch is modulated by γ MN that cause the intrafusal muscle fibres to contract;
α and γ coativation continuously adjust the spindle to maintain its sensitivity during movement;

The *spinal mechanism* is based on changes in the excitability of excitatory or inhibitory pathways, with changes on the following processes: i) decrease of pre-synaptic inhibition (described in individuals with spastic hemiplegia) – which is the mechanism that reduces the excitability of stretch reflexes (exacerbated in spasticity); ii) reduction in post-activation depression, which reduces neurotransmitters in the synapses of the fibres Ia (a fast contraction fibre in the muscle spindle); and finally the iii) reduction of fibres Ia-reciprocal inhibition, which is the process responsible for the reciprocal activation of antagonistic muscles during movement (co-activation of agonists and antagonists is impaired in individuals with spasticity) (Armutlu, 2010; Marinelli, *et al.,* 2014; Martins 2016).

[5] Muscle spindle – are stretch receptors in skeletal muscles. There are about over 27 thousand muscles spindles in the human body that lie in paralleled with the muscle fibre. The muscle spindle fibres are called intrafusal fibres, Ia – afferent and II afferent. The efferent inputs come from the γ motorneuron (Enoka 2008, Nicholls 2012)

As for the *supraspinal mechanism*, it is conventionally known that spasticity is a feature of upper motorneuron syndrome. In healthy individuals, there is a balance between excitatory/inhibitory effects coming from the CNS by the efferent pyramidal pathways (corticospinal, rubrospinal, reticulospinal, vestibulospinal and tectospinal tracts). In an individual with spasticity there is a loss or reduction of inhibitory influences conducted by the dorsal reticulospinal tract and facilitatory influences by the medial reticulospinal tract, creating an imbalance in the regulation of the spinal stretch reflex (Armutlu, 2010; Marinelli, *et al.*, 2014; Martins 2016).

This condition is a collection of issues that occur because of an insult of lesions on the upper motor neuron syndrome pathway and have both, positive and negative features (Barnes 2005, Kerr Graham and Selber 2003). Among the negative effects it causes a reduction in motor activity (related to muscle weakness), loss of dexterity and fatigability. Aspects that are disabling but can often be reduced and/or managed with effective intervention are: increased tendon reflexes, clonus[6], positive Babinski sign[7], spasticity, muscle spasms and dyssynergic patterns of co-contraction. The main positive effect of the upper motor neuron is to use the spasticity or hypertonia to "make up" for the weakness of the musculature, especially in the lower limbs (Kerr Graham, 2003; Barnes 2005; Johnson and Barnes 2008).

These negative-positive of the upper motor-neuron syndrome (Figure 2.8) effects of the upper motor neuron syndrome can generate a negative sign of muscle weakness and in the same muscle at the same time generate a positive sign of increased resistance to passive stretch. This combination is in summary muscle spasticity. It is often painful and debilitating, affecting quality of life negatively. Nevertheless, spasticity can influence the acquisition of gross motor skills and posture in both ways, negatively – causing pain, muscle shortening, contractures, reduced or absent RoM; and positively – by compensating the lack of neural control (Pandyan, *et al.*, 2005; Bar-On, *et al.*, 2015; Ashford, 2017, Nahm, *et al.*, 2018).

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[6] Clonus is an involuntary muscle contraction caused by a lesion in descending motor neurons (Boyraz, *et al.*, 2015).
[7] Babinski sign is sign of upper motor neuron dysfunction, which can be identified when a clinical test is performed by stroking the lateral sole of the foot. If this stimulation results in a dorsiflexion of the great toe that indicates an upper motor neuron lesion (Miller and Johnston, 2005).

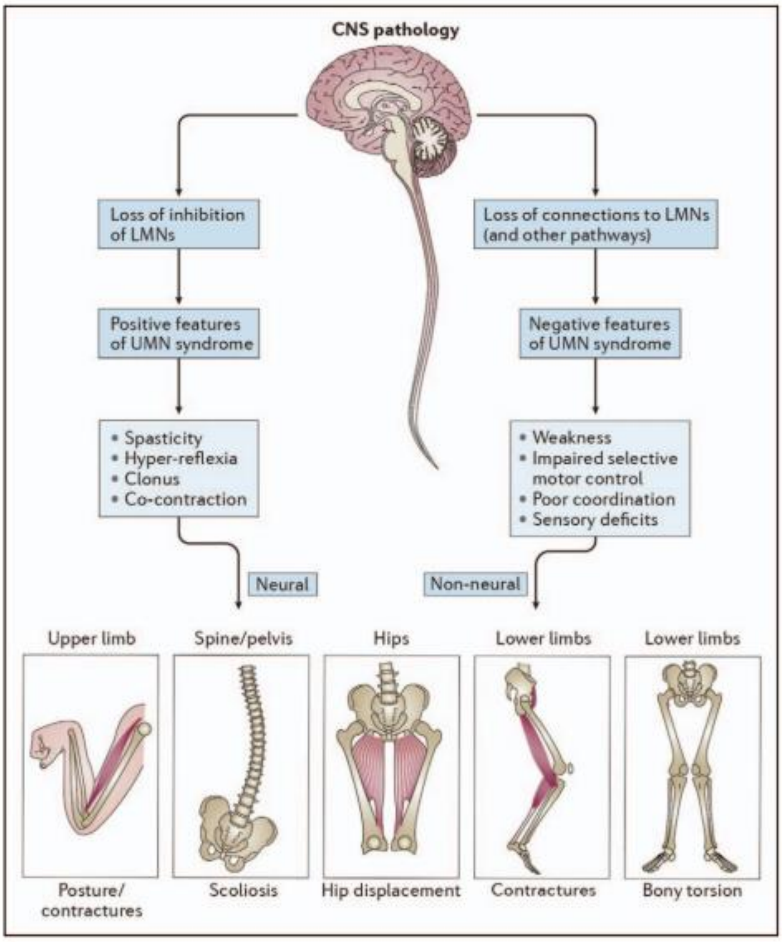

Diagram of the musculoskeletal pathology in cerebral palsy. Bony deformity, muscle shortening and joint contracture develop secondary to longstanding effects of both the positive and negative feature of the underlying central nervous system lesion.

Figure 2.8. The Positive-Negative Effects of the Upper Motor Neuron Syndrome.

Source: Nahm, *et al.*, (2018).

For spastic CP, a pyramid disorder, there is hypertonia of the muscle tone and/or a pathological reflex activation, affecting mostly the lower limb at the gastrocnemius, hamstrings, rectus femoris, adductors and psoas; and on the upper limb, shoulder external rotators, elbow, wrist and finger flexors and the elbow pronators in the upper limb (Armutlu, 2010; Trompetto, *et al.*, 2014; Bar-On, *et al.*, 2015; Martins 2016, Nahm, *et al.*, 2018).

Physiotherapy is a key component in the management of spasticity, and it should focus on the function of the child, not only on treating the impairments caused by the spasticity (Stevenson and Playford, 2016; Ashford, *et al.*, 2018).

Spasticity in Children with Cerebral Palsy

Children with spastic CP will have spasticity in at least one of their limbs (monoplegic) in the mildest presentations of the condition, up to very severe spasticity on all four limbs (quadriplegic) in the most severe presentations of the condition. Researchers and practitioners often work to reduce and/or manage spasticity in order to improve the child's ability to move and control that limb, to reduce pain and to avoid abnormalities on bone and muscle growth that can cause a series of deformations, such as equine feet.

They will have upper motorneuron syndrome with spasticity being one of its main features (Flett, 2003). This means that spasticity will have neurological and musculoskeletal components, which includes the reduction or loss of inhibitory signals, muscle weakness, primitive reflexes, changes on muscle tone, and lack or/compensated postural control (Flett, 2003; Krigger, 2006).

Physical rehabilitation and interventions targeting spasticity management in children with CP should be concerned about two main points: i) the exaggeration of the stretch reflex, which is a result of spinal mechanisms been impaired and ii) the fact the spasticity is not the only impairment of UMNs or CP, as muscle weakness, lack of neural control, muscle hypertonia, asymmetric co-contraction that are present due to supraspinal mechanisms.

HPOT a technique that may assist with the management of the negative features of spasticity, as the sitting upright postures often adopted by therapists when positioning patients on the horse, combined with rhythmic and repetitive movements could provide relaxation, muscle passive and persistent stretch and muscle activation.

Assessment of Spasticity – Modified Ashworth Scale

Before discussing the assessment of spasticity, it is important to highlight the clinical signs of spasticity, which are characterized by excessive muscle tone, exacerbated stretch reflex, spasms, pain, weak muscular contraction, alterations on movement coordination, fatigability and decreased assisted and voluntary RoM (Martins, 2016).

There are several clinical scales and types of equipment that could be used to measure spasticity, such as superficial eletromyogram (Lechner, *et al.*, 2003;

Shamsoddini, 2014; Bar-On, *et al.*, 2015; Ashford, 2017), the Tardeu Scale (Pandyan, *et al.*, 1999; Shamsoddini, *et al.*, 2014) and the MAS (Lance, 1980; Bohannon, 1987; Bohannon, *et al.*, 1987; Lechner, *et al.*, 2007; Charalambous, 2014; Trompetto, *et al.*, 2014; Barnes, 2005; Ashford, 2017).

The MAS (Figure 2.9) is one of the most widely used methods to evaluate muscle tone (Allison, Abraham, and Petersen, 1996; Yam and Leung, 2006). The MAS is a simple tool that can be reproduced within and across different assessors and it consists on a five-point ordinal scale that will grade the resistance found during a passive muscle stretching (Bohannon, 1987; Pandyan, *et al.*, 1999; Charalambous, 2014; Shamsoddini, *et al.*, 2014).

Score	Modified Ashworth Scale
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the range of movement (ROM)
2	More marked increase in muscle tone through most of the ROM, but affected part(s) easily moved
3	Considerable increase in muscle tone, passive movement difficult
4	Affected part(s) rigid in flexion or extension

Figure 2.9. Modified Ashworth Scale (MAS).

Modified from Pandyan, *et al.*, (1999).

Management of Spasticity – NICE Pathways and Hippotherapy

According to the NICE guidelines for the management of spasticity in children and young people, spasticity treatment, as any rehabilitation treatment, should be individually-centred and tailored according to the needs and preference of those needing care. NICE guidance recommends a treatment course in which the children will be firstly assessed by a physiotherapist, followed by pharmaceutical treatment combined with a physiotherapy program and surgery in the presence of deformities or need for hip replacement (National Institute for Health and Care Excellence, 2012).

It was not the purpose of this study to discuss all aspects of the course of treatment, as the focus is been given to investigate the effects of HPOT on spasticity. Therefore, focus will be given on one arrow of the NICE diagram – the physiotherapy Domain (Figure 2.10).

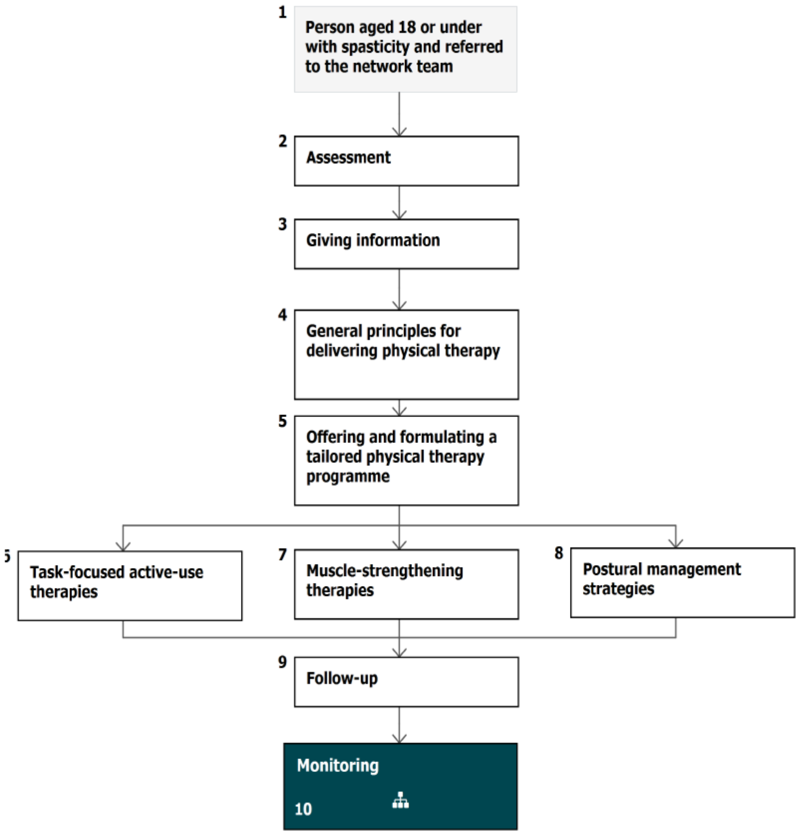

Figure 2.10. NICE Recommended Pathway for Physiotherapy Treatment in the Management of Spasticity for Health Professionals.

Source: NICE, (2017).

NICE suggests that the goals for the physical rehabilitation treatment involve the enhancement of skill development, function and ability to participate in everyday activities, in addition to preventing pain, contractures and deformities. A fairly recent review (Shamsoddini, *et al.*, 2014) evaluated papers on the management of spasticity and reported that PT, together with OT, are fundamental to spasticity management.

The authors discussed that due to the cycle of spasticity – whereby muscle over-activity generates muscle shortening and muscle shortening increases spindle sensitivity – physical rehabilitation treatments should aim to address both the shortening and the over-activity.

There are a variety of approaches to manage spasticity inside of the PT domains, from direct approaches such as cold application, passive and stretching exercises, neural mobilization, positioning, massages, kinesiotape applications, to indirect approaches, that are based in the adoption of postures and movements components, such as proprioceptive neuromuscular facilitation, sensory integration, reflexology, hydrotherapy or HPOT (Barnes, 2005; Pandyan, *et al.*, 2005; Johnson, 2008; Brashear 2010; Novak, *et al.*, 2013; Shamsoddini, *et al.*, 2014; de Mello, 2016; de Andrade, Silva 2017; NICE, 2017; Özkan, 2017).

Spasticity, Cerebral Palsy and Hippotherapy

Previous studies have shown a benefit of long-term muscle stretching (Odeen, 1981; Kirshblum, 1999; Theis, *et al.*, 2015), kinesiotherapy and passive movement (Skold, 2000; Kakebeeke, Lechner and Knapp, 2005; de Faria, *et al.*, 2016) and HPOT (Lechner, *et al.*, 2003; Hammer, *et al.*, 2005; Kakebeeke, Lechner and Knapp, 2005; McGibbon, *et al.*, 2009) on inhibition of spasticity. With respect to HPOT, this may be due to the position of the hip when riding combined to the three-dimension movements of horse that promote a single long last stretching and relaxation (Hammer, *et al.*, 2005; Kakebeeke, Lechner and Knapp, 2005). The evidence about HPOT effectiveness in the management of spasticity has been discussed before in the literature (Zadnikar and Kastrin 2011; Herrero, *et al.*, 2012a; Tseng, Chen and Tam, 2013).

A systematic review (Mcintyre, *et al.*, 2013) about techniques that effective on the treatment of CP have included 166 papers investigating any kind of intervention applied by a medical of health allied professional to treat CP. They reported that botulinum toxin, diazepam and selective dorsal rhizotomy have high level of evidence for reducing muscle spasticity and considered HPOT as “probably worth doing”, with an indication that bigger and better studies – with methodology rigor – should be carried out to enhance the evidence of this technique. (Mcintyre, *et al.*, 2013).

Nevertheless, since 2013, many other studies not included in the review above were carried out looking to evaluate the effects of HPOT in spasticity managements in CP, reporting that HPOT seen to be a good technique to relief spasticity (Alemdaroğlu, Yanıkoğlu et al. 2016, de Mello Sposito, Maria Matilde 2016, Antunes, do Pinho et al. 2016, Novak, Mcintyre et al. 2013).

Liporoni and Oliveira (2010) reported that HPOT can be considered as a therapy option to treat spasticity in people with neural sequelae due to the variety of movements that are generated when riding which leads to improvements on muscle tonus and coordination of agonists and antagonists. Another review (Oliveira, *et al.*, 2015) agrees with that report and adds that the three-dimensional movement of the horse during walk could activate intrafusal receptors, which will eventually generate an increase of the tonus (which is important to achieve postural control and coordination). During a more cadenced and slow gait, its movement will be translated to the subject at a lower frequency, which will generate a rhythmic and cadent proprioceptive stimulus, which will promote relaxation and reduce muscle tonus (Gregório, 2013; Oliveira, *et al.*, 2015).

In the meta-analysis written by Tseng, Chen and Tam (2013) it was reported that short-term HPOT is effective to reduce hip adductors activity effectively, which could affect positively sitting positions and gait acquisition. By reducing spasticity on hip adductors, a child would be able to sit crossing the legs, instead of sitting in "W" (position often chosen by children with spastic CP). This allows the child to have better sitting balance and perhaps be able to achieve function movement while sited (e.g. grasping an object, playing with a toy, using both arms). In addition, it reduces the shear stress in the hip and knee joints, which if not controlled can generate problems in the cartilage and pain (Mayer, Esquenazi and Childers, 1997).

As for gait acquisition, having a normalize tone in the adductors could help the child to achieve a more function gait, without having to do the typical "scissoring" gait (when the child walks crossing one leg in front of the other). This type of gait, although very often adopted by a child with CP, can as cause a big shear tension on hip joint, which also would lead to pain and problems in the cartilage tissue of the joint (Mayer, Esquenazi and Childers, 1997).

The scissoring tights (caused by spasticity in the adductors) can also affect hygiene, transfer from sitting to standing, keep quiet stand or sitting positions and contribute to the development of deformities (Mayer, Esquenazi and Childers, 1997).

Despite the good results regard HPOT being able to reduce spasticity on the hip adductors. Tseng, Chen and Tam (2013) have stated that the studies given evidence did not relate the improvement on the hip adductor asymmetry with functionality and the child's activity level. This is an issue that deserves attention as the fact of the child has less asymmetry may help improve gait and child's overall functionality regard mobility, as explained above, however, without any further investigation into the child's activity level, it is difficult to conclude if the reduction of this asymmetry generates an impact in the child's functionality.

The conclusion drawn by Tseng, Chen and Tam (2013) was challenged in chapter 2 of this thesis, as they have based their conclusion in only two studies (Benda, McGibbon and Grant, 2003; McGibbon, *et al.*, 2009). There is no indication in any of those two studies of bilateral values, as they just reported that one side became less asymmetrical towards the other, without referencing which side had worse activity.

This is important, as some children will have only one side with spasticity or perhaps only the lower limb, so just implying an improvement in spasticity on lower limbs or upper limbs without given the reference for both sides create some bias in the results. Furthermore, on the study by McGibbon, *et al.*, (2009) there is no report of the classification based on location (diplegia, hemiplegia, quadriplegia) and this could be a factor that influences on the results. A child with hemiplegia, for example, will have the hemi-side with worse muscle activity in comparison to the non-affected side, likewise, a child with quadriplegia may not present as big asymmetry between both sides, but that does not mean the muscle activity, tone and spasticity is normalized. Benda, McGibbon and Grant, (2003) did report this classification but only for the children that went through the second phase of the study (n=6), reporting 4 with diplegia, and 2 with quadriplegia and one of the quadriplegic children did not have any significant improvements after long term HPOT.

It is also important to highlight that all the studies involving participants with spasticity only evaluated the lower limb and mainly focused on the hip adductors, and did not considered to evaluate other important muscle groups to the acquisition of gait, such as quadriceps, or ankle extensors (Bohannon, *et al.*, 1987; Barnes, 2005; Ashford, 2017)

This raises the question of whether HPOT would be also beneficial in the management of spasticity in this muscles' groups, as the legs, when sitting the horse, will be a fixed position, as the ankles would be fixed on the stirrups and the knees by the side of the saddle or pad (Figure 2.11) (Siqueira, *et al.*, 2007). Similarly, it is possible to question whether HPOT could also improve spasticity on the upper limb, as the increase of spasticity in the upper body could potentially facilitate worse posture, loss or poor fine motor control, increase pain and decrease overall functionality (Barnes, 2005; Pandyan, *et al.*, 2005; Eliasson, 2008; Johnson, 2008; Armutlu, 2010; Brashear, 2010; NICE, 2012; Bar-On, *et al.*, 2015; Ashford, 2017; Barnes, *et al.*, 2017). During the sessions the therapist may work fixed positions also with arms, or even by requiring the child to sit up tight. These positions could also generate a single long stretch of these muscles, and therefore help on reducing spasticity, by the same mechanism of the hip adductors.

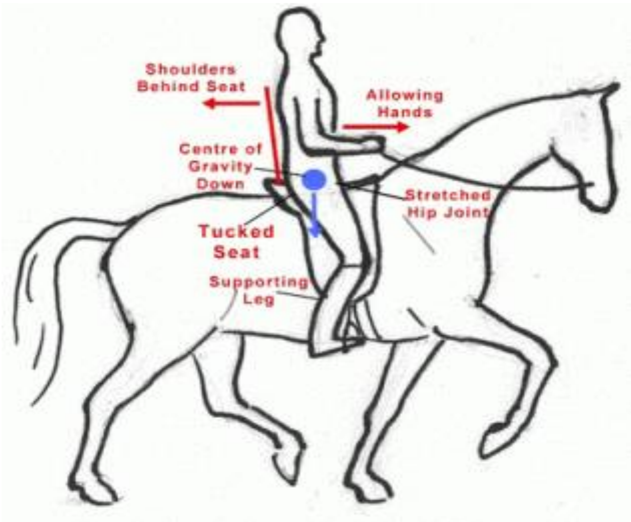

Figure 2.11. Sitting on a Horse and the Position of the Legs and Arms

(extracted from https://www.anatomia-fisioterapia.es/es/aparato-musculoesqueletico/articles/systems/musculoskeletal/lesiones-por-sobreuso-frecuentes-en-jinetes on 01/02/2019).

There is still an opportunity to enhance the evidence of HPOT on spasticity management of the lower limb, and there is a scope to assess the upper limb as well, as spasticity in the upper body affects postural acquisition, such as sitting up straight. Furthermore, the protocol of treatment and evaluation used in this study had the aim of reproducing what is being done by physiotherapists in practice, following the recommendations reported on chapter 4 of this thesis.

HPOT is not only sitting on the horse passively as the PT incorporates the equine movement to their practice, engaging sensory and neuromotor systems. Therefore, it would be naive to expect that HPOT would only affect the lower limb, as the PTs in HPOT sessions can work with the upper body, by requesting the individual to hold in the handles of a saddle, for example, or even to hold a ball or a bar, while doing some balance exercises. Furthermore, when walking or riding, an individual without physical impairment will dissociate shoulder, hip and waist, and will use other musculature such as quadriceps, gastrocnemius, hamstrings and tibialis anterior during gait and riding and as well use shoulder adductors, rotators, and flexors of the arms during both activities (Back and Clayton 2013; Bower, 2009; Enoka, 2008; Scott, 2005). Therefore, there is scope to look if HPOT would also be able to produce an effect on the upper limb and on other muscle groups of the lower limb, as the spasticity on all limbs may affect substantially the acquisition of motor skills and postures.

The gap in knowledge that was identified raised questions about the effectiveness of HPOT in other muscle groups of the lower limb and in muscles of the upper limb. In order to address these questions as effectively as possible a clinical quantifiable and widely used scale, the MAS, was chosen to evaluate children with CP levels I to V, with hemiplegia, diplegia and quadriplegia at baseline and after 6 and 12 weeks of treatment, investigating short- and long-term effects.

It is hypothesised that the rhythmicity of the horse movement and the positions adopted while passively riding the horse during HPOT treatment will be beneficial in normalizing muscle tone of children with spastic CP.

To address this hypothesis, every child will be evaluated before and after sitting the horse passively for 5 minutes, as the methodology used on McGibbon, *et al.*, (2009) and Benda, McGibbon and Grant, (2003) and those evaluations will be repeated at baseline (before the treatment starts – 0 weeks), and after 6 and 12 weeks of treatment, following what is been reported by practitioners on the chapter 4.

2.5. The Impact of Spastic Cerebral Palsy on Quality of Life and the Use of PedsQL®

Definition of Quality of Life

Quality of life (QoL) is defined by the WHO as "the individual's perception of their position in life in the context of the culture and the value system in which they live, and in relation to their goals, expectations, standards and concerns" (WHOQOL, 1995).

Due to its multidimensionality there are still different perspectives among researchers with regard to the most appropriate definition of QoL, or if that is a one to begin with (Clarke and Eiser, 2004; Ribeiro, 2006; Pereira, Teixeira and Santos, 2012). Farquhar, (1995) considered that there would be three different overall definitions for QoL. Type 1 usually incorporates concepts of satisfaction and happiness, considering that satisfaction or its absence come from a judgemental or cognitive experience, while happiness or its absence would suggest an experience of feeling, which means that QoL would include conditions and experiences of life, including inner and outside factors of an individual well-being, which make this concept very subjective (Farquhar 1995).

Type 2 consider a series of dimensions that compose QoL, its components are divided in objective dimensions involving health, functional and socioeconomic status and subjective dimensions englobing aspects of life satisfactions and self-esteem, or as described by WHO it could be divided in 5 bigger tiers: physical domain; psychological domain; level of independence; social relationships; environment; and religion/personal beliefs (Farquhar 1995; Whoqol Group 1995; Ribeiro, 2006). Type 3 focus in one or only a small number of components of quality of life with the most common type being focused on health/functional ability (Farquhar, 1995).

QoL is compromised by the impairments associated with CP and it is reduced when compared to typically developing children (Burwinkle, *et al.*, 2006; Maher, *et al.,* 2008, Varni, Tseng, Chen and Tam, 2013). To understand the impact of a disability such as CP in the lives of children with this condition, will help to support and develop well-planed therapies and services that will not only focus on enhancing the child's motor capacity, and also consider the impact of it on the child's function and health related quality of life, which can also contribute to the child's social function and overall well-being.

A recent systematic literature review (Power, *et al.*, 2018) has reported that dimensions of QoL related to physical well-being were most severely impacted in children and adolescents with CP, indicating that this area should be given great focus during interventions. Furthermore, they have highlighted that health related QoL is still quite an emerging field, and more research should be done to understand how and if therapies and treatment given to children with CP are achieving any improving on the QoL (Power, *et al.*, 2018).

This chapter will focus on type 2 – the health-related quality of life. This is a multileveled, multidimensional, subjective concept of measuring physical, psychological, sexual wellbeing and social functioning of a determined group of people in relation to health (Ingebrigtsen, 2015; Power, *et al.*, 2018). It is not the aim of this study to compare different concepts of QoL. The type 2 was chosen, not because it is better or worse than the other two, but because scales under this concept have attribute values to life duration, modified by prejudice, functional status and social opportunities, which per se are influenced by a disease/disorder, lesion, treatment of health polices (Seidl and Zannon, 2004). Its evaluation can help define and evaluate cost and benefits of treatments (e.g. HPOT) and health care and also distinguish prognostic of a health state and the evaluation of the effect of a determine intervention in a determine population (Ribeiro, 2006).

Farquhar, (1995) considered that initially there would be three different overall definitions for QoL, the global definition (type 1), the definition that break the concept down into a series of components (type 2) and a focus definition, which will highlight one or two components (type 3).

This study focussed on a type 2 definition of Health – Related Quality of Life which can be defined by the subjective assessment that a patient has of different aspects of their life in relation to their health status.

Quality of Life, Cerebral Palsy and Hippotherapy

The body of published literature has emphasised the value of health related QoL as an outcome to evaluate health care (Varni, *et al.*, 2006; Maher, *et al.*, 2008) reflecting the WHO approach to QoL and the ICF framework (World, 2001). Several studies have used proxy-reports from parents and children about their perception on QoL in a variety of categories, such as physical and psychosocial (Maher, *et al.*, 2008), reporting that children with CP age 5 and above with a cognitive capacity would be able to give consistent answers about their perception, using a proxy-reports like the PedsQL® (Varni, *et al.*, 2006; Maher, *et al.*, 2008; Tan, *et al.*, 2014).

Recent studies have also identified that motor impairment affects functioning and physical-related domains of the ICF (Chen, *et al.*, 2013b); that the GMFCS seen to be a good predictor of health-related QoL (Ingebrigtsen, 2015); and that there is significant relationship between the PedsQL® and the GMFM (Prado, *et al.*, 2013). In addition, some studies investigated the effects of HPOT in QoL, reporting that the therapy seen to be effective on improving total score and social domain of PedsQL® (Thompson, Ketcham and Hall, 2014; Rosan, Braccialli and Araujo, 2016) and on improving physical, emotional, school and total function of the same questionnaire (Thompson, Ketcham and Hall, 2014) in children with CP.

The concept of quality of life is subjective and it should consider broader aspects than symptom control or reduction of mortality, incorporating evaluation of the impact a specific disease or disorder has on the individuals life and how much it affects their daily life activities and the individuals perception of health and function (Whoqol Group, 1995; Fleck, 2000; Pereira, Teixeira and Santos, 2012).

QoL of children with CP has been evaluated in a variety of studies (Christofoletti, Hygashi and Godoy, 2007; Arnaud, *et al.*, 2008; Davis, *et al.*, 2009; Camargos, *et al.*, 2012; Rapp, *et al.*, 2016; Ingebrigtsen, 2015; Power, *et al.*, 2018).
The study conducted by Davis, *et al.*, (2009) was the first to investigating how therapeutic horse riding would influence the QoL of children with CP, and they have reported that no effect was found. They have used two different questionnaires for QoL one called Cerebral Palsy Quality of Life Questionnaire for Children that access social well-being and acceptance, functioning, participation, physical health, emotional well-being, access to services, pain, family health and feeling about disability. This questionnaire incorporates components of all definitions of QoL as it evaluates components of health, components of functioning and feelings about

disability. The second questionnaire used was the KIDSCREEN which is a generic health-related quality of life (type 2).

The authors of the study have highlighted that the lack of significant improvements on QoL after the THR could be due to the lack of sensitivity of the measures used on the study, as authors reported that the fact the questionnaires are recent developed (in relation to when the study was published – 2009) there was a lack of information regard how much difference should be expected on the questionnaires for changes to be considered significant. In addition, they have also reported that QoL is a dynamic phenomenon and therefore, the perception of the participants could have changed between evaluation 1 and 2. The authors did not report when the questionnaires were developed nor have they discussed their results in comparison to other studies using the same type of evaluation for children with CP. This was a randomized controlled trial, however, little information was given regard the validation, sensitivity, precedent or use of the questionnaires applied by Davis, *et al.*, (2009) which make challenging their conclusions, as perhaps the questionnaires were just not best choice to evaluate these children or this specific therapy. It is also challenging to identify why those questionnaires most not be suitable as little information were given about them.

Thompson, Ketcham and Hall, (2014) evaluated the effect of HPOT in children with developmental delays (e.g. CP) on the physical function and QoL and self-esteem. Eight children ages 2 to 11 were evaluated with the PedsQL® (Type 2 of QoL) and undertook 12 weeks of 45 minutes' weekly sessions of HPOT. They have demonstrated a trend towards improvement of total, school, emotional and physical components of PedsQL® after HPOT treatment. The authors have reported they did expect to see significant changes, and they have justified the lack of significant changes due to the heterogeneous sample (with variety of disabilities), lack of motivation and lack of understanding of what is being asked. Thompson, Ketcham and Hall, (2014)'s was one of the first studies evaluation the effect of HPOT in CP children, and the positive trend found is a positive result. However, as they have included other disabilities such as myotonic dystrophy and Mowat Wilson syndrome, this probably caused big bias on their analysis as they treated all the subjects in one single group. In addition, the age rate is quite different and there is no report of using age appropriate version of the PedsQL®.

The study conducted by Rosan, Braccialli and Araujo, (2016) also evaluated the effects of HPOT in the QoL of children with CP, by evaluating the parents. They have used the CP quality of life children questionnaire, like Davis, *et al.*, (2009) and the PedsQL® like Thompson, Ketcham and Hall, (2014). Six children with CP undertook weekly HPOT sessions for 12 weeks. The duration of the sessions was not reported. All children included in the study were classified as GMFCS level IV and unable to walk, two of them had athetosis (abnormal involuntary movement) and four spastic CP. They have reported that the PedsQL® was shown to be more adequate than the questionnaire used by Davis, *et al.*, (2009), as no significant effect was found on the evaluation with the CP QoL children questionnaire, but significant changes were found on the total scores of PedsQL®. This was the first study done in HPOT comparing two different QoL questionnaires and its results add to the body of evidence that the PedsQL® could be consider a valuable tool to evaluate children with CP.

However, it is clear that there is still a need to enhance the evidence for the effect HPOT QoL in children with CP, by using validated and reliable measurements, such as the PedsQL® with a more homogenous sample and clearly define protocol of treatment (Herrero, *et al.*, 2012a; Tseng, Chen and Tam, 2013; Thompson, Ketcham and Hall, 2014; el Rosario-Montejo, *et al.*, 2015; Champagne, Corriveau and Dugas, 2016; Rosan, Braccialli and Araujo, 2016).

For this reason, it was decided to use the PedsQL® at this present study (Appendix 8), as it would corroborate with the methodology previously used in research and facilitate the discussions among researchers and health professionals. The PedsQL® is a short scale developed on Children's Hospital and Health Centre in San Diego, California that integrates a generic core scales and disease-specific modules into one measure system. The Parent Proxy Report was also chosen to be used on other studies (Thompson, Ketcham and Hall, 2014; Rosan, Braccialli and Araujo, 2016), and it has a reliability of total scale score of 0.90. It is also valid in distinguishing healthy children and children with acute and/or chronical health conditions. It changes over time, as it is responsive to the condition progression or to evaluate the effect of an intervention over time and multidimensional, evaluating physical, emotional, social and school functioning categories, covering the core dimensions preconized by the WHO (Varni, Seid and Kurtin, 2001a; Varni, 2017). The PedsQL® has four dimensions that investigate how difficult is for the child to do a pre-coded task. Zero would indicate that the child has no difficulty at all doing that pre-determined task, while four would indicate that is extremely difficult for the child to complete the activity. Considering that, lower scores would indicate a child has less or no difficulty on doing daily activities, indicating a better overall QoL.

These four categories can be directly affected by the motor ability of the child, as a child that is considered severe, or classified with motor V (motor ability severely affected - not able to walk) will most likely have more difficulty in doing a task in the four categories than a child that is level I (motor ability mildly affected – able to walk).

2.6. Cerebral Palsy: Physical Rehabilitation – Physiotherapy and Hippotherapy

Cerebral Palsy and Physiotherapy

Some studies have identified that common physical impairments found in the CP population, such as spasticity, muscle weakness, postural stability, balance, range of motion and movement quality have a directly impact in the individuals' overall gross motor function (Park and Kim, 2013; Bartlett, *et al.*, 2014; Curtis, *et al.*, 2015) making the improvement of impaired motor function, one of the principal aims of physical training, to enhance participation and QoL (Curtis, *et al.*, 2015).

The role of the physiotherapist (PT) in the rehabilitation of children with CP is to manage the condition, using evidenced based practice to support the child to reach their optimal physical and functional level (Anttila, *et al.*, 2008). There are a variety of techniques which are used by PTs to improve and/or maintain the multiple functional impairments of CP, such as neurodevelopmental therapy, strength training, orthotic devices, robot-assisted therapies, virtual reality, equine assisted therapies, among others (Taub, Uswatte and Elbert, 2002; Anttila, *et al.*, 2008; Herrero, *et al.*, 2012b; Massetti, *et al.*, 2014; Champagne, Corriveau and Dugas, 2016; Moreau, *et al.*, 2016; Rosan, Braccialli and Araujo, 2016; Arı and Günel, 2017; El-hakiem and Agha, 2017; Park, 2017).

Long-term physical and occupational therapy helps decrease the impact of these multiple impairments, it is known, however, that although participating in physiotherapy sessions can help individuals overcome these disabilities and gain more function, often it can be painful and challenging for both patients and professionals and hard to keep the interest and enthusiasm of the patient (Benda, McGibbon and Grant, 2003; Rimmer, 2006; Chang, *et al*., 2011).

In order to maintain a disabled person’s engagement with therapy, it is important for doctors, physical and occupational therapists to develop new strategies for improving patient motivation. Key factors for consideration in the development and provision of an effective physical rehabilitation intervention or therapy include consideration of the level of functioning of the patient, the environment and community this patient is part of, provision of variety in the exercises a patient is asked to do whilst maintaining a clear focus on enhancing functionality, strength, balance, cardiovascular and respiratory outcomes, mobility and autonomy (Benda, McGibbon and Grant, 2003; Rimmer, 2006; WHO, 2011; Bodkin, *et al*., 2016).

3. Chapter 3: Hippotherapy and its Potential to Alleviate Physical Symptoms of Children with Cerebral Palsy

3.1. The Potential of Hippotherapy

The rehabilitation process should be activity-based, relevant to the individual, focusing in improve postural stability and muscle strength, reduce spasticity and improve the gait (Surtleff, *et al*., 2012; Lee, *et al*., 2014). Hippotherapy, as a physiotherapeutic technique, can be a good alternative for the treatment of these patients, by providing better hip, pelvic and trunk positions, which influence a child posture, balance and coordination (Lee, *et al*., 2014). In addition, the movement of the horse may expose the patient to a variety of proprioceptive stimuli, which require constant adaptations, which can lead to changes on global motor patterns (Garner and Rigby, 2014; AHA, 2015).

HPOT is used by physiotherapists to improve gross motor function, balance and mobility of physically impaired patients. Therapists use the movement of the horse during walking gait, to create motor outputs to increase postural control in participants with neurological disorders such as CP, multiple sclerosis or spinal cord injury (Lechner, *et al*., 2003; Herrero, *et al*., 2010; Long, 2013).

Therapists that use HPOT propose that the horse's gait promotes movement patterns like human gait (Zadnikar and Kastrin, 2011; Tseng, Chen and Tam, 2013). Combined with the therapist intervention, this therapy may alleviate symptoms, lead to improvements in functional ability by improving postural control and consequently may delay degeneration and enhance QoL. Whilst a range of research papers and professional publications advocate these hypotheses, recent literature reviews and meta-analyses have criticised the quality of a large proportion of the published studies on HPOT for participants with CP (Benda, McGibbon and Grant, 2003; Sterba, 2007; Tseng, Chen and Tam, 2013).

The recent review by Tseng, Chen and Tam, (2013) combined studies with therapeutic horseback riding (THR) and HPOT and included some methodological flaws as a meta-analysis was conducted across studies using different methodology. Therefore, it is pertinent for further studies to not only expand a systematic literature review in the subject area, with more rigor on the analysis of the studies and in how they are combined, as well to develop a rigorous methodology to investigate the effect of HPOT in physical outcomes, such as balance and gross motor function in children with CP.

3.2. Hippotherapy Definition and Historical Background

The term hippotherapy, from the junction of the Greek words *hippos* (horse) and *therapeia* (therapy) indicates therapy using the horse (ANDE, 2015). The use of the horse for medical purposes was first described by the ancient Greek Hippocrates who advised riding practice to enhance health and preserve the human body of many diseases (ANDE, 2015).

In the United Kingdom (UK) HPOT became a formal and recognized technique between 1970 and 1980 with the creation of The Association of Chartered Physiotherapists in Therapeutic Riding – UK, which recently (2016) has changed names to Chartered Physiotherapists in Therapeutic Riding and Hippotherapy after gaining recognition as a professional network from the Chartered Society of Physiotherapy. Roughly twenty years before that, HPOT was already a recognized technique in Germany (1960's). In the American continent the recognition of this therapy as a technique came later, in the late 1980's in Brazil, with the creation of the National Association of Hippotherapy – Brazil, (ANDE, 2015; CPTRH, 2015) and in the beginning of the nineties (1992) in the United States of America, when the AHA was formed.

HPOT is a technique that can be conducted by a different range of therapists, whether working in an interdisciplinary team or in their own practice. The potential physical and psychological benefits are often presented as a consensus across researchers, therapists and associations. However, equine movement is used in different types of therapy and this has resulted in confusion in the literature with regards to the specific definition of HPOT (Benda, McGibbon and Grant, 2003; Debuse, Chandler and Gibb, 2005). It is important to clearly define this therapy and apply this definition with care in research studies and outputs, as mis-categorization can lead to incorrect conclusions being drawn about its effectiveness in the rehabilitation process of a specific population (Debuse, Chandler and Gibb, 2005).

3.3. Overview of the Horse's Movement and Interaction with a Subject

The Locomotion of the Horse: A Brief Overview

Horses are quadrupeds that can perform a variety of gaits based on the synchronisation of the movements of its limbs. Each gait is recognized by the sequence, speed and timing of the footfalls which is maintained by the movement pattern of the limbs being repeated stride after stride, which, by itself, is the cycle of limb movement (Clayton, 2004).

Gait is defined by the coordination pattern of the limb, being performed recurrently, stride after stride. In the equine gait there are a variety of combinations that allow inter-limb coordination, as a horse can have a two-, three- or four-beat gait, which are typically expressed as walk, trot, canter and gallop, depending on the speed and which gait is considered desirable through training (Fleck, 1992; Clayton, 2004; Greve and Dyson, 2013; Clayton, 2013; Clayton and Hobbs, 2017).

As a stride is a unit of the gait and a complete cycle of the limb movement, it is key to understand the importance of the left-right limb movement coordination, as it is a relevant information to understand horses' gait and its interaction with the subject (Clayton, 2004; Clayton and Hobbs, 2017).

In each gait stride, each limb will have two phases, the *stance* and *swing* phase. During the stance phase the hoof is on the floor, supporting the horse's weight and providing propulsion. On the swing phase the hoof has no contact with the floor, and it is swinging in preparation to the next stance phase for that limb (Clayton, 2004).

When starting off from a standstill, the horse's thrust starts with its hind legs, followed by the movement of the front limbs (Harris, 1993). During walk, each hoof will contact the ground separately, and two or three legs are always on the ground, making this gait one of the most stable and easiest to ride (Fleck, 1992; Harris, 1993; Clayton, 2004) . It is also the gait most used for HPOT treatment. If considering a stride cycle to start from one of the hind legs, a possible sequence for a four-beat walk would be: (1) left hind, (2) left fore, (3) right hind, (4) right fore, which will result in a speed of approximately 4 miles per hour (Harris, 1993) (Figure 3.1).

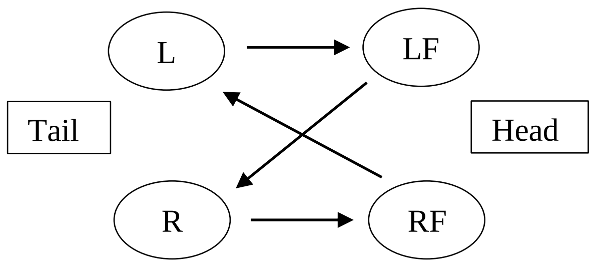

Figure 3.1. Demonstration of stride phase during four-beat walk in the lateral sequence.

RF: right forelimb; LF: left fore limb; RH: right hind limb; LH: Left hind limb, adapted from

Source: Clayton, (2004).

In a symmetrical gait, the movements of the contralateral limb pairs are equally separated in time and in space, with forces being transmitted to the subject following a symmetric pattern (Clayton, 2004; Clayton and Hobbs, 2017). Although a four-beat walk is classified as symmetric gait (Back and Clayton, 2013), every being will present normal asymmetries in movement pattern, occurring because of anatomical or functional characteristics of the animal, that are not related with age or injury (Clayton, 2004; Clayton and Hobbs, 2017).

As it happens during the horse’s gait pattern, in the human gait, there is a weight-shift from one limb (the one touching the ground) to the other, in cyclic repetitive pattern. For humans, the locomotion is bipedal, meaning that during normal walk, there will be always one limb on the ground (Enoka, 2008; Robertson, *et al.*, 2014). The period of support is called the stance phase and the period of non-support, the swing phase (Figure 3.2). As described above, a stride is also a gait unit, but for human walk, a stride will contain two steps (Enoka, 2008).

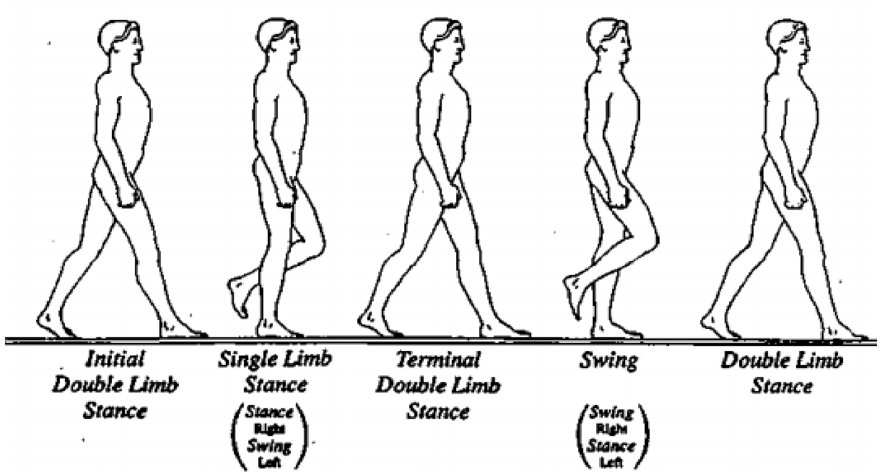

Figure 3.2. Gait Cycle: Swing and Stance Phases

Source: Ayyappa, (1997).

Gait characteristics can be directly affected by neuromuscular and musculoskeletal function and by ligaments and joint constraints, and limb positions (Ayyappa, 1997). The CNS together with the musculoskeletal system coordinate the pattern of gait movement, by receiving and decoding feedback from motoneurons, and sending information that will dictate and control the activity of muscles (Enoka, 2008; Rosenbaum, 2009; Rigby, Garner and Skurla, 2009). The lower limb guides the movement itself, and the trunk and upper limb help maintain the body equilibrium. The displacement of the pelvis during walk has a particular role, as not only it is the body part that connects the lower limb to the trunk, but also it provides the pattern of the movement, as it moves in all three planes and around all three axes (Figure 2.6) and in synergy with the shoulders (Rigby, Garner and Skurla, 2009).

The rationale for using the walk gait of the horse, typically cited by those working with HPOT or any other type of Equine Assisted Therapy (EAT), lies around the fact that the horse moves the subject in a similar repetitive and cyclic patterns of the natural human walk (Debuse, Chandler and Gibb, 2005; Sterba, 2007; Kang, Jung and Yu, 2012; Tseng, Chen and Tam, 2013; Garner and Rigby, 2014; Lee, Kim and Yong, 2014). During walk the pelvis will pitch, roll and yaw, moving in the upward vertical direction, during weight transfer and experiences cyclic movements in the lateral and medial direction. This displacement of the pelvis generates a displacement of Centre of Mass (CoM) towards the limb that is supporting the weight (Enoka, 2008; Rigby, Garner and Skurla, 2009; Janura, *et al.,* 2012).

Biomechanics of Riding and Horse-Subject Interaction

To start to understand how the subject moves when during horse's walking gait, it is important to highlight the movements of the horse's trunk and head. The horse's trunk translates and rotates in three dimensions, its movement, the movement of the saddle and the subject are often described considering their translation along the vertical, transverse and longitudinal axes (Figure 2.5) (Back and Clayton, 2013; Clayton and Hobbs, 2017). During walk, the horse's back moves consistently, having its maximal lateral bending with the contact of the ipsilateral hind hoof (Back and Clayton, 2013; Clayton and Hobbs, 2017).

The head is lowered and raised twice during a stride cycle, being raised at forelimb contact and lowered at forelimb mid-stance, in addition, its movement is velocity-dependant, with head heights being correlated with the walk velocity (Back and Clayton, 2013; Clayton and Hobbs, 2017).

Although the coordination of movements in quadrupeds, including the horse, have been studied by many researchers, the coordination between subject and horse is still a subject of great interest among researchers (Lagarde, *et al*., 2005; Nevison and Timmis, 2013; Clayton and Hobbs, 2017). The relationship between the horse and subject is complex, since the subject may adapt to the horse movement and shape, and the horse may adapt to the subject's weight. Other components such as a subject's skills, the type of saddle or pad used or even the type of surface the horse is walking on may also interfere in the coordination between horse and subject.

The first point of description to start to understand the relationship between subject and horse lies around the concept of CoM and balance. In biomechanics, the CoM is the point where a motionless body, if supported at that point, will remain balanced (Robertson, *et al*., 2014). The CoM is not a fixed point and, while on the horse to keep balance the subject's CoM should ideally lie above the horse's CoM (Harris, 1993; Robertson, *et al*., 2014). Nevertheless, the subject's ability to balance, when on the horse could be affected by their own asymmetries, by the horse asymmetries, the subject's sitting position or by the subject's ability to ride (Harris, 1993).

Therefore, the balance between the subject and horse is dynamic and ideally the subject will follow the motion of the horse. During locomotion, the Range of Motion (RoM) of horse's back motion is the same with the subject's weight, but the cycle is more extended. The translation of the movement of the horse's back can be seen through the movement of subject's pelvis as it has direct contact with the saddle, the pad or the horse's back, which pitches around the transverse axis, it rolls around the anteroposterior axis and yaw on the vertical axis (Figure 3.3) (Back and Clayton, 2013; Clayton and Hobbs, 2017). During a horse's walking stride, the subject's pelvis will have two pitching cycles, posteriorly from the hind limb contact to the forelimb contact, and anteriorly from forelimb contact, to the next hind contact. As for yawing and rolling movements, the horse, the saddle and the subject's pelvis will have only one cycle during a stride. When a hind limb lifts off the floor the horse's trunk and the subject's pelvis will roll towards the limb; as for the yaw motion, the subject's pelvis will twist toward the weight-bearing hind limb and in opposite direction of the subject's trunk (Clayton and Hobbs, 2017).

Scientific studies investigating the interaction of subject and horse during walk gait, and the pattern of movement of the human pelvis when on the horse and when walking is scant (Nevison and Timmis, 2013; Garner and Rigby, 2014).

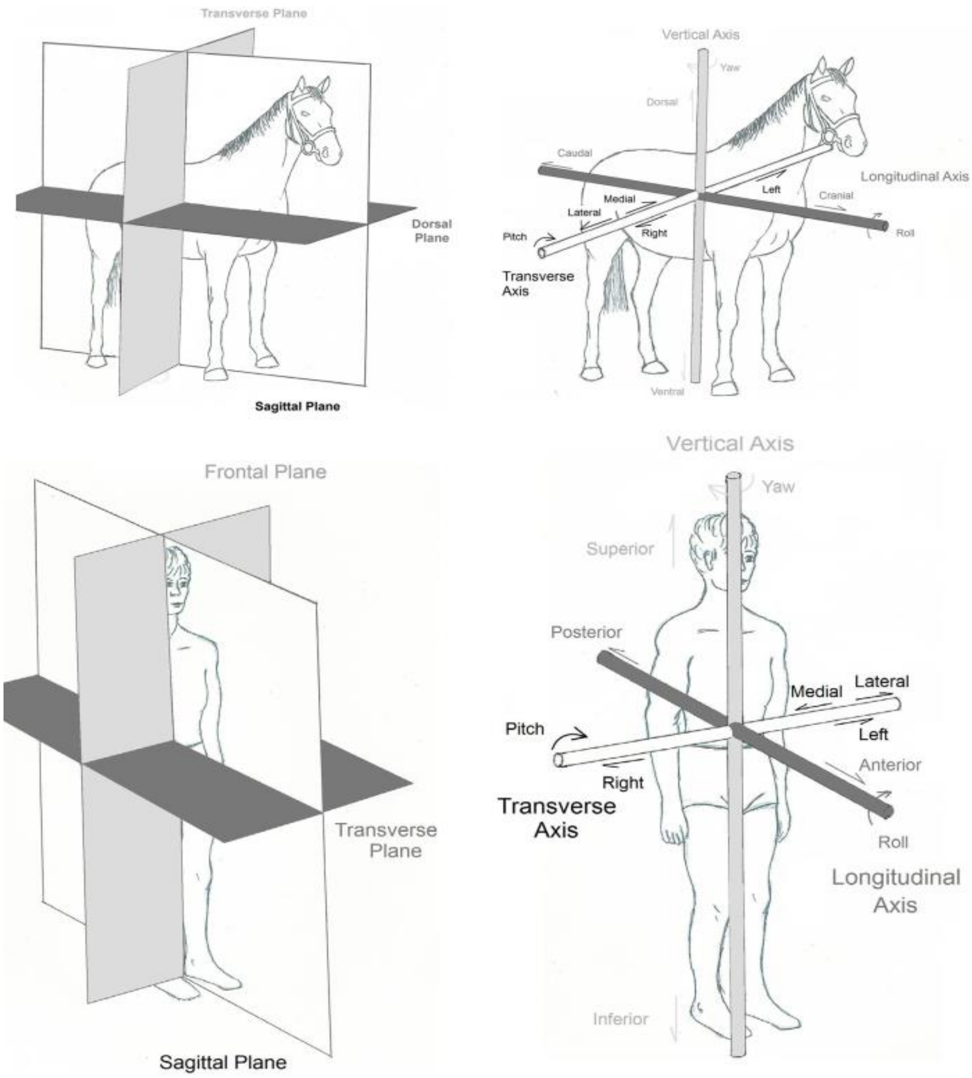

Figure 3.3. Equine and Human Body Axis and Terminology.

Adapted from Clayton and Hobbs, (2017).

Expected Outcomes for Hippotherapy

The three-dimensional movement that is translated from the horse to the subject, and the consequences of being sat on a slightly tall and narrow moving base, require the subject to recruit a series of muscles and activate the vestibular and sensorimotor systems. For these reasons, it is hypothesised that physically disabled people, when receiving HPOT, will engage more of the musculature and sensory systems that are required for walking, and this may then result in enhanced activation of muscle fibres and strength in comparison to those not receiving of HPOT. The dislocation of centre of pressure will enable those individuals receiving HPOT to improve their balance and postural control, which may lead to an overall improvement in their locomotion and motor control (Benda, McGibbon and Grant, 2003; Herrero, *et al.*, 2010; Tseng, Chen and Tam, 2013).

A study by Garner and Rigby, (2014) quantitatively measured kinematics of the pelvis when walking and when on the horse in walk gait to try elucidating whether the horse moves the pelvis in the similar way as it is displaced during human walk. They evaluated 6 able-bodied inexperienced subject, age 8-12, and used horses that were familiar with EAT practice. Reflective markers and motion capture software were used to gather the data.

Among their results, it was reported that during the vertical displacement phase the pelvis exhibits two vertical peaks and two valleys per cycle, when walking and when on the horse. Both trajectories are sinusoidal, but that obtained from the pelvic movement while on the horse has more undulations, in response to the quadrupedal gait. Considering the medial-lateral displacement, the sway occurs once per cycle, in both situations however, the lateral displacement during walk peaks is around 25% through the gait cycle, whereas during riding it happens to be closer to 50%.

The anterior-posterior displacement is sinusoidal for both conditions, and, as with the vertical displacement, the forward motion has the peak of anterior displacement of the pelvis during riding coinciding with the peak vertical displacement.

Overall the study concluded that pelvis trajectories of displacement have some similar patterns between walking and riding, indicating that the horse could generate movement in the human pelvis that could somewhat mimic the human walk (Garner and Rigby, 2014).

These studies highlight the reason why HPOT may be a good technique to improve balance and gross motor function of children with CP. However, it is important to consider three things that are still very relevant to be discussed.

Published literature reviews in the area (Herrero, *et al.,* 2011; Sterba, *et al.,* 2007; Whalen and Case-Smith, 2012 and Tseng, Chen and Tam, 2013), strongly criticised the methodology of the studies, raising questions about the heterogeneity of the samples, the use of different methods of evaluation and the variety in the HPOT protocol of treatment, regard its frequency and duration. These issues make it clear that there is still scope in the literature to i) evaluate the effect of HPOT in children with validated gold standard tools that will allow to better communication not only between researchers, but also between practitioners; ii) gather evidence among practitioners and researchers to what is the most used frequency and duration of HPOT treatment, as it is pressing that clinical research translate practice and practice translates research and iii) investigate the effect of HPOT in samples that are more homogenous, or at least, more detailed classified, so researchers and practitioners can discuss the use of this technique in a manner that can benefit specific groups of patients, with less assumption and more evidence.

The classification of the individuals recruited to participate in research studies is a matter of importance to be strongly considered. First, because it will help to build practice based in evidence and second because it facilitates the communication not only among practitioners and researchers, but also between practitioners and carers (Shaw, Connelly and Zecevic, 2010; Mutlu, *et al.*, 2018). A classification, such the GMFCS is not meant to put the individual into a squared rigid box, not does it mean that every treatment will work equally to every person under a determined classification, however, it helps every individual involved in the care of the child with CP to develop a clear treatment path, to design specific objectives of rehabilitation and to draw realistic expectations of achievement. On the last published meta-analysis by Tseng, Chen and Tam, (2013), only three studies (Hamill, Washington and White, 2007; Chang, *et al.,* 2012; Kwon, *et al.*, 2015) have separated their recruited participants into different GMFCS levels. Five (Damiano, *et al.*, 2006; Mcgibbon, *et al.*, 2009; Chang, *et al.*, 2012; Kwon, *et al.*, 2015; Deutz, *et al.*, 2018) of the nine studies included in the meta-analysis did not separate the participants by classification at all. This is a potential issue, as children classify as GMFCS IV and V will not have the same functional motor ability than children classify as GMFCS I and II (mild presentation of CP).

These reasons made it clear that there is still scope to build the evidence of the effect of HPOT in the rehabilitation process of children with CP and this work will attempt to add further evidence of HPOT treatment.

3.4. Objective of the Study

1. To conduct a systematic literature review in HPOT and CP
2. To conduct a survey with physiotherapists in the UK and in Brazil to understand their practice and perspectives regard HPOT.
3. To conduct an experimental study with children with Cerebral Palsy that will undertake HPOT treatment and have their gross motor function, balance, spasticity and quality of life after 12 weeks of treatment

4. Chapter 4: The Effect of Hippotherapy on Children with Cerebral Palsy: A Systematic Literature Review

This chapter presents a systematic review of the research literature that examines HPOT being used as a rehabilitation therapy for children with CP.

4.1. Introduction and Rationale for the Systematic Review

Literature reviews and meta-analyses have criticised the quality of a large proportion of the published studies on HPOT for participants with CP, highlighting a lack of evidence of the clinical significance of the intervention and subjective assessments of effect (Benda, McGibbon and Grant, 2003; Sterba, *et al.*, 2007; Tseng, Chen and Tam, 2013).

Tseng, Chen and Tam, (2013) concluded from their meta-analysis that there was not enough evidence to prove that HPOT has a positive effect on gross motor function and gait. Moreover, they concluded that there is some evidence that suggests that HPOT improves postural control in participants with CP and that it is effective in normalizing hip adductor activity, based only on the preliminary result of McGibbon, *et al.*, (2009) and Benda, McGibbon and Grant (2003). Tseng, Chen and Tam (2013) themselves only included 14 papers in their review that investigated HPOT or Therapeutic Riding effects on gross motor function, muscle asymmetry, balance and posture. The studies included had a pre/post design, a variable frequency and duration of treatment and a variable CP population across the studies included, with authors implying that further investigation with more homogenous samples and for longer periods could provide better evidence of HPOT effects. This indicates more studies with this design and with more methodological rigor are still needed.

The last study included in the most recent literature review in the area (Tseng, Chen and Tam, 2013) was published in 2011 and since then no systematic review was carried out investigating the physical effects of HPOT in children with CP. Therefore, it is pertinent for a new systematic review to be carried out, focusing exclusively on HPOT effects on physical function, expanding what was previously done (gross motor function, posture and balance and muscle symmetry) and investigating spasticity, gait components, pelvic kinematics and functional performance.

This review supersedes previous literature reviews involving HPOT and children with CP (Sterba, *et al.*, 2007; Zadnikar, *et al.*, 2011; Tseng, Chen and Tam, 2013) by extending the review period in time and scope and by evaluating the effect of HPOT on a bigger range of physical outcomes (balance, posture, motor function, spasticity, functional performance, gait and muscle activity) and also on quality of life. Furthermore, it is important to highlight that these previous literature reviews have had slightly different aims. Namely, i) Tseng, Chen and Tam, (2013), aimed to evaluate the effect of equine assisted therapies (EAT) on gross motor outcomes in children with CP; ii) Zadinikar, *et al.*, (2011) aimed to present an overview of the effects of HPOT and THR on postural control or balance of children CP; and iii) Sterba, *et al.*, (2007) aimed to investigate whether clinicians are justified in recommending horseback riding (HBR) for gross motor rehabilitation of children with CP.

Critically, those reviews have included studies investigating different types of EAT, which is, as defined by the Chartered Physiotherapists in Therapeutic Riding – UK (CPTRH, retrieved May 2018), divided into 4 different categories: HPOT, THR, HBR and therapeutic vaulting. In previous literature reviews' authors may have presumed that these 4 categories, especially HPOT and THR, could generate the same physical benefits as some studies using THR have reported significant positive improvement on gross motor function of children with CP, when compared to baseline scores (MacKinnon, *et al.*, 1995; Sterba, *et al.*, 2002; Cheng, *et al.*, 2004). No further discussion was given on the relevance of congregating HPOT and THR in same reviews.

4.2. Methodology of Systematic Review

Prisma® Guidelines and Study Purpose

According to Prisma (Moher, *et al.*, 2009, p.1) "*A systematic review is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review.*"

To meet Prisma criteria and to reduce bias, the methodology adopted for systematic review studies require a minimum of two independent evaluators to follow the methodology described below and analyse the papers at the same time. The scores should then be discussed and agreed. The scores agreed are presented in the results section. A flow chart (Figure 4.2), as indicated by Prisma Statements (Moher, *et al.*, 2009), is used to indicate the process involving identification, screening, eligibility and inclusion of the papers. This process has been followed in this review and the Prisma Statement Checklist (Appendix 1) is attached to this document to demonstrate compliance with this process.

This present systematic review only addressed studies that were investigating the effect of HPOT but not any other EATs, for two specific reasons: i) HPOT is a technique that can be conducted by a different range of therapists, whether working in an interdisciplinary team or on their own practice, and uses equine movement in association with conventional physiotherapy techniques to benefit physically disabled patients; ii) that equine movement can be used in different types of techniques generates confusion in the literature with regards to the specific definition of EAT and HPOT (Benda, McGibbon and Grant, 2003; Debuse, Chandler and Gibb, 2005). This misinterpretation or the variation of the definition across studies may also be creating a series of bias within the research that is being conducted in this area, making it difficult to analyse and conclude the effectiveness of this technique in the rehabilitation process of a specific population (Debuse, Chandler and Gibb, 2005).

Data Source

A literature search utilising online research database was conducted. The databases searched were Medline (PubMed), PeDro, CINAHL and Scopus. According to the medical library website of Cambridge University, PubMed is listed as great general database and it is considered a great starting point to health literature search, SCOPUS is also listed as a good multi-disciplinary database, being considered one of the main medical and health databases (https://library.medschl.cam.ac.uk/research-support/databases/; accessed on 5th of April 2020). The database "PeDro" was chosen because it is a scientific database focused specifically in Physiotherapy (https://www.pedro.org.au/; accessed on 05th of April 2020); CINAHL brings the most current nursing and allied health literature (EBSCO: https://www.ebscohost.com/nursing/products/cinahl-databases/cinahl-complete –

accessed on 05th of April 2020), closing the chosen databases for this current literature review.

Search string filters were used, considering the period from 01st January 1988 until 31st May 2018, for papers published as full article and in English in all four databases chosen.

"Hippotherapy" was chosen as a Mesh term because any other horse-related term would bring studies of other therapies that use the horse, or even riding, which was not within the scope of this review. "Cerebral Palsy" was chosen so there was no need to think about word variations and to refine the search of the literature, as this review was only interested on looking into papers investigating the effects of HPOT in people with CP. The application of Mesh was done as such demonstrated on figure 4.1 (Chapman, D 2009). The terms were used combined, as follows: "Hippotherapy AND Cerebral Palsy".

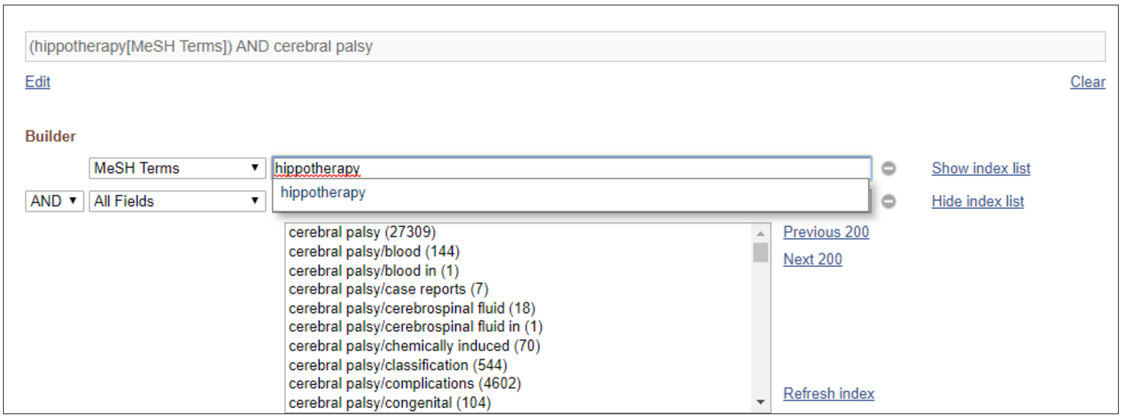

Figure 4.1. Equine and Human Body Axis and Terminology.

Eligibility Criteria

The outline of eligibility criteria is described below, and every term was defined according to the literature to ensure both evaluators had a clear concept of which studies should be included or excluded. The PICO model for quantitative papers was used to design the study, following the PRISMA guidelines, to perform the search of papers investigating the effect of HPOT in people with Cerebral Palsy. The search could include peer-reviewed quantitative studies as experimental studies: randomized or open-label; and as observational study: cohort, case series and cross-sectional study.

P: Children with Cerebral Palsy

I: Hippotherapy (no alternate term allowed – eg: riding therapy, riding for the disabled, equine assisted therapy)[8]

C: Conventional Physical Therapy; No therapy; Other types of physical therapy (Bobath technique, Pilates, etc.); Before and After HPOT treatment.

O: the effect of HPOT on the improvement of physical outcomes, including balance, gait, posture, spasticity, muscle activity, functional performance and motor function were included.

Study Appraisal and Synthesis Method

The guidelines for critical review form for quantitative studies was designed by Law, *et al.*, (1998) at McMaster University. These guidelines cover the background reasoning for the definitions of study quality and support the researcher in addressing 16 closed-ended, scorable questions designed to evaluate the relative quality of the papers in a field of research.

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[8] Papers that used other types of therapy with horses, such as "horseback riding" or "therapeutic horseback riding" were excluded, as according to AHA, HPOT is a therapeutic strategy explored by rehabilitation professionals using the unique movement of the horse to achieve functional goals (Frank, McCloskey and Dole, 2011; Shurtleff and Engsberg, 2012) and it is, therefore, different to horseback riding and THR. Studies using horse simulators, that were extracted using the terms above, were also excluded from the study as the use of a horse simulator does not comply with AHA definitions of HPOT.

Papers that were using HPOT but investigated a different population from that cited above or that were not investigating the effect of HPOT on the physical outcomes cited above were also excluded. Papers using a simulator to apply THR or another type of EAT and those classified below "fair" according to Law, *et al.*, (1998) were also excluded.

For each article, each question was scored either as 1 or 0, where 1 indicates that the study met the criterion completely (Table 4.2). The overall score for each paper was classified as poor (score 6-8), fair (score 9-10), good (score 11-12), very good (13-14) or excellent (15-16). The questions were divided into eight categories: study purpose, literature, design, sample, outcomes, intervention, results, conclusions and implications (Appendix 2).

The quantitative study type was categorized as: systematic reviews of large Randomized Control Trials (RCT); large RCT (I), smaller RCTs, systematic review of cohort (II), cohort with control group; systematic reviews of case controls (III), case series, cohort study, case-control (IV), expert opinion, case study or report (V). The presence of a blind assessor will be indicated with the character (+) and its absence with the character (-).

As this study is an extension and refinement of previous literature reviews, by involving studies that were evaluating the effect of HPOT (only) in children with CP, it was decided to use the guidelines of Law, *et al.*, (1998) to analyse the papers. The reasons for this are: i) it has been used previously in published literature exploring the same theme; ii) by using the same classification system, the discussion with previously published work is more sensible and reliable; iii) these guidelines are written in basic terms that can be understood by researchers, clinicians and students; and (iv) it provides a quantitative qualification for the papers (Table 4.1). This is a peer-reviewed method, used before by researchers in the field. The quantitative method of evaluation, following the Table 4.1 allows the research to evaluate, critically, every paper included in the literature review. This method is simple and reproducible.

All eligible papers were classified according to categories of interest such as the type of participant population utilised, characteristics of the therapy sessions (time, length, frequency), the type of clinical tests used to evaluate effectiveness, scientific evaluation criteria utilised, the type of the study (e.g. randomized control trials or case series) and 'quality' components (Law, *et al.*, 1998).

The search string and the evaluation of the papers was conducted by two examiners, independently. First, they set down to discuss the inclusion of the papers that were then included, considering all the points of PICO model described above. They proceed to do an independent evaluation of the papers, following the criteria described on Table 4.1. The results of the evaluation of the included papers were then compared. If there was a discrepancy on the scores a third evaluator would be invited to do the analysis following Law, *et al.*, (1998).

A list, such as found on Appendix 3 was given for both examiners to fulfil, with all the papers found. Just new papers from 2017 till 31st of May 2018 were added in order to update the review.

Table 4.1. Methodological Quality of Papers.

Methodological quality of research articles: Critical Review Form – Quantitative Studies (Law M, *et al.*, 1998)
1. Purpose clearly stated?
2. Relevant background literature reviewed?
3. Design appropriate for study question?
4. Absence of any bias (sampling, intervention, or measurement) influencing results?
5. Sample described in detail?
6. Sample size justified?
7. Informed consent obtained?
8. Outcome measures reliable?
9. Outcome measures valid?
10. Intervention described in detail?
11. Results reported with statistical significance?
12. Analysis methods appropriate?
13. Significant differences between groups clinically meaningful?
14. Conclusions appropriate from results?
15. Implications of results influencing clinical practice reported?
16. Main limitations or biases of study discussed?

4.3. Results

Characteristics of Research Studies of Hippotherapy

The database search yielded 325 studies. Figure 4.1 shows the number of articles selected for analysis and reasons for exclusion, following the Prisma Statement flow diagram. Forty articles derived from the database search were considered eligible and fully appraised by the criteria defined in Law, *et al.*, (1998). From those, eight were excluded; two for not presenting results, five for using simulators and one for being THR, leaving 32 studies published between 1988 and 2018 that were eligible to be included in this literature review.

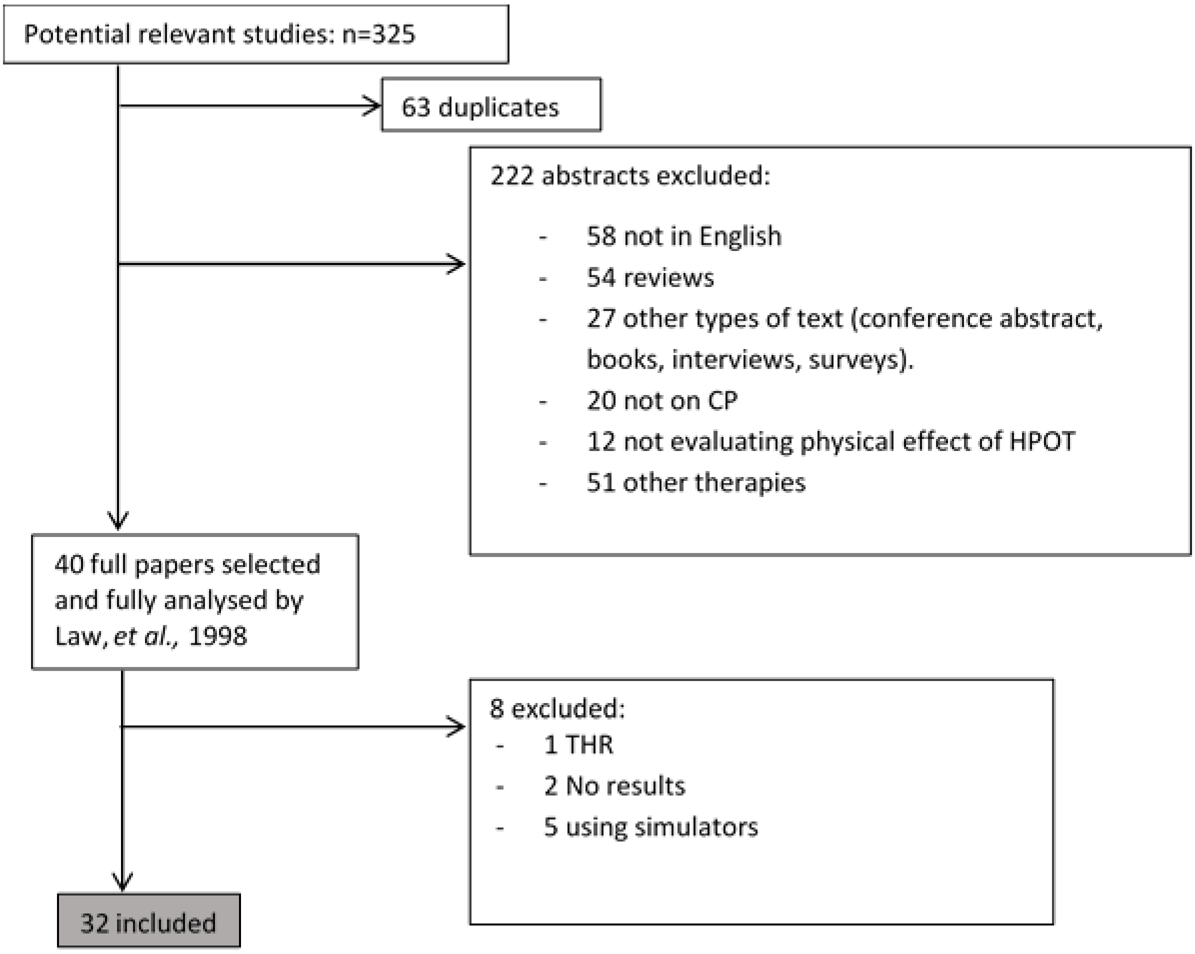

Figure 4.2. Flow Chart of Paper Identification and Inclusion.

In line with the quality criteria (Law, *et al.*, 1998) presented in Table 4.2, eleven papers were classified as "excellent", twelve as "very good", six were classified as "good" and three as "fair". The most common methodological shortcomings[9] within the thirty-two studies were i) sample size was not justified (18 studies); ii) inherent bias (18 studies); and iii) lack of significant difference between group clinically meaningful (13 studies). All the studies did however present a clear purpose, the researchers obtained informed consent from participants and have given an appropriate conclusion for the results as shown in Table 4.3. No discrepancies were found between the evaluations of the two reviewers.

[9] Shortcomings transcribed directly and exactly from Law, *et al.*, 1998 criteria of evaluation.

The most evaluated measurement outcomes across the papers included were gross motor function, balance, posture and gait. Other measures such as QoL and wellbeing, spasticity and functional performance were evaluated by at least one of the studies.

Across the studies four types of experimental design were used: i) before and after the HPOT treatment only, ii) HPOT vs. conventional physiotherapy and iii) HPOT vs. control (no treatment) iv) HPOT vs. any other type of physical therapy (e.g. Pilates, Bobat) Only four studies were case series or case studies (Haehl, *et al.,* 1999; Hamill, *et al.,* 2007; Shurtleff and Engsberg, 2012; Mutoh, *et al.,* 2016).

Table 4.2 presents the results of the analysis using Law, *et al.,* (1998) as well their classification according to the score received. Paper methodology and sample sizes are presented on table 4.3 as well which research design was used by each paper (classified by the researcher or by the authors of the paper) and the by the Law, *et al.*, (1998) classification.

Table 4.2. Critical Appraisal of Articles Included on the Review.

#	Authors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	total	Score
1	**McGibbon, *et al*., 1998**	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	14	Very Good
2	**Haehl, Giuliani and Lewis, 1999**	1	1	0	0	0	0	1	1	1	1	0	1	0	1	0	1	9	Fair
3	**Benda, McGibbon and Grant, 2003**	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	15	Excellent
4	**Casady, *et al*., 2004**	1	1	1	0	1	0	1	1	1	1	1	1	0	1	1	1	13	Very Good
5	**Hamill, Washington and White, 2007**	1	1	1	1	1	0	1	1	1	1	0	0	0	1	1	1	12	Good
6	**Shurtleff, *et al*., 2009**	1	1	1	0	1	0	1	1	0	1	1	1	0	1	1	1	12	Good
7	**McGibbon, *et al*., 2009**	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	13	Very Good
8	**McGee, *et al*., 2009**	1	1	1	0	1	0	1	1	0	0	1	1	0	1	1	1	11	Good
9	**Shurtleff and Engsberg, 2010**	1	1	1	0	1	0	1	1	0	1	1	1	0	1	1	1	12	Good
10	**Frank, *et al*., 2011**	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	14	Very Good
11	**Kwon, *et al*., 2011**	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	14	Very Good
12	**Kang, *et al*., 2012**	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	14	Very Good
13	**Silkwood-Sherer, *et al*., 2012**	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	14	Very Good
14	**El-Meniawy and Thabet, 2012**	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	15	Excellent
15	**Shurtleff and Engsberg, 2012**	1	1	1	0	1	1	1	1	0	1	0	1	0	1	0	1	11	Good
16	**Chang, *et al*., 2012**	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15	Excellent
17	**Fizkova, *et al*., 2013**	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	14	Very Good
18	**Manikowaska, *et al*., 2013**	1	0	1	0	0	0	1	1	1	1	1	1	0	1	1	0	10	Fair
19	**Park, *et al*., 2014**	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15	Excellent
20	**Mackow, *et al*., 2014**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	Excellent
21	**Lee, et al., 2014b**	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1	13	Very Good
22	**Kwon, *et al*., 2015**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	Excellent
23	**Mutoh, *et al*., 2016**	1	0	1	0	1	0	1	1	1	0	1	1	0	1	0	1	10	Fair
24	**Rigby, *et al*., 2016**	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	13	Very Good
25	**Antunes, *et al*., 2016**	1	1	1	0	1	0	1	1	1	1	1	1	0	1	1	1	13	Very Good
26	**Champagne, Corriveau and Dugas, 2016.**	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15	Excellent
27	**Hsieh, *et al*., 2016**	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	14	Very Good
28	**Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016**	1	0	1	1	1	0	1	1	1	1	0	1	0	1	1	1	12	Good
29	**Moraes, *et al*., 2016**	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15	Excellent
30	**Mutoh, *et al*., 2018**	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	15	Excellent
31	**Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	Excellent
32	**Deutz, *et al*. 2018**	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15	Excellent

BA: blind assessor; H: horse; S: horse simulator; CP: cerebral palsy;

Table 4.3. Type of Studies Included

#	Authors	BA	Level	Study type	Who classified?	Samples	Outcome measurement and method of evaluation	Type of study/analysis
1	**McGibbon, *et al*., 1998**	−	IV	Cohort study	P	N=5	Gross motor function/ GMFM-88-E Gait – Energy Expenditure Index	Repeated-measures within subjects. Friedman two-way analysis of variance by ranks to analyse differences within subjects scores.
2	**Haehl, Giuliani and Lewis, 1999**	−	V	*Case study*	R	N=2	Postural Kinematics – Peak Performance system Functional Performance - PEDI	Data presented per individual.
3	**Benda, McGibbon and Grant, 2003**	−	II	Cohort study	P	N=15	Muscle Symmetry - EMG	Pre-test/post-test. Independent t-test two tailed, equal variance assumed) to compare the changes after treatment
4	**Casady, *et al*., 2004**	+	IV	Cohort study	P	N=11	Gross motor function – GMFM-88 Functional Performance – PEDI	Time-series, quasi-experimental design. Post hoc of multiple comparisons for treatment
5	**Hamill, Washington and White, 2007**	−	IV	*Case Study*	R	N=3	Sitting Posture – GMFM-88-B and SAS	Data presented per individual. Percentage of GMFM used.
6	**Shurtleff, *et al*., 2009**	−	IV	Cohort study with control	P	N=11 HPOT; N=8 control	Trunk/head stability – video motion camera	Pre-postoperative with follow up. Repeated measures analysis of variance.
7	**McGibbon, *et al*., 2009**	−	II	Small RCT	P	Phase I: N=25 HPOT, N= 22 barrel Phase 2: N=6 HPOT	Symmetry of Adductors – EMG Gross motor function – GMFM-66 Self-Perception – Self-perception profile	Pre-test/post-test RCT Phase I: Wilcoxon to changes within group and Mann-Whitney to changes between groups. Phase 2: visual analysis
8	**McGee, *et al*., 2009**	−	IV	Cohort study	R	N=9	Gait Parameters - GAITRite	Repeated measures. Wilcoxon was used to compared before-after treatment (because small sample – according to authors).
9	**Shurtleff and Engsberg, 2010**	−	V	Cohort with control group	R	N=6 (CP children) HPOT; N=6 (healthy adults)	Trunk and head stability – video motion camera	Paired t-test was used to compare treatment effects.

#	Authors	BA	Level	Study type	Who classified?	Samples	Outcome measurement and method of evaluation	Type of study/analysis
10	**Frank, *et al*., 2011**	−	V	Case Report	P	N=1	Self-competence – Pictoral Scale of perceived competence Gross motor function – GMFM-66	Reported individual measures.
11	**Kwon, *et al*., 2011**	+	III	Cohort study with control group	P	N=16 HPOT; N=16 control	Gait Parameters – 3-D motion analysis Gross motor function – GMFM-88-D, E and GMFM-66 Balance - PBBS	No randomized prospective control trial. T-test and repeated measures 2-way analysis for intervention analysis. Covariance for group analysis.
12	**Kang, *et al*., 2012**	−	II	Small RCT	P	N=15 (HPOT); n=15 (control); N=15 (CPT)	Sitting balance – Force Plate	t-test to analyse difference between before and after treatment. 1-way ANOVA with bonferroni to evaluate differences between groups.
13	**Silkwood-Sherer, *et al.*, 2012**	−	IV	Cohort study	P	N=16	Balance – PBBS Function – Activities Scale for Kids – Performance	Repeated measures design. Within group differences with Friedman analysis. Wilcoxon with Bonferroni for treatment analysis.
14	**El-Meniawy and Thabet, 2012**	−	II	Small RCT	P	N=15 HPOT, N=15 CPT	Posture – Formetric instrument system	Repeated measures. Levene test, independent T-test and paired t-test.
15	**Shurtleff and Engsberg, 2012**	−	IV	*Case study*	P	N=1	Head and trunk control – video motion camera	Pre/post measures. Reported individual measures
16	**Chang, *et al*., 2012**	−	II	Cohort study	R	N=19 (level I and II); 14 (level III and IV)	Gross motor function – GMFM-88 Balance – PBBS	t-tests for treatment; RMANOVA for groups
17	**Fizkova, *et al*., 2013**	−	II	Cohort study	R	N= 11	Gait Parameters – Vicon MX system	Repeated measures. Wilcoxon used to before-after treatment.
18	**Manikowaska, *et al*., 2013**	−	IV	Cohort study	R	N=16	Gait Parameters – DynaPort MiniMod	Repeated measures. Wilcoxon to analyse before-after treatment
19	**Park, *et al*., 2014**	−	II	Cohort with control group	R	N=34 HPOT; n=21 control	Gross motor function – GMFM-88 and 66 Functional Performance - PEDI	Chi-squared for distributions of GMFCS; t test for difference within groups

#	Authors	BA	Level	Study type	Who classified?	Samples	Outcome measurement and method of evaluation	Type of study/analysis
20	**Mackow, *et al*., 2014**	−	II	Cohort study	R	N=19	Centre of gravity – Cosmogamma Balance Platform	Repeated measures. T test for dependent samples to compare differences after treatment.
21	**Lee, et al., 2014b**	−	II	Small RCT	P	N= 13 HPOT; N=13 simulator	Balance – Force Plate and PBBS	Repeated measures. T test to analyse difference between before and after treatment in each group.
22	**Kwon, *et al*., 2015**	+	II	Small RCT	P	N=45 HPOT; N=46 Control	Gross Motor Function – GMFM - 88 and 66 Balance - PBBS	Wilcoxon for treatment; Mann-Whitney to control x HPOT group.
23	**Mutoh, *et al*., 2016**	−	IV	*Case series*	P	N=3	Gait Parameters – Portable Motion Recorder	T-test for each parameter before and after treatment.
24	**Rigby, *et al*., 2016**	−	III	Cohort with control group	R	N= 8 HPOT, N=8 control	Cardiorespiratory responses – blood pressure, HR and respiratory gases Pelvic Kinematics – video motion cameras	Repeated measures. ANOVA was used to analyse changes after treatment.
25	**Antunes, *et al*., 2016**	−	IV	Small RCT	P	N= 10 HPOT, N= 10 control	Gait Parameters – Free4Act system Spasticity of adductors - MAS	Feasibility study with crossover trial. Mann Whitney or T-test used for baseline differences between groups. Outcome measures and Delta-variance used to value after treatment protocol. Wilcoxon or T-test for differences between groups after treatment.
26	**Champagne, Corriveau and Dugas, 2016**	−	II	Cohort study	P	N=13	Gross motor function – GMFM-88-D, E; Motor proficiency – Bruininks-Oseretski Motor Proficiency	Prospective Quasi-experimental design; Wilcoxon for treatment with bonferroni correction.
27	**Hsieh, *et al*., 2016**	−	IV	Cohort Study	R	N=14	Body function, activity and participation – ICF-CY assessments	Repeated measures. Wilcoxon was used to analyse treatment effect.

#	Authors	BA	Level	Study type	Who classified?	Samples	Outcome measurement and method of evaluation	Type of study/analysis
28	**Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016**	–	III	Cohort study with control group	R	N= 19 HPOT; n=20 control	Sitting Balance - SAS	Repeated measures. Tests not stated in the paper.
29	**Moraes, *et al*., 2016**	–	II	Cohort Study	R	N=15	Postural Balance – AMTI force plate; Balance – BBS Functional performance – PEDI	Repeated measure with exploratory analysis of the data for outliers. Anova with Greenhouse-Geisser was used for differences after treatment.
30	**Mutoh, *et al*., 2018**	-	II	Cohort Study	P	N=20	Gross motor function – GMFM-66 Gait Parameters – 10mwt + motion recorder	Prospective longitudinal study. Analysis of variance, bonferroni and linear regression
31	**Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018**	-	I	RCT	P	N=22 treatment N=22 control	Muscle Spasticity – MAS	Pre/post measures. T-test for paired sample to investigate differences between pre/post and differences between groups. Effect size calculated.
32	**Deutz, *et al*. 2018**		I	RCT	P	N=35 early treatments; N=35 late treatment	Gross motor function – GMFM-66-D, E; Quality of life – Child Health Questionnaire	A Randomized Open-Label Crossover Study

RCT: randomized controlled trial; P: classified by the paper; R: classified by the PhD researcher; N: sample size; CPT: conventional physiotherapy; HPOT: hippotherapy; CP: cerebral palsy; MAS: modified Ashworth scale, PEDI: paediatric evaluation of disability inventory; GMFM: gross motor function measure; BBS: Berg balance scale; PBS: paediatric berg balance scale; SAS: sitting assessment scale; ICF: international classification of functioning; EMG: electromyography; mwt: minutes walking test.

Across the studies a total of 458 children with CP received HPOT treatment. The individuals described across the studies have been given different types of CP classifications, i) according to the topography of the condition: diplegic, hemiplegic and tetraplegic children; ii) according to the motor function of the condition: spastic, ataxic and dyskinetic; iii) according to muscle tonus classification: spastic; and iv) according to GMFCS classification: levels I to V.

Ten studies focused on the effect of HPOT on the gross motor function measure scores and ten on balance, eight on functional performance, seven on gait, six on posture, three on muscle activity/spasticity and two on pelvic kinematics, not exclusively (note: a study might have evaluated more than one outcome).

Across the studies, the duration of HPOT treatment varied from one session only to 2 years of treatment periodically, the frequency varying from one to three times a week and the duration of one session from 4 to 60 minutes. The results of the studies are presented below and have been evaluated separately and according to the outcomes.

This indicates that the studies have different protocols regard duration of sessions and treatment, which their samples were not always homogenous regard the type of CP and that authors have different perspectives of what outcomes HPOT may be effective in improving. Furthermore, the way the outcomes were being evaluated also varied from one study to another.

Evidence from Studies Using the Gross Motor Function Measure

There were twelve studies that used the GMFM to evaluate the effect of HPOT in the gross motor function of children with CP (McGibbon, *et al.,* 1998; Casady, *et al.,* 2004; Hamill, Washington and White, 2007; McGibbon, *et al.,* 2009 – Phase II; Frank, *et al.,* 2011; Known, *et al.,* 2011; Chang, *et al.,* 2012; Park, *et al.,* 2014; Known, *et al.,* 2015; Champagne, Corriveau and Dugas, 2016; Mutoh, *et al.*, 2018; Deutz, *et al*. 2018)

Within these studies, 254 children with CP received HPOT treatment and were evaluated with the GMFM before and after the treatment. Two studies had children doing conventional physiotherapy while doing HPOT (McGibbon, *et al.,* 1998; Park, *et al.,* 2014; Kwon, *et al.,* 2015) and three studies (Kwon, *et al.,* 2011; Park, *et al.,* 2014; Kwon, *et al.,* 2015) had a control group. Three studies did not report significant findings (Hamill, Washington and White, 2007; McGibbon, *et al.,* 2009; Frank, *et al.,* 2011).

Nine studies used the GMFCS to classify the participants, five included children level I-IV (Mcgibbon, *et al.,* 2009; Chang, *et al.,* 2012; Kwon, *et al.,* 2015; Deutz, *et al.*, 2018) and the remaining four have only included levels I and II. Nevertheless, only three studies separate the participants accordingly to their GMFCS when analysing GMFM scores (Hamill, Washington and White, 2007; Chang, *et al.,* 2012; Kwon, *et al.,* 2015). Only two studies (Frank, *et al.,* 2011; Kwon, *et al.*, 2015) included children with ataxic CP, and one (Kwon, *et al.,* 2015) with dyskinetic. All the other eight studies have included spastic CP, diplegic, hemiplegic and quadriplegic participants.

The general characteristics of the studies and their general findings can be found in table 4.4.

Table 4.4. General Characteristics of the Studies Involving Gross Motor Function.

Authors	HPOT	Control	CPT	Participant General Characteristics	Age (y)	Duration	Intensity and Frequency	Significant Improvement after the Treatment (p<0.05).
Mcgibbon, *et al.*, 1998	5	0	1	Diplegic and hemiplegic	9.6	8 wks.	Twice/wk.; ND	Significant increase in dimension E for all children (p<0.05)
Casady, *et al.*, 2004	11	0	0	Spastic CP	2--6	10 wks.	Once/wk., 30 min/d	Significant increase in all dimensions, except Dimension A (p<0.05).
Hamill, Washington and White, 2007	3	0	0	Quadriplegic GMFCS V	2--4	10 wks.	Once/wk., 50 min/d	No significant improvement.
Mcgibbon, *et al.*, 2009 (phase 2)	6	0	0	Spastic CP/ ability to walk ± device, GMFCS II-IV	5--12	12 wks.	Once/wk., 30 min/d	No significant improvement.
Frank, *et al.*, 2011	1	0	0	Mild ataxic CP	6	8 wks.	Twice/wk.; 45min/d	No significant improvement.
Kwon, *et al.*, 2011	16	16	0	Bilateral spastic/ GMFCS I-II	4--9	8 wks.	Twice/wk., 30 min/d	GMFM B, C, D and E improved significantly on HPOT group and better when compared to the control group (p<0.05).
Chang, *et al.*, 2012	33	0	0	Spastic bilateral GMFCS II-IV	4--6	8 wks.	Twice/wk., 30 min/d	Significant improvement on Dimension E for functional walkers and on dimensions C and D for non-walkers (p<0.05).
Park, *et al.*, 2014	34	21	0	Spastic CP GMFCS I-IV	3--12	8 wks.	Twice/wk.; 45min/d	Dimensions B and C were significantly higher than the scores from control group, after treatment (p<0.05).
Kwon, *et al.*, 2015	46	46	0	Spastic, dyskinetic and ataxic; GMFCS I-IV	5.7±1.9	8 wks.	Twice/wk.; 30min/d	Dimensions B, C, D and E significantly better after treatment and in comparison to control group (p<0.05).
Champagne, Corriveau and Dugas, 2016	13	0	0	Hemiplegic and diplegic GMFCS I-II	7.3±2.7	10 wks.	Once/wk.; 30 min/d	Dimensions D and E significantly improved (p<0.05).
Mutoh, *et al*., 2018	20	0	0	Bilateral Spastic CP GMFCS I-III	4--19	48 wks.	Once/wk.; 30 min/d	Outcome not affected by GMFCS. GMFM 66 and dimension E improved significantly after 48wks and after a year re-evaluation from baseline.
Deutz, *et al*. 2018	66	0	0	Bilateral Spastic CP; GMFCS II-IV	9.1±3.3	16 to 20 wks.	Once to twice/wk.; ND	No changes on GMFM total scores, but significant changes were found on dimension E.

Wk.(s): week(s); CP: Cerebral Palsy; Min: minutes; ND: not described; GMFCS: gross motor function classification system; d: day; y: years; CPT: conventional physiotherapy; HPOT: hippotherapy; GMFM: gross motor function measure; B, C, D and E: dimensions of GMFM.

Evidence from Studies Investigating Balance and Posture of Children with Cerebral Palsy

Ten studies evaluated the influence of HPOT on the balance outcome of 183 children with CP (Hamill, Washington and White, 2007; Kwon, *et al.*, 2011; Silkwood-Sherer, *et al.*, 2012; Kang, *et al.*, 2012; Chang, *et al.*, 2012; Mackow, *et al.*, 2014; Lee, Kim and Na, 2014; Kwon, *et al.*, 2015; Moraes, *et al.*, 2016; Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016) . The classification of CP was completely heterogeneous across the studies, grouping spastic CP with other types of the condition, which can generate bias on the results due to the different presentation of pyramidal and non-spastic CP. Only half of the studies had a control group. Balance was evaluated indirectly, by looking into CoP displacement and velocity by Kang, *et al.*, (2012) and Moraes, *et al.*, (2016) and by looking into CoG position by Mackow, *et al.*, (2014). Known, *et al.*, (2011), Silkwood-Sherer, *et al.*, (2012), Chang, *et al.*, (2012), Known, *et al.*, (2015) and Lee, *et al.*, (2014) have used PBBS to evaluate patients balance in dynamic activities after HPOT treatment and Hamill, Washington and White, 2007 and Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016 the SAS, which evaluate sitting balance. All the studies have reported significant improvements on the scores after HPOT sessions.

In four of the studies the frequency and duration of HPOT treatment were the same, with the sessions occurring twice a week for 30 minutes for 8 weeks (Kwon, *et al.*, 2011; Kang, *et al.*, 2012; Chang, *et al.*, 2012; Mackow, *et al.*, 2014; Kwon, *et al.*, 2015). However, the duration of treatment varied from 1 to 24 weeks and the frequency from one to three times a week with most protocols delivering a 30 minutes HPOT session.

Five studies evaluated posture and postural stability and HPOT was applied to 38 children with CP (Haehl, Giuliani and Lewis, 1999; Shurtleff, Standeven and Engsberg, 2009; Shurtleff and Engsberg, 2010; El-Meniawy and Thabet, 2012; Shurtleff and Engsberg, 2012).

Three of the studies were from the same research group (Shurtleff, *et al.*, 2009; Shurtleff and Engsberg, 2010; Shurtleff, *et al.*, 2012). They applied therapy once a week, for 45 minutes over 12 weeks. They used videography and reflective biomarkers to analyse the posture, dynamic stability and trunk movement and the angles of some joints in the trunk (e.g. C7) by doing a test using a motorized barrel that had 1 translational degree of freedom and reciprocal speed from 0-1Hz. They included children with spastic CP from 5 to 13 years old, and in total 18 children were treated with HPOT. They have used motorized barrel and kinematics variables to quantify changes in motor learning affecting head/trunk stability.

In contrast to the three studies described above, El-Meniawy, *et al.*, (2012) evaluated a static posture, using a photometric evaluations system to access back geometry in 30 children randomly assigned to two groups, HPOT and conventional physiotherapy. They applied HPOT for 13 weeks, with weekly sessions lasting for 30 minutes. They reported that the HPOT group had improved significantly more than the conventional physiotherapy group. Hael, *et al.*, (1999) did not report significant improvement on the posture outcomes. The specific details of each study may be found on the Table 4.5.

Table 4.5. General Characteristics of Studies Evaluating Balance and Posture Components.

Authors	HPOT	Control	CPT	Participant General Characteristics	Age (y)	Duration	Intensity and Frequency	Measurements	Balance/posture Components	Significant Improvement after the Treatment (p<0.05).
Haehl, Giuliani and Lewis, 1999	2	0	0	Spastic CP	ND	12 wks.	Once/wk.; 60 min/d	Postural Kinematics – Peak Performance system	Postural orientation and stability, trunk coordination	Improvement between upper and lower trunk coordination. Indication to evaluate relationship between person/horse.
Hamill, Washington and White, 2007	3	0	0	Quadriplegic GMFCS V	2--4	10 wks.	Once/wk., 50 min/d	SAS	Sitting balance	Downward trend for two of the participants.
Shurtleff, *et al*., 2009	11	8	0	Spastic CP/able to sit unaided; GMFCS II-IV	5--13	12 wks.	Once/wk.; 45 min/d	video motion camera	Trunk and head stability Reaching/targeting	Significant changes in stability and reaching after 12wks.
Shurtleff and Engsberg, 2010	6	6	0	Spastic CP - diplegia	6--7	12 wks.	Once/wk.; 45 min/d	video motion camera	Trunk and head stability	Reduced anterior-posterior head rotation and translation after 12 wks.
Kwon, *et al.*, 2011	16	16	0	Bilateral spastic/ walk independently	4--9	8 wks.	twice/wk., 30 min/d	PBBS	Balance on everyday tasks	Significant improvement on PBBS scores after HPOT (p<0.05).
Chang, *et al.*, 2012	33	0	0	Spastic bilateral	4--6	8 wks.	twice/wk., 30 min/d	PBBS	Balance on everyday tasks	Significant improvement on PBBS scores after HPOT (p<0.05).
Kang, *et al.*, 2012	14	14	15	Hemiplegic and diplegic CP/ ability to walk	7--8	8 wks.	30 min/d, twice/wk.	Force Plate (PDM Force measuring plate)	Sitting Balance: CoP pathway and velocity	Pathway and Velocity of CoP significantly decrease after HPOT and in comparison with the other groups (p<0.05).

Authors	HPOT	Control	CPT	Participant General Characteristics	Age (y)	Duration	Intensity and Frequency	Measurements	Balance/posture Components	Significant Improvement after the Treatment (p<0.05).
Silkwood-Sherer, *et al.*, 2012	5	0	0	Diplegic (1), quadriparesis (2) and hemiparesis (1)	10±3.3	6 wks.	twice/wk., 40-45min/d	PBBS	Balance on everyday tasks	PBBS scores significantly better post intervention and a median increase in the time spent in single leg stance, which was significantly longer when compared to baseline (p<0.05).
El-Meniawy and Thabet, 2012	15	0	15	spastic diplegic/ MAS 1 to +1/ able to walk - device	6--8	13 wks.	Once/wk.; 30 min/d3	Formetric instrument system	Back geometry parameters	HPOT group had significant improvement in all variables when compared to control group
Shurtleff and Engsberg, 2012	1	0	0	Spastic CP - diplegia	6	12 wks.	Once/wk.; 45 min/d	video motion camera	Head and trunk control	Measure was done after 24 weeks showing no further improvement.
Lee, *et al.*, 2014b	13	13	0	MAS< +1/ ability to walk		12 wks.	three/wk., 1h/d	PBBS	Balance on everyday tasks	HPOT and Simulator groups significantly improved on PBBS scores after intervention and there were no difference between groups.
Mackow, *et al.*, 2014	19	0	0	spastic CP, GMFCS I-III	4--13	1 wk.	15 min/d	Force Plate (Cosmogamma Balance Platform)	CoG transference in frontal plan towards the antigravity side.	Significant decrease (p<0.05) on CoG displacement and it moved towards the antigravity side.
Kwon, *et al.*, 2015	46	46	0	Spastic (41), dyskinetic (2) and ataxic (2)	5.7±1.9	8 wks.	twice/wk.; 30min/d	PBBS	Balance on everyday tasks	Significant improvement on PBBS scores after HPOT and in comparison, to control (p<0.05).

Authors	HPOT	Control	CPT	Participant General Characteristics	Age (y)	Duration	Intensity and Frequency	Measurements	Balance/posture Components	Significant Improvement after the Treatment (p<0.05).
Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016	19	20	0	Spastic diplegia and hemiplegia, levels I-II	8.4±2.2	12 wks.	once/wk.; 30min/d	SAS	Balance on sitting position	Significant improvement on trunk control while sitting (p<0.05).
Moraes, *et al.*, 2016	15	0	0	Quadriplegic, hemiplegic and diparesis. Levels I-IV	5--10	24 wks.	ND; 30min/d	PBBS and Force Plate (AMTI AccuSway Plus force platform)	Balance on everyday tasks and Sitting Balance: CoP anteroposterior and medio-lateral displacement and velocity.	PBBS scores significantly better post intervention, after 24 weeks. CoP displacement and velocity decreased significantly after 12 and 24 weeks (p<0.05).

Wk.(s): week(s); CP: Cerebral Palsy; Min: minutes; ND: not described; GMFCS: gross motor function classification system; d: day; y: years; CPT: conventional physiotherapy; HPOT: hippotherapy; PBBS: paediatric berg balance scale; CoG: centre of gravity; CoP: centre of pressure; SAS: sitting assessment scale, BBS: berg balance scale.

Evidence from Studies Investigating Gait Components and Ability in Children with Cerebral Palsy

Seven studies evaluated the effect of HPOT on gait spatiotemporal and kinematics parameters (McGibbon, *et al.*, 1998; McGee and Reese, 2009; Kwon, *et al.*, 2011; Manikowska, *et al.*, 2013; Fízková, *et al.*, 2013; Mutoh, *et al.*, 2016; Antunes, *et al.*, 2016). The duration of HPOT sessions varied from 1 week, in four of the studies to 2 years (Mutoh, *et al.*, 2016). In total, 70 children aged 4-25 have had gait components evaluated before and after HPOT treatment. Just two studies (Kwon, *et al.*, 2011; Antunes, *et al.*, 2016) had a control group, in the earliest, 10 healthy children were evaluated for reference values and in the second 16 children were receiving conventional physiotherapy. Six studies used a variety of biomechanical tools to evaluate different parameters of gait, among them being Plug-In Gait systems and GAITRite system. McGibbon, *et al.*, (1998) did not use any motion device or accelerometer, only using the 10 metres walking test, and have collected data by observing, counting the amount of steps and recording how long the participant would take to cross the 10 metres pathway. The summary of results is described on Table 4.6.

Table 4.6. Summary of the Results of the Studies Evaluating Gait.

Authors	Results
McGibbon, *et al.*, 1998	No statistical differences shown when compared pre-post-tests.
McGee, *et al*., 2009	No statistical differences shown when compared pre-post-tests.
Kwon, *et al*., 2011	Significantly improved walking speed, stride length and pelvic kinematics after treatment ($p<0.05$).
Fizkova, *et al*., 2013	Decrease in the second plantar flexion during initial swing, in knee flexion during the stance phase, in the rip range in sagittal plane and in the pelvic obliquity after HPOT treatment ($p<0.05$). Indicate improvement in bipedal locomotion.
Manikowaska, *et al*., 2013	Improved walking speed significantly after on HPOT session of 30 minutes ($p<0.05$).
Antunes, *et al*., 2016	Significant improve on the percentage of rolling phase and double support of the gait after HPOT treatment on the group that followed the walk-trot protocol ($p<0.05$).
Mutoh, *et al*., 2016	Significant improve on gait speed, step length, mean acceleration and horizontal/vertical displacement ratio after 2 years of HPOT ($p<0.05$).
Mutoh, *et al*., 2018	Gradual and significant increase in walking speed, stride length and mean acceleration during 10 mwt ($p<0.001$).

Evidence from Studies Investigating Spasticity and Muscle Activity in Children with Cerebral Palsy

Four studies evaluated spasticity and/or muscle activity (Lechner, *et al.*, 2003; McGibbon, *et al.*, 2009; Antunes, *et al.*, 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018). Two studies (Benda, McGibbon and Grant, 2003; McGibbon, *et al.*, 2009) that evaluated the effects of HPOT on muscle activity (asymmetry) were done by the same research group. Both of them used one group of CP individuals in the HPOT group and another group of CP in the barrel group. The muscle electrical activity was measured by Surface Electromyography.

Benda, McGibbon and Grant (2003) focussed on evaluating the immediate effect of an eight-minute-long HPOT session on the asymmetry of several muscles: C4 para-spinal, T12 para-spinal, posterior thoracic and lumbar and abductor muscles of upper tight. Fifteen participants were recruited, 7of them have received HPOT and 8 of them did 8 minutes sitting on a barrel. Results presented showed enhanced muscle symmetry of 64.6% after participants received HPOT, whilst to the barrel group the improvement was 12.8%, implying a significant reduction of muscle asymmetry on the HPOT group ($p<0.05$).

McGibbon, *et al.*, (2009) focused on the asymmetry of adductor muscle during walking and the study was divided in two phases. Phase I investigated the immediate effect of one 10-minute session of HPOT and compared to the immediate effect of 10-minute session of barrel-sitting on the adductor symmetry only. There was a statistically significant mean decrease of adductors asymmetry on the HPOT group when compared to baseline data and no significant change was found on the barrel group. Phase II investigated the long terms effect of HPOT on the asymmetry of hip adductor muscles during walking. Six children from the Phase I carried out to the Phase II and received 30 minutes once-weekly of HPOT for 12 weeks. Evaluations were done before Phase 1 (T1), prior to 12-week treatment (T2), end of treatment (T3) and after a period of 36 weeks after T1 (T4). At T3, four of six children have shown improvements on adductor asymmetry when walking, this improvement was maintained until T4 but none of the results were statistically significant on phase II.

The other two studies (Antunes, *et al.*, 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018) used the MAS to evaluate spasticity of hip adductors in both of their groups and have described a significant decrease of the spasticity as a result of both treatments.

Evidence from Studies Investigating the Kinematics of the Lower Limb in Children with CP

Kwon, *et al.*, (2011) and Rigby, *et al.*, (2017) investigated the kinematics parameters of the lower limb in response of HPOT treatment. Kwon, *et al.*, (2011) also evaluated pelvic and hip kinematics in the sagittal plane while walking. Sixteen children received HPOT + conventional physiotherapy and sixteen only the second. HPOT significantly improved average pelvic anterior tilt and pelvic anterior tilt at initial contact, stance phase.

Rigby, *et al.*, (2017) evaluated pelvic displacement during walking in a treadmill and during a sitting on simulated horseback riding equipment. The simulator was not used in the HPOT session, only in the evaluations. Measures were taken at baseline and after 8 weeks of HPOT and compared to control. During the horseback riding simulator evaluation that was no difference between control group and the group with CP, however there were no significant changes when baseline measures were compared to those after 8 weeks of treatment.

Evidence from Studies Investigating Body Function and Functional Performance in Children with CP

Eight studies evaluated functional performance/independence of children with CP after HPOT treatment (Haehl, Giuliani and Lewis, 1999; Casady and Nichols-Larsen, 2004; Frank, McCloskey and Dole, 2011; Silkwood-Sherer, *et al.,* 2012; Park, *et al.,* 2014; Champagne, Corriveau and Dugas, 2016; Moraes, *et al.*, 2016; Hsieh, *et al.,* 2016). Only one (Hsieh, *et al.,* 2016) have focused exclusively in this outcome. They have evaluated 14 children with CP that have undertaken HPOT treatment for 12 weeks, once a week for 30 minutes. Over the treatment, the frequency of impairment at moderate, severe and complete levels decreased in the Body Functions and Activities and Participant components of ICF-CY. Significant improvements were found in neuro-musculoskeletal and movement-related functions, muscle tone functions, involuntary movement reaction functions and play when compared to baseline ($p<0.05$).

Four studies (Haehl, Giuliani and Lewis, 1999; Casady and Nichols-Larsen, 2004; Park, *et al.,* 2014; Moraes, *et al.,* 2016) used the Paediatric Evaluation of Disability Inventory to assess functional performance and reported significant improvement on functional performance after HPOT.

Champagne, Corriveau and Dugas, (2016) have used Bruininks-Oseretski Test of Motor Proficiency – Short Form that looks specifically at function based on motor performances and reported a significant improvement on fine motor precision, balance and strength, when compared baseline and immediately after intervention ($p<0.05$). Silkwood-Sherer, *et al.*, (2012) used the Activities Scale for Kids Performance reporting not only a significant improvement on this scale after intervention, but also a significant association between it and the PBBS post-intervention scores ($p<0.05$). Finally, Frank, *et al.*, (2011) used the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (and investigated self-perceived qualities of children up to the age of 7 years old reporting positive, but not significant changes.

4.4. Discussion

General Findings

This review evaluated studies that examined the effect of HPOT on the physical abilities (balance, posture, gross motor function, gait, functional performance and muscle activity) of children with CP. The quality of 32 studies was appraised, using the criteria guideline created by Law, *et al.*, (1998), that have met the inclusion criteria. In this study, a statistical analysis of the results was not performed due to variability of treatment protocol (duration, intensity and frequency of HPOT sessions), patients' characteristics (CP diagnosis and classification used) and different types of evaluations.

Despite using only HPOT as a descriptor in Mesh 51 papers were identified to be using EAT or other therapies, which were then excluded during the screening process, mainly because those papers have used "hippotherapy" as a key word. Although physiotherapy associations such as AHA, CPTRH and ANDE have defined the concepts of HPOT, EAT and THR, it seems that there is still inappropriate use of these terms in the research literature with incorrect definitions being used in study descriptions (Debuse, Chandler and Gibb, 2005). The aim of this study was specifically to review the research literature that correctly applied the term HPOT when describing what they did. This study does not in any way presume that THR or other types of EAT is less effective than HPOT. They may produce similar or different effects, and further studies could be carried out to investigate the effects of other types of EAT in enhancing physical functioning in neuro-musculoskeletal impaired individuals.

Studies included in this review have investigated the effects of HPOT in gross motor function, balance and posture, gait parameters, kinematics and functional performance of children with spastic, ataxic and dyskinetic CP. Population across the studies were not always homogenous with regards to the type of CP, nor when considering the GMFCS levels of the subjects included. Furthermore, studies also varied in the frequency and duration of HPOT sessions, as well in the duration of the study.

The heterogeneity of participant disability classification/description, length of session and session frequency has been discussed by the previous literature reviews and studies involving EAT and HPOT (Debuse, Chandler and Gibb, 2005; Sterba, *et al.*, 2007; Herrero, *et al.*, 2011; Zadnikar and Kastrin, 2011; Tseng, Chen and Tam, 2013). These attributes have been used in the reviews as arguments to underrate the effectiveness of HPOT in physically impaired individuals, especially in the CP population. More studies have been recommended, however, it is not clear on the literature how long, neither how large those studies should be. There have not been discussed why they would need to be larger or longer, if some randomized studies, such as (Chang, *et al.*, 2012; Park, *et al.*, 2014; Known, *et al.*, 2015; Champagne, Corriveau and Dugas, 2016) have brought statistically significant results of the effect of HPOT by applying it for 8 weeks to 10 weeks.

This review could not find enough evidence to support exactly how long HPOT treatment should be carried out to be effective, and perhaps there is not a correct answer to that as in practice the therapist in charge of the sessions should assess individually the needs of the subject undertaking HPOT. However, there is evidence to suggest a recommendation for HPOT treatment to last a period of between 8 and 12 weeks, if wishing to enhance physical outcomes such as balance, posture, gait parameters and gross motor function of children with CP. No studies examined how long HPOT is being carried out in clinical practice, such knowledge, if gathered, could be used in further study protocols.

According to the WHO, “The rehabilitation of people with disabilities is a process aimed at enabling them to reach and maintain their optimal physical, sensory, intellectual, psychological and social functional levels and it provides disabled people with the tools they need to attain independence and self-determination”. The rehabilitation process should enable a disabled person to reach and maintain their optimal functional levels. The variety of symptoms across subjects with CP makes it very difficult to prescribe a unique pattern or standard for a specific rehabilitation strategy, taking in consideration that each individual might reach this optimal functional level at different speeds, with different types of exercises or rehabilitation techniques offered at different frequency and intensity. Those factors may explain why there does not appear to be a consistent duration and frequency of intervention in research studies thereby leading to uncertainty as to how long, how often and which intensity a therapy should be done to actually achieve a favourable outcome (Debuse, 2005; World Health Organization, 2011).

Regarding participant heterogeneity, as reported above, every person will have their own particularities and own impairments, and every impairment will have different levels and different consequences on affecting body functioning. Even across children with spastic CP the presentation of the condition and the impairments it will cause will vary from one individual to another.

These make it very tricky to analyse an effectiveness of therapy based on an overall score of a group, and although statistically speaking, there were demonstrated some positive effects of HPOT in determine physical outcomes, when compared disable treated individuals with non-disable or non- HPOT treated individuals, when talking on a clinical environment it is still need to be considered by doctors and therapist, individually, whether that patient would probably benefit or not of this technique (Debuse, Chandler and Gibb, 2005; Tseng, Chen and Tam, 2013).

Hippotherapy Effects in Gross Motor Function Measure Scores

Previous literature reviews (Herrero, *et al.*, 2011; Sterba, *et al.*, 2007; Whalen and Case-Smith, 2012 and Tseng, Chen and Tam, 2013) have evaluated the effect of HPOT on GMFM scores. However, only Whalen and Case-Smith, (2012) have concluded that there is evidence suggests that HPOT for 45 minutes, once a week for at least 8-10 weeks of treatment result in significant improvements on GMFM scores, specifically dimension E.

The last study included by Tseng, Chen and Tam (2013) was published in 2011, by Known, *et al*., (2011) and there were two questions raised by the authors of the meta-analysis: Does EAT significantly improve GMFM? Is GMFM sensitive enough to evaluate an EAT outcome? As an update this review added four studies more that could help on the evidence of effectiveness of HPOT in GMFM and used only studies that were looking in the effect of HPOT.

The results of this systematic review may not directly satisfy the questions raised previously, however the studies that were added at this present literature review reported not only statistically significant improvements on the GMFM scores, especially on dimensions D and E, but they were also appraised as "excellent" by the Law, *et al.*, (1998) criteria.

Based on the findings reported in this systematic review of the literature there is evidence to suggest that HPOT is very likely to generate improvements on GMFM scores after at least 8 weeks of treatment in children with CP, GMFCS levels I, II, III and IV. Nevertheless, only one study presented results separating the individuals across levels, which may generate bias in the results reported in the studies above, as a child in level I probably will achieve 100% of the scores or very close to that on dimensions A and B, and would be able to achieve complete action in all dimensions, as a child in level I is able to walk and perform gross motor tasks independently. A child at level IV usually will need support when sitting and is likely to need a wheelchair to be transported. These variances, therefore, would generate a great difference on the tasks performed by each child, a child on Level I will always have a better score and, therefore, more likely to complete a motor task in all dimensions than a child in level IV or V. It is then recommended that the results obtained by analysing GMFM are separated by the GMFCS levels, to reduce bias and error on data analysis.

In addition, it is recommended further studies that would correlate the scores obtained in the GMFM with other components of functionality and quality of life, to enhance the clinical implications of HPOT.

Hippotherapy Effects on Balance and Posture

Improvements on dynamic and static balance, and reduction of CoP displacement in static postures were observed in the studies presented in this review (Hamill, Washington and White, 2007; Kwon, *et al.*, 2011; Chang, *et al.*, 2012; Silkwood-Sherer, *et al.*, 2012; Lee, Kim and Na, 2014; Mackow, *et al.*, 2014; Kwon, *et al.*, 2015; Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016; Moraes, *et al.*, 2016)

A child with CP may lack control of the activation of core muscles to control movements of the trunk or body relative to a moving surface, to keep the equilibrium (Terada, *et al.*, 2004; Pantal, *et al.*, 2009). Researchers advocate that the child mounting the horse passively combined with the exercises led by the PT learn to anticipate actions and to activate the musculature. This learnt reaction could lead to reduce the displacement of CoP while on the horse. This would then be translated on improvements on static and dynamic balance, as demonstrated by few studies using a variety of tools such as the Paediatric Berg Scales, force plate and sitting assessment scale (Kwon, *et al.*, 2015; Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016; Moraes, *et al.*, 2016).

The positive responses on balance and postural improvements, demonstrated through improvements in paediatric Berg scale scores and the decrease in postural sways and asymmetries, could indicate that HPOT may be, somehow, inducing responses from the subject that would require a posture and balance adjustment when riding, and these adjustments seem to be persistent when the child is out of the horse.

This literature does not provide evidence that explains the mechanisms of how the horse may be creating these responses, however our findings help to increase the considerations that the multidimensional movement of the horse in conjunction to the neuromotor techniques do require responses from the subject as the subject's centre of gravity is displaced, by rhythmical movements promoted by the horse walk (Sterba, *et al.*, 2007; El-Meniawy, *et al.,* 2012).

Hippotherapy Effects on Gait Components, Muscle Activity and Kinematics of the Lower Limb

A total of seventy children used in studies included in this review have received HPOT and have had spatiotemporal and kinematics gait patterns of gait evaluated after the therapy. The parameters evaluated were right/left swing, double support, step and stride length, pelvic anterior tilt at initial contact, pelvic range of motion, maximal hip extension at terminal stance, hip flexion at initial contact and range of hip flexion/extension, plantar and knee flexion. The results of the studies indicated changes in walking speed and plantar flexion, after HPOT, suggesting this could be recommended to help improve bipedal locomotion. The studies evaluating gait were quite variable within each other with respect to measurements, duration of treatment and time and frequency of sessions, which make it complicated the congregate these studies in one evaluation and consider them as strong body of evidence for the effect of HPOT in improving gait patterns. These results met what was previously described by Tseng, Chen and Tam, (2013), that there was not enough to statistically evidence the effectiveness of HPOT in gait patterns on CP population.

Hippotherapy Effects on Functional Performance

Despite all methodological discrepancies among the studies that were extensively discussed above, authors of all studies suggested that HPOT can be beneficial to enhance functional performance and participation. Furthermore, two studies (Casady and Nichols-Larsen, 2004; Silkwood-Sherer, *et al.*, 2012) have also reported that there is a strong relationship between gross motor function and functionality and between balance and functionality.

4.5. Limitations of the Literature Review

This systematic review included only studies that fully met the inclusion criteria, which lead to the exclusion of 58 studies that were not in English, 50 studies that were involving other type of EAT or conventional physiotherapy and 12 evaluating different effects from the ones proposed by this study. This could indicate some loss of important data by excluding these studies, as i) studies published in other languages may have as same or better quality as the ones published in English, and they could have brought similar or different results that could indicate a change on our discussion; ii) as discussed above, the use of incorrect terms when talking about HPOT, could led to an exclusion of study for only being not clear which type of EAT they were using. iii) There may be there different outcomes that HPOT could be beneficial and that is not being considered by this study.

4.6. Conclusions of the Literature Review

This systematic literature review therefore concludes that there is evidence to suggest that HPOT can be beneficial on improving gross motor function, balance and functional performance of children with CP. However, it is clear that there are important methodological discrepancies among the studies, which may generate bias and error on the data analysis. These methodological differences can lead to the question of whether the results presented by those studies can truly be translated to practice.

Furthermore, this review also highlighted the difficulty of recruiting a homogenous sample of children with CP, due to the variety of classifications, symptoms, areas of lesion and severity. As mention previously, this also is a cause of concern, as children with CP with different classification according to the motor ability and severity of the condition will respond differently to any type o rehabilitation technique and they will also have different needs and expectations regard what they can achieve.

4.7. Implications for Future Work

This study highlights the need and importance for a study that would investigate the relationship of the possible positive effects of HPOT on physical impairments and body function and, furthermore, it indicates the need to understand how HPOT is being carried out on practices and clinics, outside of research environment, to better understand their perception and performance regard this therapy.

This review helped to identify key gaps in knowledge in the present literature:

- The lack of consensus on methods of evaluation in research studies, and how this compares with HPOT practice;
- The lack of consensus on frequency and duration of the therapeutic intervention in the literature, and how this compares with HPOT practice
- Limited evidence of HPOT effect on GMFM according to different levels of GMFCS in children with spastic CP;
- Limited evidence of HPOT's effect on dynamic balance while mounting the horse passively and quality of life;
- Limited evidence of HPOT effects on spasticity in the lower limb and absent evidence of its effect on spasticity on the upper limb;
- Limited evidence on the participants' physical response to the horse's stimuli;

To tackle the gap in knowledge on the lack of consensus on methods of evaluation and duration/frequency of treatment a survey with physiotherapists in England and Brazil was developed and its results will be presented in chapter 4 to investigate if HPOT practice is similar across the two different countries and different HPOT schools.

To tackle the gap in knowledge, regard the effects of HPOT in gross motor function, balance, spasticity and quality of life, pre/post designed prospective studies will take place and be presented in chapter 5 to 8. Those chapter will also use the evidence acquired in chapter 4 (the survey).

5. Chapter 5: An Exploratory Survey of the Characteristics of Hippotherapy Sessions to Treat Children with Cerebral Palsy

This chapter presents the results of a survey that sought the perspective of physiotherapists with regards to the efficacy of HPOT when used to physically rehabilitate children with CP.

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5.1. Introduction and Survey Rationale

Evidence of Hippotherapy

Published literature reviews (Sterba, 2007; Tseng, Chen and Tam, 2013) reported that there is a lack of consensus in the literature regarding what physical outcomes are expected to improve after HPOT treatment and how these outcomes should be evaluated. They commented on the quality of a large proportion of the published studies on HPOT for participants with CP (Benda, McGibbon and Grant (2003; Debuse, Chandler and Gibb, 2005; Sterba, *et al.*, 2007; Tseng, Chen and Tam, 2013), due to the differences on methodology and protocol of those studies. The authors of the reviews have concluded that there remains a lack of consistent and strong evidence for the clinical significance of the intervention (e.g. how the intervention influenced the patient to bring about the improvement).

Studies included in the published literature reviews (Sterba, *et al.*, 2007; Zadnikar and Kastrin, 2011; Herrero Gallego, *et al.*, 2012; Tseng, Chen and Tam, 2013) cited papers where treatment protocols appear to examine a research question rather than replicating typical treatment regimes. No studies investigated the practitioners' perspective of the effects or conduct of HPOT were included in the reviews. Furthermore, the reviews criticism focused on the differences of how the sessions were carried out, regard its time, frequency and duration and if the treatment was being evaluated from both a practitioner and a scientific perspective (Debuse, Chandler and Gibb, 2005; Sterba, *et al*., 2007; Frank, *et al*., 2011; Tseng, Chen and Tam, 2013).

To date, only two published studies appear to focus on the perspective of therapists performing HPOT (Debuse, Chandler and Gibb, 2005; Cerquozzi, *et al*., 2007). Cerquozzi *et al.*, (2007) examined the occupational therapists (OTs) role in delivering HPOT (Cerquozzi, *et al*., 2007) and concluded that OT's use the movement and activities on the horse to focus on multiple interventions, focusing on enhancing motor and cognitive skills. Debuse, Chandler and Gibb (2005) examined the views of British and Germans PT's on the management of HPOT. This study cast some light on the perception of what PT's regard as the main physical effects of HPOT and identified how those outcomes were evaluated. Furthermore, the study also provided some insights about HPOT practice in the UK and in Germany, comparing the perceptions, the training and method of evaluations used by PTs in both countries.

Whilst, Debuse, Chandler and Gibb (2005) contributed to the knowledge base supporting HPOT practice, some questions were not answered, such as whether sessions possessed similar or varied characteristics, for instance in the type of equipment used, individual session frequency and duration, and duration of the treatment programme. Furthermore, the study indicated that differences exist across practitioners in Germany and in the UK. Nevertheless, when looking at the perceived benefits of HPOT across practitioners there was generally agreement across practitioners in both countries (Germany and the UK). However, the authors concluded that there was variable use of appropriate outcome measures to evaluate these effects (Debuse, Chandler and Gibb, 2005), similarly to the findings of the systematic reviews discussed on the previous chapter 2 and 3, that the evidence for HPOT being beneficial is weak due to the variety on the studies' protocols (Benda, McGibbon and Grant, 2003; Sterba, *et al*., 2007; Tseng, Chen and Tam, 2013).

The systematic review presented in the previous chapter 3 indicated that HPOT may have positive effects on GMFM scores (Chang, *et al.*, 2012; Park, *et al.*, 2014;

Known, *et al.*, 2015), balance (Kwon, *et al.*, 2011; Hyun Jung, *et al.*, 2012; Silkwood-Sherer, *et al.*, 2012; Lee, Kim and Na, 2014; Mackow, *et al.*, 2014), gait (Kwon, *et al.*, 2011; Fízková, *et al.*, 2013; Manikowska, *et al.*, 2013) and spasticity (Lechner, *et al.*, 2003; McGibbon, *et al.*, 2009) of children with CP. However, in line with the conclusions of Debuse, Chandler and Gibb (2005), those studies were using a variety of validated measurements to evaluate the same outcome, sometimes without further justification for the measurements chosen, which make it more difficult to discuss the effects of HPOT.

Moreover, the studies investigating the physical effects of HPOT in children with CP varied in duration, one-time sessions to two years, duration of sessions varying from 5 to 60 minutes and frequency varying from one to three times a week. This is a potential issue when you need to compare the effects of HPOT on a determined physical outcome, as the variation of the duration of treatment and the duration of sessions may cause different effects, with the therapy being efficient. This variance was further aggravated by the lack of justification or critical thinking around the use of these frequencies or duration of treatment, with many authors cross-referencing previous research without criticizing the approach chosen to regard the protocol of treatment.

Differences in evaluation methods or even on the type of equipment being used during the HPOT were also potential issues highlighted by Tseng, Chen and Tam, (2013). If studies are evaluating the same outcomes with different measurements it is challenging to perform a meta-analysis of the data when comparing different studies. Furthermore, when considering the possible implications research may have on clinical practice, it can be very challenging for a practitioner to decide what is the most sensible tool to evaluate the progress of their clients or even the best way to carry out the HPOT sessions themselves. These variabilities can contribute to a gap between research and practice, which may be lying around the applicability of the findings in research due to use of protocols that not always represents the tools, the reality and the access of practitioners providing care (Kazdin, 2008). In addition, there is a lack of studies investigating if those differences among research papers also happen among PTs.

The purpose of research is to contribute evidence to the knowledge base by investigating how physiotherapists are conducting HPOT in their practices. This is important because if there are similarity among PTs, a research study with a protocol based on what is being done by practitioners would be a great contribution for the knowledge base of HPOT. As discussed above, published systematic reviews highlight the lack of consensus among researchers and it would be interesting to assess if this also happens among physiotherapists. The findings that will be presented in this chapter will consider the practitioners' voice and expertise, considering the process of individual care and the methods of evaluation, as contributors of the construction of knowledge (Mann and Darrah, 2006; Kazdin, 2008; Shaw, Connell and Zecezic, 2010) as observed in the figure 5.1.

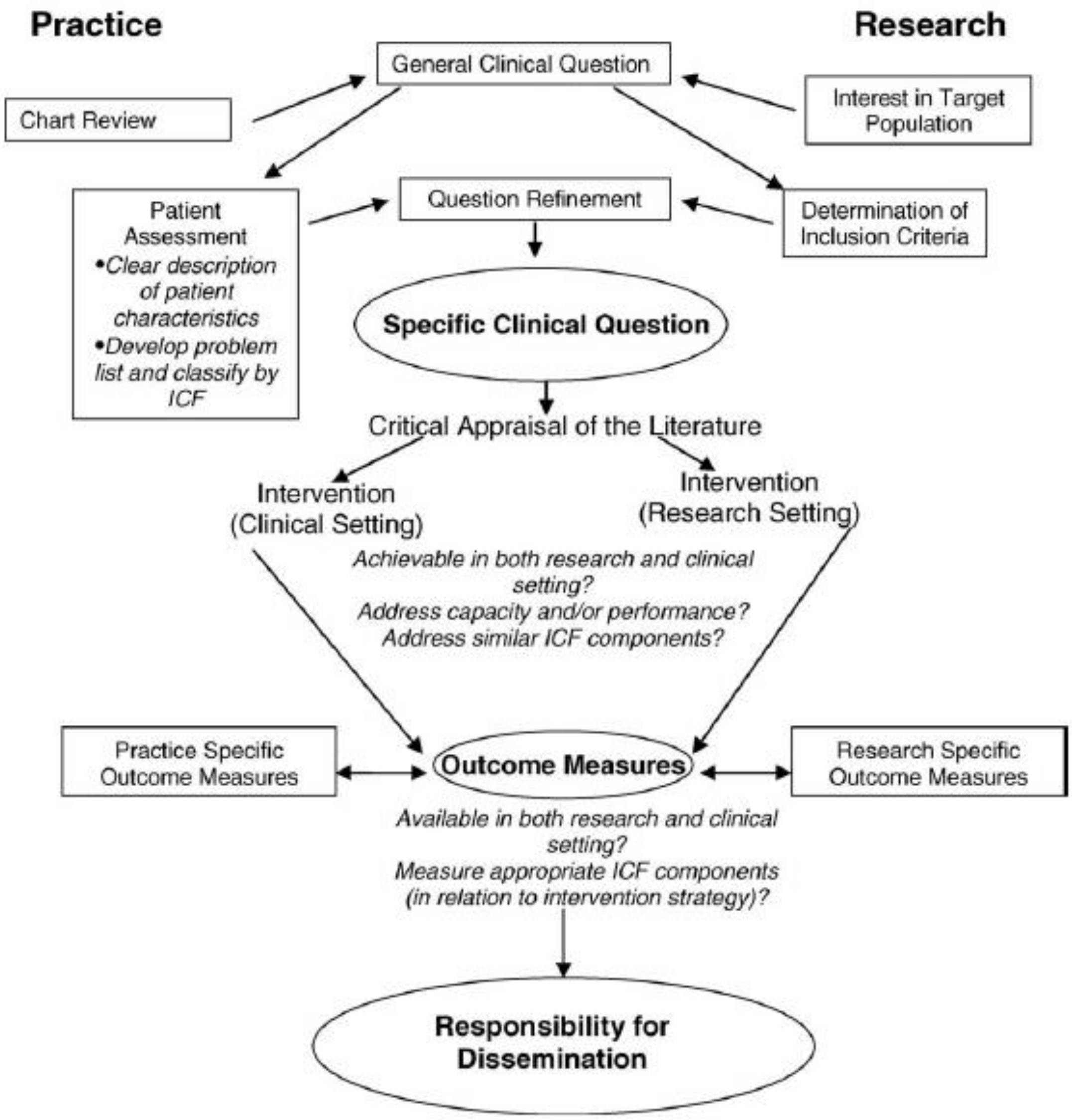

Figure 5.1. Research and Clinical Practice Integration.

Source: Mann and Darrah, (2006).

Considering the above, it is important to consider practitioners' views and their actual practice when designing a protocol of research to evaluate the effects of a specific therapy in a specified population, in the case of this thesis the effect of HPOT on children with CP. The findings for this chapter, combined with conclusions arising from chapter 3, will influence the design of the protocol of the experimental studies presented in chapters 5-8.

Hippotherapy in Brazil and in the United Kingdom

Debuse, Chandler and Gibb (2005) have previously compared PT's perception of HPOT in the UK and in Germany. It was the first time such study was carried out. The authors chose two countries as sample locations, as HPOT may be practised differently in different parts of the world. The results of their study highlighted considerable differences between HPOT practice in the UK and Germany, agreeing with previous critiques raised above in the differences of protocol on research. However, Debuse, Chandler and Gibb (2005) have shown that PTs in both countries seem to agree with regards to their perception of HPOT having a positive effect on regulating muscle tone, improving postural control and producing psychological benefits in children with CP. Nevertheless, those observed effects were being evaluated with inadequate measurement.

Being the first of its kind, the Debuse, Chandler and Gibb (2005) study is of great importance in understanding how PTs do HPOT in different countries and how they perceive its effects. However, the fact the PTs are not using validated measurement it raised the question to whether they are really seeing those effects mentioned above in the first place. Furthermore, only 13% of the German PTs were assessed, and the UK is not a lead country in this kind of treatment and research, which makes it difficult to extrapolate the conclusions to other regions.

Thus, there is still scope to understand more about PTs doing HPOT, considering the differences in protocols across studies published after Debuse, Chandler and Gibb (2005) it is also notable that not a single study investigating the effects of HPOT in children with CP was developed or published in the UK, but originated in other countries including Brazil, Germany, Korea, Spain and USA instead. Despite the UK not being the lead in research for HPOT, nor the leader in conducting this type of therapy, there is still value in understanding more of how practitioners conduct HPOT here, particularly because the experimental studies presented in this thesis investigate the physical effects of HPOT in children with CP in the UK. Furthermore, it is also of interest to compare HPOT practices with other countries as variation on practice could influence how effective HPOT is.

A deliberate choice was made about what would be the second country to compare to the UK, and the country chosen was Brazil for three specific reasons:

i) It appears that HPOT is more widely used in Brazil than in the UK, with over 1000 PTs qualified to perform HPOT. Furthermore, HPOT research in Brazil has been growing substantially throughout the years, with a couple of studies published in English and matching the inclusion criteria of the systematic review (Antunes, *et al.*, 2016 and Moraes, *et al.*, 2016). Furthermore, the systematic search on the databases used in the literature review with the Mesh terms "Hippotherapy AND Cerebral Palsy" (in English) yelled 7 Brazilian studies in Scopus[10] and 4 in Cinahl[11];

ii) Due to language and the expertise of the researcher that received the physiotherapy qualification and did the internship in HPOT back in Brazil. As previously stated, several other countries have published studies in HPOT (Germany, Korea, Spain, USA), however, the researcher only have had a physiotherapy and an HPOT experience in Brazil, which were crucial on the translation of the English survey to the Portuguese survey and in the analysis of the results;

iii) This thesis was funded and supported by a Research Program of the Brazilian Government, which, among of its aims, hoped to straighten the research

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[10] List of papers published from Brazil in Scopus database: https://www.scopus.com/results/results.uri?sort=plf-f&src=s&st1=hippotherapy+AND+cerebral+palsy+&nlo=&nlr=&nls=&sid=d7b54f499ae630e524019f13ea933cc6&sot=b&sdt=cl&cluster=scoaffilctry%2c%22Brazil%22%2ct&sl=47&s=TITLE-ABS-KEY%28hippotherapy+AND+cerebral+palsy+%29&origin=resultslist&zone=leftSideBar&editSaveSearch=&txGid=3e53748f5f83d8b17b5330b99b5b8911

[11] List of papers published from Brazil in Cinahl Database: http://web.b.ebscohost.com/ehost/results?vid=3&sid=01824f87-9125-4799-9ff7-a26f476fb97b%40sessionmgr102&bquery=hippotherapy+AND+cerebral+palsy&bdata=JmRiPXJ6aCZ0eXBlPTAmc2l0ZT1laG9zdC1saXZl

relationship between the UK and Brazil. The student considered that increasing knowledge and understanding of how HPOT was being carried out in Brazil was extremely important towards fulfilling the aim of the program.

This evidence helped designed the two main aims of the survey, which was to increase knowledge and understanding about similarities and differences in HPOT practice among practitioners, and to influence the design of further studies in thesis.

5.2. Aim of the Study

The aim of this study to increase knowledge and understanding of how HPOT is practiced by physiotherapists in the UK and in Brazil when rehabilitating children with CP considering their clinical practice.

5.3. Hypothesis of the Study

It was hypothesized that surveying the perspective of physiotherapists regard the effects of HPOT in the rehabilitation process of children with CP could help to increase the understanding of the therapy itself and to drive the development of the research question and methodology of the experimental chapter.

5.4. Research Questions

Main Research Question

What are the characteristics of Hippotherapy practiced in the UK and in Brazil and what are the hippotherapy outcomes in the physical rehabilitation process of children with CP? A question directed to physiotherapists practicing HPOT in the UK and in Brazil.

Research Questions on the Specific Sub-sessions of the Survey

In order to answer the main research question of this study, the survey applied to physiotherapists was divided into three sections, as described below.

Section 1: How are hippotherapy sessions are conducted in the UK and in Brazil?

The questions focussed on the type of equipment used on the horse (saddle / HPOT pad as they may influence the positioning of the subject and therefore the translation of the equine gait to the human lower torso) and the use of a horse handler and side-walker.

- Are PT's in the UK and in Brazil following the AHA guidelines?
- What equipment are they using? Why?

Section 2: What are the characteristics of hippotherapy sessions?

- How long does a HPOT session typically last in Brazil and in the UK?
- How often do patients attend HPOT sessions per week in each country?

Section 3: What are the physical outcomes physiotherapists are expecting to improve after hippotherapy treatment and how do they evaluate these improvements?

This section focused on the physical outcomes that might be expected by the PTs after HPOT treatment. As mentioned above, previous literature has shown possible outcomes (Sterba, *et al.*, 2007, Chen and Tam, 2013). The pre-coded answers for forms of evaluating one outcome or another, were based on what has been used most in the literature, e.g. balance is most often evaluated by the use of the Berg scale or force plate (Chang, Chen and Huang, 2011; Kwon, *et al.*, 2011; Kang, Jung and Yu, 2012).

- Is there a consensus regarding the type of physical outcome HPOT treatment is considered able to improve in children with CP?
- What are the methods used to evaluate the effectiveness of HPOT?

5.5. Methodology of the Survey

Survey Structure

Pilot Study

A pilot of the survey, was conducted before the survey was launched to all physiotherapists. A form to be fulfilled was sent to physiotherapists in the UK in order to gather their opinion on the structured of the survey (Appendix 4). After the pilot, the suggestion of the therapists regards the characteristics of some questions was considered. Initially there were some open questions such as question 11 and 40 (Appendix 5). The surveyed physiotherapists have suggesting avoiding “open” questions, as it would give an infinite types of answers and the its analysis would not be sensitive enough to answer the research questions, therefore a decision was made to change all the questions to closed-ended, so the survey would supply only quantitative answers. Some English issues were found and corrected and to the questions where participants were asking about how they would evaluate an outcome the option “other” was added with the possibility of the participant indicate a different method if wished. The physiotherapists surveyed in the pilot version also raised the potential risk of the absence of clear concept of what is HPOT and how to define Cerebral Palsy, as these terms sometimes appeared differently in the literature. A decision was then made to include definitions of these terms in the beginning of the survey, as shown on the item below.

The pilot was applied to test the quality of the questions, not to find results, so there was no data analysis from the pilot answers.

The English version of survey was then translated to Portuguese, by a Brazilian Physiotherapist, the researcher of this study. The physiotherapist had practice in HPOT in Brazil, and had the ability to not only translate accurately and culturally the survey to be applied to Brazilian physiotherapists. The Portuguese version was checked for

Portuguese mistakes and suggestions by a Brazilian Physiotherapist lecturer. No formal report was made.

Although, it is best practice that the translation would have been done by two persons, there was no option within the team that would be able to write, read and speak both languages. However, and as described above, the translation was made by a native Portuguese speaker that has worked with HPOT in Brazil.

Semi-Structured Survey and its Sections

This study employed a semi-structured survey directed to physiotherapists who are involved in delivering HPOT to children with CP in two different countries, the United Kingdom and Brazil.

An online survey software, Qualtrics®, was used to deliver the survey. Hippotherapy centres and organisations co-ordinating the delivery of this therapy in the countries cited above were contacted and a request was made to disseminate the survey within their organisations. The survey was also advertised through social media, in specific interest groups for physiotherapy and HPOT. An English and a Portuguese version were provided to reflect the official languages spoken in the targeted countries. The survey was designed taking into consideration directions given by Breakwell, Smith and Wright (2012) about the use of correct terminology to avoid any ambiguity of day-to-day language and also to be sure that responders would understand key definitions influencing inclusion and exclusion criteria for participants. For this reason, at the start of the survey the following descriptions of CP and AHA definition of hippotherapy were given:

"Hippotherapy refers to the incorporation of equine movement by physical therapy professionals. These professionals use the equine movement within their evidence-based practice and clinical reasoning to engage the sensorimotor and neuromotor systems of their patients to create functional change. Used with other neuromotor and sensorimotor techniques, hippotherapy is part of a patient's integrated plan of care

(Modified definition based on the (American Hippotherapy Association, 2015a).

"Cerebral palsy is considered a neurological disorder caused by a non-progressive brain injury or malformation that occurs while the child's brain is under development. Cerebral palsy primarily affects body movement and muscle coordination (Hankins and Speer, 2003; CerebralPalsy.org, 2015)."

At the start of the survey, potential participants were clearly directed that the inclusion criteria for participation was to be a registered Physiotherapist delivering HPOT. It was explained that it was not the focus of this survey to investigate the practice of professionals such as Occupational Therapists or Psychologists (other professionals that may be using HPOT), or those involved with Equine Assisted Therapy, and they were politely declined and thanked for their interest.

The participant information sheet (PIS) explained the scope of the survey. Its aims were given, and the respondents were informed that their participation would be completely anonymous and voluntary. It was also explained through the PIS that data could not be withdrawn once the survey was submitted as names were not requested to ensure anonymity.

Details of the design and aims of each session are described below and the survey is presented in Appendix 5.

Section I – How are Hippotherapy Sessions Conducted?

Section I was comprised of eight closed-ended questions. There were four dichotomous questions ("yes or no" style) and four multiple-choice questions. One of the "yes or no" questions was also a contingency question, which means that a second question was generated according to a specific answer (Sincero, 2012a). In the multiple-choice questions participants had to choose just one answer that most applied to their routine, and in two of them it was given to the participant the option to choose "other" and to input a different answer that may be different from the ones pre-coded by the researcher (Breakwell, Smith and Wright, 2012; Sincero, 2012a; Sincero, 2012b). To avoid any confusion regard the types of equipment and helpers a definition was given for each one on the beginning of the section I, as instructed by (Breakwell, Smith and Wright, 2012). The definitions are as below (directly extracted from the survey):

"For the purpose of this survey, a 'saddle' is defined as "a seat fastened on the back of a horse or other animal for riding, typically made of leather and raised at the front and rear". A 'bareback pad' is defined as a soft pad which conforms to the back of the horse and does not influence the position of the rider.

Also consider the follow definitions:
Side-walker: *'An individual who has received specific training to assist a therapist during treatment sessions. Their responsibilities include patient safety on and off the horse and assistance during therapy or therapeutic interventions'.*
Horse handler: *'Indicates the individual preparing and handling the horse prior to and during a treatment session .They respond to directions by the therapist to alter the movement of the horse to cause an adaptive response in the client during hippotherapy' (American Hippotherapy Association, 2015b; Oxford Dictionary, 2015)."*

In this section it was important to elucidate if the therapists are making use of the correct equipment, in order to protect the horse, the patient and the therapist (American Hippotherapy Association, 2015b). If the PT follows AHA guidelines, the patient should not lead the horse and the therapist should be involved in delivering the therapy itself, meaning that a horse handler and a side-walker are then necessary to ensure the therapy is conducted in the safest way.

Section II – Characteristics of Hippotherapy Sessions

This section of the survey comprised of six closed-ended questions. There was one contingency question ("yes or no" style) and a subsequent question to be answered only if the answer of the question was "yes" (Sincero, 2012a). There were three quantifiable questions, in which participants had to choose how long or how often they do a significant approach. Following the directions published by Breakwell, Smith and Wright, (2012) care was taken to not use any ambiguous terms, such as frequently, often or never. For example, for session duration categories such as "30 minutes" or "once a week" were offered. The remaining two questions were multiple choice with the option of ticking all that apply to the specific situation.

This section was built to elucidate the typical format of HPOT sessions, including how long and often they should be and how long and often the PTs are actually doing it and to also cover what are the main group of exercises they often focus on during their therapy sessions, as this all could generate different effects. As previously discussed in the literature reviews investigating the effects of HPOT in children with CP, there are differences in the length of HPOT sessions and the frequency of HPOT sessions (Sterba, *et al.*, 2007; Herrero, *et al.,* 2011; Zadnikar, *et al.*, 2011; Whalen and Case-Smith, 2012; Tseng, Chen and Tam, 2013). This section of the survey aimed to elucidate if this divergence also happens among practitioners and/or if there is some agreement between practitioners and what is being used the most in the literature.

Section III – Hippotherapy Physical Outcomes as Expected by Practising Physiotherapists

There were 24 closed-ended format questions, four of them were dichotomous questions ('yes or no' format), two were contingency questions, one was a scaled question i.e. a question where the participants would be required to rate the answers, three matrix questions – questions that are arranged together for having the same type of answer (Sincero, 2012a). The remaining questions were multiple choice style questions with the option of input of an "other" answer if the participant did not agree with any of the pre-coded answers given.

Questions target how PTs evaluate the HPOT sessions and which of those outcomes: balance, posture, gross motor function, gait, spasticity, muscle strength, functional capacity, proprioception and motor control they expect to improve after treatment.

Sample Size Calculation

In order to calculate the potential sample size (i.e. the number if professionals conducting HPOT sessions) the respective professional associations in both countries were contacted by email and telephone, the Chartered Society of Physiotherapy (CSP) and CPTRH in the United Kingdom, and the Brazilian Charter of Physiotherapists and the *Associacao Nacional de Equoterapia* (ANDE), which is the Brazilian National Association of Hippotherapy. Unfortunately, none of the institutions had the register of how many professionals are currently practising HPOT.

To calculate the target sample size we have used the equation below (Equation 5.1) (Breakwell, Smith and Wright, 2012):

Equation 5.1. Sample Size Calculation

$$n = \frac{\frac{Z^2 . \rho . (1-\rho)}{e^2}}{1 + \frac{Z^2 . \rho . (1-\rho)}{e^2 . N}}$$

Where:

η= sample size; N= total population; Z= z-score = 1.96 (95%); p= standard deviation of 0.5

e= margin error of 0.05.

As it was not possible to access to the exact number of physiotherapists qualified to work with HPOT in both countries, a decision was made to make calculations as explained below.

For the Brazilian Population of Physiotherapists Working with Hippotherapy

For the Brazilian population of physiotherapists, from the chartered of physiotherapy website it was found that 1,794 PTs have completed the Brazilian HPOT course. Completing the HPOT course does not necessarily mean the therapists were doing HPOT at the moment of the study, neither it means that they were working with children with CP. Therefore, we proceed to look how many HPOT centres were registered in the Brazilian Association of physiotherapists, only 255 were available.

An attempt was made to contact all the 255 centres in Brazil, and it was found that 10 centres did not exist anymore and that only 90 centres, out of the remain 245 have had their contacts available throughout websites, social media, e-mail accounts and telephone.

Of those eight have declared they did not have a PT on their team, which left 82 possible centres with at least one PT. Therefore, the calculation based on the Equation 5.1 was done again based on an N of 82 possible respondents, given a number of 67 expected respondents to be considered representative.

Considering that each centre would have at least 1 physiotherapist (PT) working with HPOT (N=82) and following the equation 5.1:

$N = \frac{384.16}{5.68}$, therefore N = 67 respondents considering e=0.05 and confidence of 95%.

For the United Kingdom based Physiotherapists Working with Hippotherapy

In the UK, due to data protection concerns, the UK Chartered Society of Physiotherapy were not able to give a number of how many physiotherapists practice in the UK, therefore, a decision was made to use the same number given by Debuse, Chandler and Gibb, (2005) which was 21 PT qualified in HPOT (Debuse, Chandler and Gibb, 2005). It is important to highlight here that it was not possible to know for sure if all the 21 therapists were still working with HPOT whilst the survey was being conduct neither that they were working with children with CP.

Considering N=21 (Debuse, Chandler and Gibb, 2005).

$n = \frac{384.16}{19.293}$, therefore $n = 20$ respondents considering e=0.05 and confidence of 95%.

Consequently, for the survey presented in Portuguese the target was for 67 respondents to complete it fully, while for the English version of it, the target was to obtain at least 20 responses.

Data Extraction and Statistical Analysis

Data Extraction

Data was extracted from Qualtrics® in an Excel® format and descriptive statistics were produced. Some of the statements presented were directly transcribed from the survey data with no changes and as the survey was also responded to by speakers of the Portuguese language, statements were directly translated to English, following the same rules. The statements given to any "other" question in Portuguese will be directly translated to English to be presented in this study. Descriptive and quantitative statistical analysis of the data is presented.

Statistical Analysis

To proceed with statistical analysis three software were used: IBM SPSS Statistics 20® to do analysis of frequencies and means; Effect Size Calculators (Becker, 2000, accessed in May 2017) to calculate effect sizes of the results and MEDCALC®

- easy-to-use statistical software (MedCalc, accessed in May 2017) to calculate the comparison of proportions.

Analysis of frequencies was used to calculate the percentage of respondents that chose that specific choice of answer per question that is being analysed. For one of the questions, they could only choose one answer, and in some of them they could choose more than one, in such cases, the percentage was calculated based on a number of possible cases.

Once the percentages per category were calculated, for both, Brazilian and UK respondents, the proportions were compared with Chi-Squared (χ^2) as it is the most commonly used method to compare proportions (Equation 5.2) (Fink, 2003). This test enables comparison of the observed frequencies (calculates with analysis of frequencies) with the expected frequencies (referring to the hypothetical distribution). This test was used to examine if there was a difference between the choices of Brazilian respondents to the choices of UK respondents. MEDCALC® was used to do the calculations automatically, however, it is important to understand how these calculations occur.

Equation 5.2. Chi-Square Equation

$$\chi^2(1) = \eta(ad - bc)^2/(a + c)(b + d)(a + b)(c + d)$$

(1) = refers to the degrees of freedom

η = refers to the total number of cases

The MEDCALC® software uses the "η-1" Chi-squared test and it was chosen because it can be used to small sample sizes (Campbell, 2007), so in this case η was substituted by η-1.

It was expected that the null hypothesis - d that there would be no difference between the answers chosen by PT's in the United Kingdom and the answers chosen by PT's in Brazil, as the ANDE – BR and CPTRH – UK would be followed if they were following the AHA guidelines for hippotherapy training of PT's and HPOT sessions. Where the *p* value is greater than 0.05, Brazilian choice will be considered no different than UK PTs choice of answers, and therefore their answers could be considered as being from one population and be combined together for further analyses. Where the responses from Brazilian's were significantly different than UK's answers, their data would be considered separately in further analyses.

To evaluate if one or more choices of answer was chosen more than another, Paired-samples *t* tests were used, as there was a need to compare two experimental conditions with the same participants taking part in these conditions (Field, 2009). A paired-sample *t* test compares the mean difference between the sample ($\bar{D}$) and the difference we would expect to find between populations means (η_D) taking the standard error of differences into account ($s_{\mathrm{D}}/\sqrt{N}$); (N) referring to the sample. The equation 5.3 is as follow:

Equation 5.3. Paired-sample *t* test calculation

$$t = \frac{\bar{\mathrm{D}} - \eta_{\mathrm{D}}}{s_{\mathrm{D}}/\sqrt{\mathrm{N}}}$$

The confidence interval (Bca 95% CI), and the *t* size compared using degrees of freedom (*df*) will be reported, together with Mean, Standard Error (SE) and *p* values. To investigate the magnitude of the findings are effect-sizes will be computed converting *t*-values in *r*-values and Cohen's *d*-values. The effect sizes were automatically calculated by the Effect Size Calculators (Becker, 2000, accessed in May 2017) following the equations 5.4 and 5.5.

Equation 5.4. Calculation of effect size (*r*) using *t* values:

$$r = \sqrt{\frac{t^2}{t^2 + df}}$$

Equation 5.5. Calculation of Cohen's *d*:

$$d = \frac{2t}{\sqrt{df}}$$

The benchmarks given for Cohen's *d* are: *d*= 0.2 (small), 0.5 (medium) and 0.8 (large) and the ones given for *r*-values are: *r*= 0.10 (small effect); 0.30 (medium effect) and 0.50 (large effect) (Field, 2009).

When no significant difference was found between UK PTs and Brazilian PTs analysis will be carried out as they were the same group.

5.6. Results

The survey was open online for 5 weeks and it was fully answered by 36 PTs of who 11 were UK based PTs, 52.3% of the target population and 24 Brazilian, representing 35.8% of the target number of respondents sought to complete the survey. This is unfortunately below the sample size required as one could not be sure of the exact number of PTs doing HPOT with children with CP at the moment of the survey, with the sample size being only an estimation of what could be considered as potential participants. The decision to accept the sample size as it is, below the target, was taken for three reasons: i) the target number was an estimation, but did not necessarily match to reality in Brazil and in the UK; ii) all the practices, where there was public contacted available were contacted within the first week of the study; iii) there was a limited time to use the software.

Section I – How do United Kingdom and Brazilian Physiotherapists Conduct Hippotherapy?

All respondents reported that they follow the guidelines of AHA by having a horse handler and a side-walker in every HPOT session. All PTs report that they use a HPOT pad and 79% of them reportedly use a saddle for HPOT sessions as well. There was no difference between the UK responders and the Brazilian responders (p>0.05) when comparing reasons to use HPOT pad and reasons to use saddle, so they were considered as one group.

There was no significant difference between the reasons given to use a saddle, as 48% of all PTs chose to use one for safety; 45.7% for stabilization of the lower torso; 31.4% to stretch hip adductors and 31.4% indicated using one for other purposes. The statements given for "other reason" for saddle can be found on Table 5.1.

Table 5.1. Statements given to "other reasons" to choose a saddle.

UK – based PTs	Brazilian PTs
"Biomechanical reasons"	"To exercise the abdominals, stretch anterior and posterior muscles of the trunk"
"Horse comfort, change of positions"	"Better contact between patient and horse"
"To use stirrups for weight-bearing and selective lower limb control"	"Better position and stability when riding"
"To progress to therapeutic riding"	"It is easier to position the patient"
"When moving clients from HPOT to riding for disable"	"Patients with more trunk stability"
"To make transition to riding"	"Better position of the pelvis"
	"Postural control"
	"Facilitate balance and practice with lead rope"

With respect to the HPOT pad there were some significant differences when the reasons to use it were compared. Typically, PT's who use the HPOT pad do it to focus therapy on balance and proprioception (M=0.91, SE=0.04) rather than for safety (M=0.11, SE=0.05). This difference $\overline{D}$= 0.80, BCa 95% CI [0.63, 0.96], was significant t (34) = 10.01, p=0.000 and r=0.86 and d=3.23 which means is a substantive finding effect size. When comparing the focus on balance and proprioception (M=0.91, SE=0.04) to focus on comfort (M=0.22; SE=0.07) the difference $\overline{D}$= 0.68, BCa 95% CI [0.52, 0.84], the choice to use a HPOT pad to focus on balance and proprioception was significantly higher t (34) = 8.61, p=0.000, r=0.82 and d=2.95.

Focus on balance and proprioception was also a significant higher choice when compared to “other reasons” (M=0.11, SE=0.05). This difference $\overline{D}$= 0.80, BCa 95% CI [0.63, 0.96], was significant *t* (34) = 10.01, *p*=0.000 and *r*=0.86 and *d*=3.23 (figure 5.2).

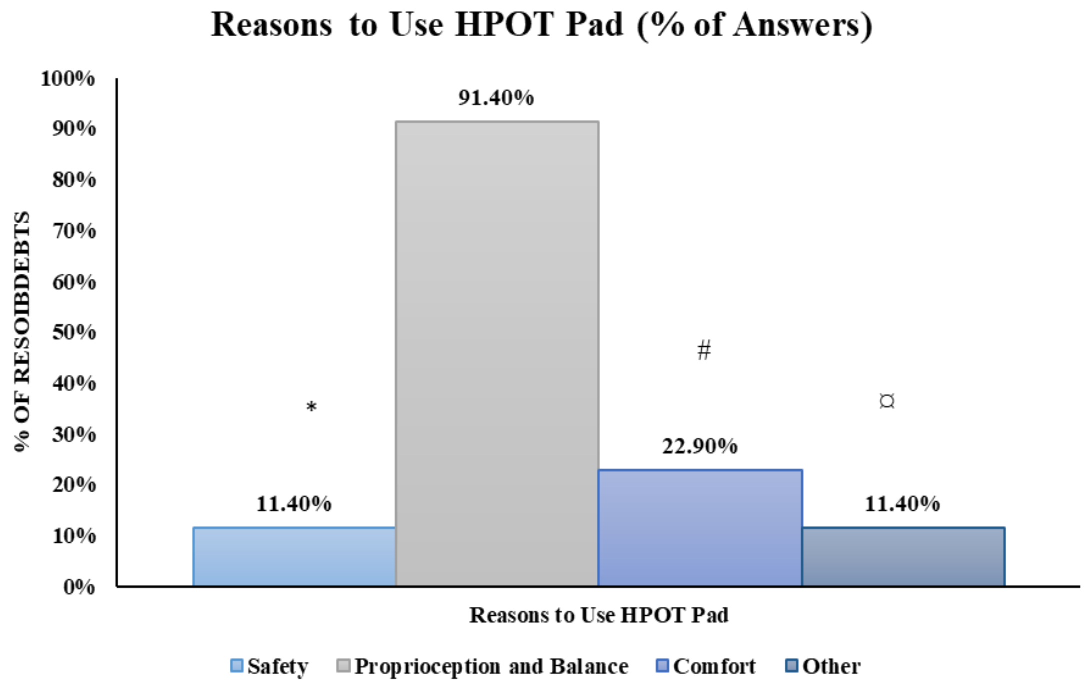


Figure 5.2. Reasons for using a hippotherapy pad.

*p<0.000 when Proprioception and balance were compared to Safety. #p<0.000 when they were compared to comfort; and ¤ p<0.000 when compared to other reasons.

Section II – The Characteristics of Hippotherapy Sessions

Section II results highlight the typical duration and frequency of HPOT sessions in both countries, and what the PTs may be focusing the exercises during the HPOT session. There was no difference between the answers chosen by Brazilians and the ones chosen by UK PTs (χ^2=2.836, p=0.418). With respect to the frequency of

HPOT sessions, 100% of the UK respondents and 83.3% of the Brazilians said that their patients attend a HPOT session once a week against.

Concerning the typical duration of sessions, the majority reported that the sessions lasted for 30 minutes. This option was chosen significantly more often than any other option. A session of less than 30 minutes was also selected significantly more than the choice of 60 minutes (Figure 5.3).

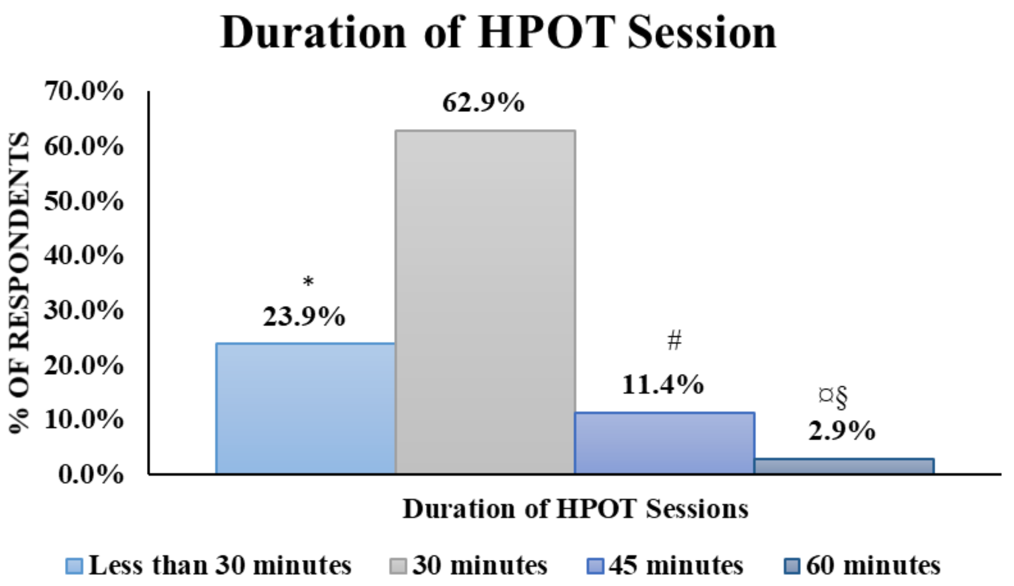


Figure 5.3. Presents How Long a HPOT Session Would Typically Last.

*p<0.009 when 30 minutes (M=0.62, SE=0.08) was compared to less than 30 minutes (M=0.22, SE=0.07); $\overline{D}$= 0.4; BCa 95% CI [0.10, 0.69], as *t* (34) = 2.79 and *r*=0.43; *d*=0.95. #p<0.000 when 30 minutes it was compared to 45 minutes (M=0.11 SE=0.05); $\overline{D}$= 0.51 BCa 95% CI [0.27, 0.75], as *t* (34) = 4.33, *r*=0.59 and *d*=1.48; ¤ p<0.000 when 30 minutes was compared to 60 minutes (M=0.02 SE=0.02); $\overline{D}$ =0.60 BCa 95% CI [0.41, 0.78], as *t* (34) = 6.41, *r*=0.73, and *d*=2.19; and §p<0.01 when less than 30 minutes was compared to 60 minutes $\overline{D}$= 0.20 BCa 95% CI [0.03, 0.36 *t* (34) = 2.50, and *r*=0.39.

The questionnaire presented 5 options for the types of exercises the PTs chose to focus on and it was possible to choose more than one type of exercise. They were: exercises focusing on enhancing strength, flexibility, reducing spasticity, on improving balance and on improving posture. When we compared UK *versus* BR, there was a significant difference between the frequency of choice of flexibility (χ^2=

7.02, *p*=0.008, BCa 95% CI [-9.07, 59.81]), balance (χ^2= 4.50, *p*=0.03, BCa 95% CI [-0.92, 64.31]) and posture (χ^2= 4.03, *p*=0.04, BCa 95% CI [-3.07, 51.95]) (Figure 5.4).

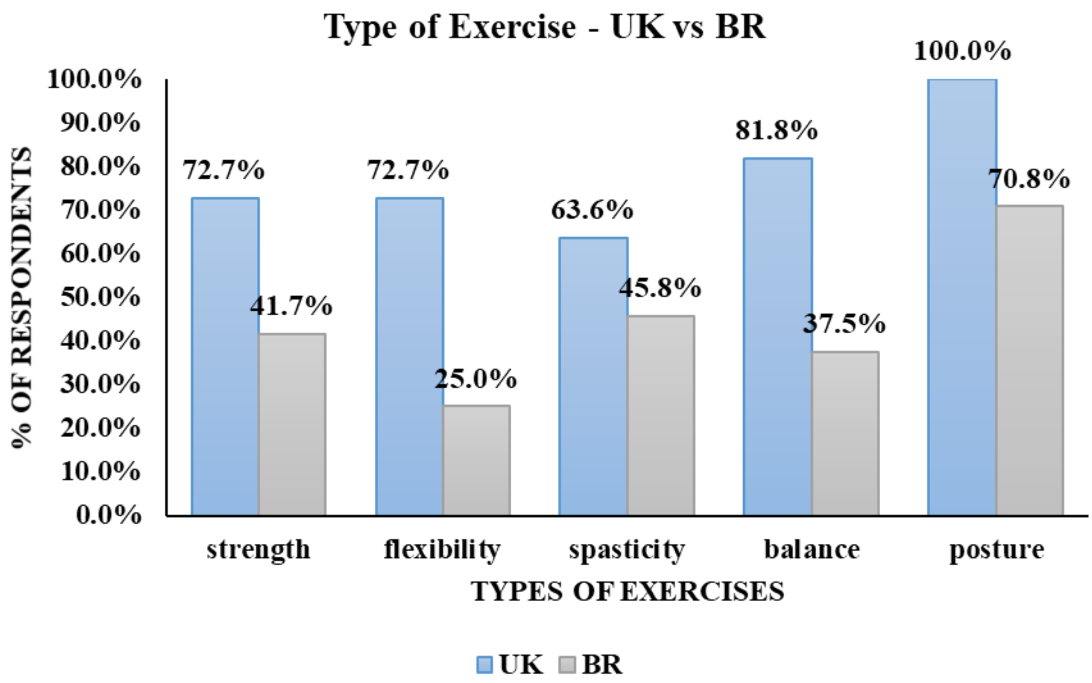


Figure 5.4. Types of Exercises.

UK PTs *vs* Brazilian PTs. *p<0.008 E*vs*B for flexibility. #p<0.03 UK *vs* BR for balance; ¤ p<0.04 UK *vs* BR for posture.

As UK and BR have chosen differently in three categories, the analysis to investigate which category was chosen the most was done separately, per country. The comparisons that were significantly different are reported on Table 5.2.

Table 5.2. Type of exercises per country.

		Paired Differences			*t*	*df*	*Sig.*	Effect Size	
		Mean Difference (D)	BCa 95% CI						
			Lower	Upper				*r*	*d*
UK PTs	Posture (M=1, SE=0) *vs* Spasticity (M=0.64, SE=0.15)	0.36	0.02	0.70	2.39	10.00	**0.04**	0.37	0.81
Brazilian PTs	Posture (M=0.71, SE=0.09) *vs* Balance (M=0.42,SE=0.10)	0.29	0.10	0.49	3.08	23.00	**0.01**	0.46	1.05
	Posture *vs* Strength (M=0.42, SE=0.10)	0.29	0.03	0.56	2.29	23.00	**0.03**	0.36	0.78

M: mean; D: mean difference; SE: standard error; CI: confidence interval; t: t-test; df: degrees of freedom, sig: p value, r: r value, d: Cohen's

Section III – What Physical Outcomes do English and Brazilian Physiotherapists Consider as being Improved by Hippotherapy?

The results of this section will summarize the physical outcomes expected to improve after HPOT and how they have been evaluated, as well when it is recommended that discharge of the patients.

Types of Evaluation to Detect Clinical Progress

PTs were asked how they evaluate their patients' progress after one single session of HPOT and how they evaluate the overall treatment progress and how often that happens.

When analyzing the results for evaluations of one session only, 54.5% of UK respondents reported using only clinical observations, against only 16.7% of BR respondents, exclusively. This difference was significant (χ^2=5.129, BCa 95% CI [0.38, 68.90], *p*=0.02). Half of BR PTs have reported to actually use published methods, against 36.4% of UK PTs, there was not a significant difference between UK and BR for this method of evaluation (χ^2=0.546, BCa 95% CI [-25.31, 46.51], *p*=0.45).

With regards to how often PTs re-evaluate their patients to assess treatment progression, both PTs UK (63.6% - 8PTs) and BR (45.8% - 10PTs) chose the option "other" as the pre-coded questions did not match their practice. When looking into the statements given in the open question, 60% of Brazilian PTs reported to re-assess their patients every 12 weeks, while 85.7% of UK PTs that have chosen "other" stated they re-evaluate their patients every 6 weeks.

Looking into what kind of evaluation PTs do to appraise the overall progression of HPOT treatment, 4 pre-coded answers were given (Clinical Observation, Clinical Tests, Self-developed Measures and Published Methods). There was no significant difference found between the choices of UK PTs and Brazilian PTs. The comparisons among the methods can be found on Figure 5.5, with "published methods" being the most chosen type of evaluation.

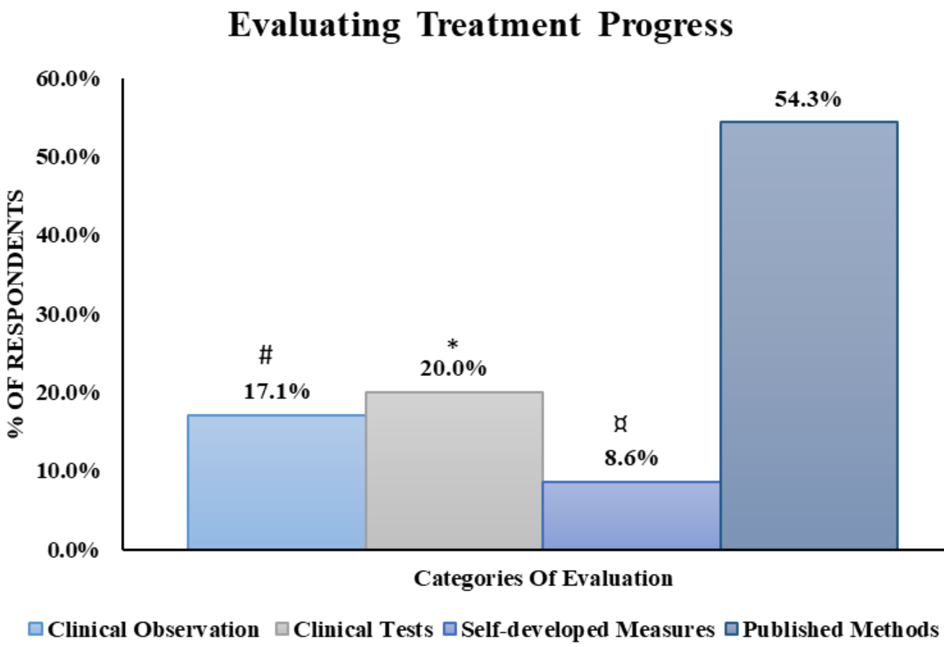


Figure 5.5. Evaluating Treatment Progress.

Published methods (M=0.54, SE=0.08) *versus* Clinical tests (M=0.20, SE=0.08) $\overline{D}$= 0.34 BCa 95% CI [0.06, 0.61], *t*(34)= 2.52, **p*=0.01, *r*=0.39, *d*=0.86); Published methods *versus* Clinical Observation (M=0.17, SE=0.06); $\overline{D}$= 0.37 BCa 95% CI [0.10, 0.63], *t* (34) = 2.85, #*p*=0.007, *r*=0.43, *d*=0.97; and Published methods *versus* Self-Developed Measures (M=0.09, SE=0.04); $\overline{D}$= 0.46 BCa 95% CI [0.23, 0.68], *t* (34) = 4.11, ¤*p*=0.000, *r*=0.57, *d*=1.41.

Physical Outcomes and How They Are Evaluated

PTs were asked about 10 different outcomes: Balance, Posture, Gait, Muscle Strength, Spasticity, Gross Motor Function, Functional Capacity, Joint Mobility and Spasticity. They could choose more than one outcome, as this would most likely match to their perspective on practice. There was not a difference between UK-PTs and BR-PTs perspective about the outcome's choice. Therefore, the data was collated. The two most expected outcomes to improve were Balance (82.9%) and Motor Control (80%).

Table 5.3. Summary of Comparison among Physical Outcomes.

		Paired Differences			*t*	*df*	*Sig.*	Effect Size	
		Mean Difference (D)	BCa 95% CI						
			Lower	Upper				*R*	*d*
Balance (M=0.83, SE=0.06) *Versus*	Posture (M=0.71, SE=0.07)	0.11	0.00	0.23	2.09	34.00	**0.04**	0.33	0.71
	Gait (M=0.71, SE=0.07)	0.11	0.00	0.23	2.09	34.00	**0.04**	0.33	0.71
	Gross Motor Function (M=0.69, SE=0.08)	0.14	0.02	0.26	2.38	34.00	**0.02**	0.37	0.81
	Muscle Strength (M=0.69, SE=0.08)	0.14	0.02	0.26	2.38	34.00	**0.02**	0.37	0.81
	Spasticity (M=0.66, SE=0.08)	0.17	0.04	0.30	2.65	34.00	**0.01**	0.41	0.90
	Joint Mobility (M=0.66, SE=0.08)	0.17	0.04	0.30	2.65	34.00	**0.01**	0.41	0.90
	Proprioception (M=0.66, SE=0.08)	0.17	0.04	0.30	2.65	34.00	**0.01**	0.41	0.90
	Functional Capacity (M=0.60, SE=0.08)	0.23	0.08	0.37	3.17	34.00	**0.00**	0.47	1.08
Motor Control (M=0.80, SE=0.06) *versus*	Gross Motor Function	0.11	0.00	0.23	2.09	34.00	**0.04**	0.33	0.71
	Muscle Strength	0.11	0.00	0.23	2.09	34.00	**0.04**	0.33	0.71
	Proprioception	0.14	0.02	0.26	2.38	34.00	**0.02**	0.37	0.81
	Joint Mobility	0.14	0.02	0.26	2.38	34.00	**0.02**	0.37	0.81
	Spasticity	0.14	0.02	0.26	2.38	34.00	**0.02**	0.37	0.81
	Functional Capacity	0.20	0.06	0.34	2.92	34.00	**0.01**	0.44	1.00
Posture *versus*	Functional Capacity	0.11	0.00	0.23	2.09	34.00	**0.04**	0.33	0.71

M: mean; D: mean difference; SE: standard error; CI: confidence interval; t: t-test; df: degrees of freedom, sig: p value, r: r value, d: Cohen's D

PTs were also requested to state how they were evaluating, if they were evaluating, every single one of the outcomes. For every outcome, they were given choices of validated evaluations, subjective analysis and the chance to state which one they would use in case that answer was not pre-coded alternative.

UK PTs and Brazilian PTs participants were again compared, for every outcome and for every choice of evaluation given. For balance, posture, spasticity and joint mobility significant differences were found when comparing UK-PTs to BR-PTs regard the choice of evaluation for each of these outcomes. Figure 5.6 shows the percentages for each option and outcome.

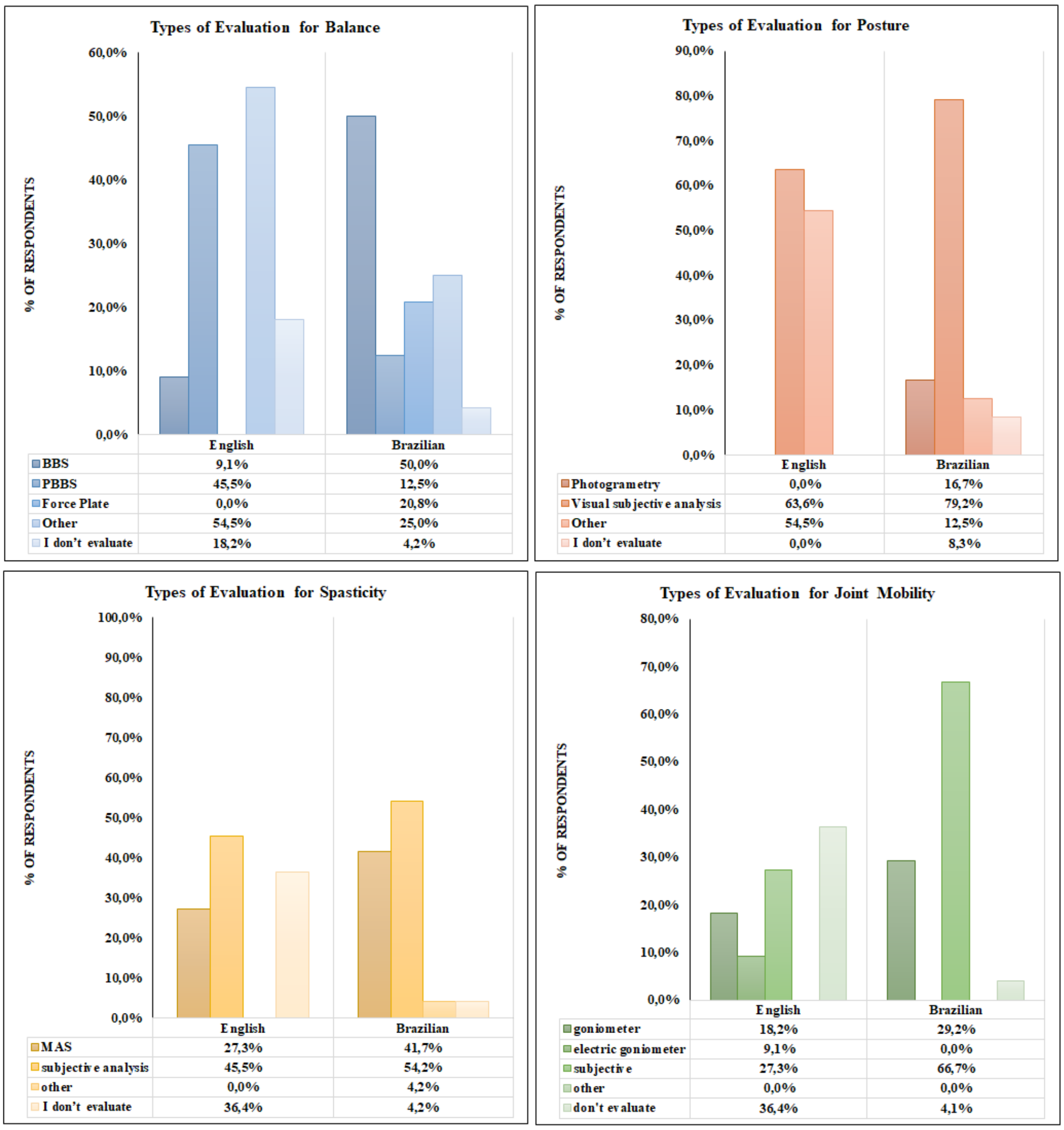


Figure 5.6. Types of Evaluation per outcome.

BBS: Berg Balance Scale; PBBS: Paediatric Berg Balance Scale; MAS: Modified Ashworth Scale.

For "Balance", there were two choices of methods that were significantly different when UK PTs and BR PTs responses were compared, the Berg Balance Scale (BBS) (χ^2=5.25, BCa 95% CI [2.53, 63.58], p<0.02), being chosen by 50% of Brazilian PTs, being the most used scale for Brazilians against only 9.1% of the UK PTs. The UK-PTs preferred method was the Pediatric Berg Balance Scale (PBBS) which was chosen by 45.5% of the UK-PTs and only 12.5% of the BR-PTs (χ^2=4.29, BCa 95% CI [-2.65, 64.88], *p*<0.03).

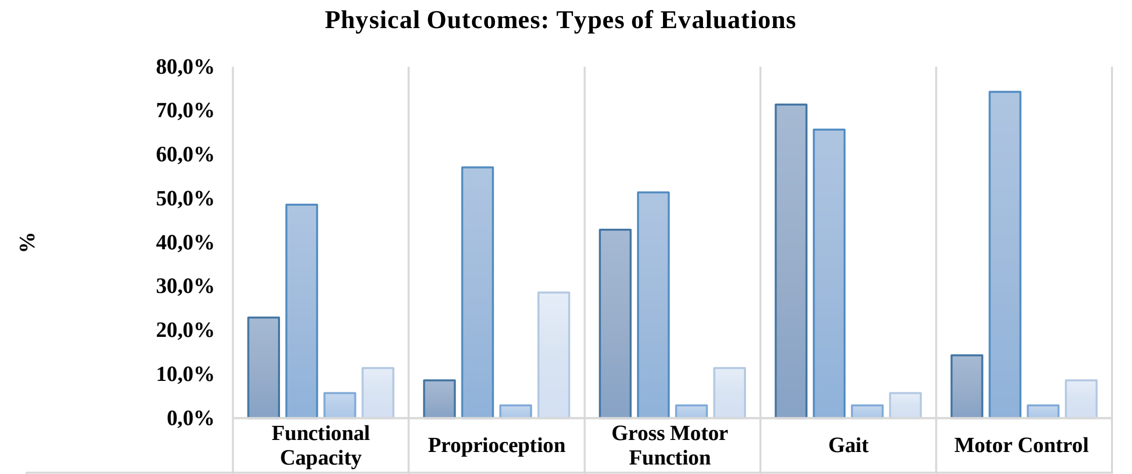
For "Posture", UK and Brazilian PTs significantly diverged on choosing the "other" option only (χ^2=6.76, BCa 95% CI [5.05, 72.36], *p*<0.009) with 54.5% of UK-PTs choosing this option, against only 12.5% of BR-PTs. UK PTs have significantly reported evaluating posture with visual subjective analysis (63.6%), as when compared to "photogrammetry" and "do not evaluate" *p*=0.002, *r*=0.79 and *d*=2.64 in both cases. A significant amount of Brazilian PTs (79.2%) have reported to do visual subjective analysis of posture, this choice was significantly higher than any other choice given, with *p*<0.0001 for all comparisons.

For "Spasticity" the choice "do not evaluate" was chosen by 36% of UK PTs against only 4.2% of BR PTs (χ^2=6.19, BCa 95% CI [1.60, 65.29], *p*<0.01). In the BR-PTs group the choice to use MAS was significant higher than "other" ($\overline{D}$ =0.37 BCa 95% CI [0.16, 0.58], *t*(23)= 3.71, *p*=0.001, *r*=0.61, and *d*=1.54) and then "do not evaluate" ($\overline{D}$ =0.37 BCa 95% CI [0.13, 0.61], *t*(23)= 3.191, *p*=0.004, *r*=0.55, and *d*=1.33). The "subjective analysis" was also significantly more chosen than "other" and "do not evaluate" ($\overline{D}$ =0.50 BCa 95% CI [0.25, 0.74], *t*(23)= 4.15, *p*=0.001, *r*=0.65, and *d*=1.73) for both comparisons. The UK PTs Group, chose "subjective analysis" significantly more than "other" ($\overline{D}$ =0.45 BCa 95% CI [0.10, 0.80], *t*(10)= 2.88, *p*=0.01, *r*=0.67, and *d*=1.82).

For "Joint Mobility" 66.7% of BR PTs reported use subjective analysis against 27.3% of UK-PTs (χ^2=4.58, BCa 95% CI [-0.83, 67.06], *p*=0.03) and 36.4% of UK PTs reported not evaluate this outcome, against only 4.1% of BR PTs (χ^2=6.25, BCa 95% CI [1.73, 65.38], *p*=0.01). The UK PTs group, was when "do not evaluate" the most chosen one (36.4%) was compared to "other" ($\overline{D}$ =0.36 BCa 95% CI [0.25, 0.70], *t*(10)= 2.39, *p*=0.03, *r*=0.60, and *d*=1.51). For the BR-PT group the goniometers were significantly more chosen than any other type of evaluation p<0.01.

As for the other outcomes: Gross Motor Function, Functional Capacity, Muscle Strength, Proprioception, Gait and Motor Control, no differences were found between

UK and Brazilian physiotherapists. The significant comparisons of these outcomes are summarized on the Table 5.6 and the percentages represented in Figure 5.7. Subjective analysis was the most chosen form of evaluation in all of the 6 physical outcomes.



	Functional Capacity	Proprioception	Gross Motor Function	Gait	Motor Control
Specific Measure*	22,9%	8,6%	42,9%	71,4%	14,3%
Subjective Analysis	48,6%	57,1%	51,4%	65,7%	74,3%
Other	5,7%	2,9%	2,9%	2,9%	2,9%
Don't evaluate	11,4%	28,6%	11,4%	5,7%	8,6%

Figure 5.7. Type of Evaluations per Physical Outcomes.

*Specific Measure for "Motor Control": Kinematics; for "Gait": Validated Gait Tests (e.g. shuttle walking test); "Proprioception": Clinical Test of Sensory Integration and Balance (CTSIB); "Muscle Strength": dynamometer; "Functional Capacity": International Classification of Function (ICF); "Gross Motor Function": GMFM.

All the UK respondents 91.7% of the BR reported that they regard HPOT as capable of improving synergy between adductor and abductors. Respondents (97% UK; 89% BR) also believed that it has the same effect with the flexors and extensors. All of the respondents (UK and BR) believe HPOT is able to decrease variability in the gait components, such as stride length, and consequently increase physical performance. Hip adductors and abductors seen to be worked most by PT's (UK and BR), but when talking about muscle characteristics: (1) spasticity of hip adductors and flexors seen to be the one with more improvements; (2) strength seen to improve mostly on hip extensors (UK) and extensors and adductors (BR); (3) tonus was seen to improve mostly on hip adductors.

Considering the muscle groups of the trunk and upper limb most respondents have considered that HPOT would have a bigger impact on normalizing muscle tonus and muscle strength of the abdominals compared to other muscle groups. Brazilian PTs' report an overall improvement on spasticity equally in all the groups, while E. mainly see an improvement on pectoralis. All the respondents have stated that HPOT is also able to improve the dissociation of hip and shoulders during ambulation and that patients should be discharged of HPOT once they have reached a plateau, so to say, once there is no further physical improvement (Table 5.4).

Table 5.4. Comparison of Types of Evaluations per Outcome.

		Paired Differences			*t*	*df*	*Sig.*	Effect Size	
		Mean Difference (D)	Bca 95% CI						
			Lower	Upper				*r*	*d*
Motor control	Subjective Analysis (M=0.74, SE=0.07) *versus* Kinematics (M=0.14, SE=0.06)	0.60	0.43	0.77	7.14	34	**0.00**	0.77	2.44
	Subjective Analysis *versus* Other (M=0.03, SE=0.02)	0.71	0.56	0.87	9.22	34	**0.00**	0.84	3.16
	Subjective Analysis *versus* Do Not Evaluate (M=0.09, SE=0.04)	0.66	0.44	0.88	6.08	34	**0.00**	0.72	2.08
	Kinematics *versus* Other	0.11	0.00	0.23	2.09	34	**0.04**	0.33	0.71
Gait	Gait Tests (M=0.71, SE=0.07) *versus* Subjective Analysis (M=0.66, SE=0.08)	0.69	0.52	0.85	8.61	34	**0.00**	0.82	2.95
	Gait Tests *versus* Do Not Evaluate (M=0.06, SE=0.04)	0.66	0.45	0.86	6.58	34	**0.00**	0.74	2.25
	Subjective Analysis *versus* Other (M=0.03, SE=0.02)	0.63	0.46	0.80	7.59	34	**0.00**	0.79	2.60
	Subjective Analysis *versus* Do Not Evaluate	0.60	0.39	0.81	5.88	34	**0.00**	0.71	2.01
Gross motor Function	Subjective Analysis (M=0.51, SE=0.08) *versus* Other (M=0.03, SE=0.02)	0.49	0.31	0.66	5.67	34	**0.00**	0.69	1.94
	Subjective Analysis *versus* Do Not Evaluate (M=0.11, SE=0.05)	0.40	0.16	0.64	3.41	34	**0.00**	0.50	1.16
	GMFM *versus* Other	0.40	0.23	0.57	4.76	34	**0.00**	0.63	1.63
	GMFM *versus* Do Not Evaluate	0.31	0.08	0.55	2.75	34	**0.01**	0.42	0.94

		Paired Differences			***t***	***df***	***Sig***	**Effect Size**	
		Mean Difference (D)	**Bca 95% CI**						
			Lower	**Upper**				***r***	***d***
Muscle Strength	Subjective Analysis (M=0.66, SE=0.08) *versus* Dynamometer (M=0, SE=0)	0.66	0.49	0.82	8.07	34	**0.00**	0.81	2.76
	Subjective Analysis versus Other (M=0.11, SE=0.05)	0.54	0.35	0.74	5.73	34	**0.00**	0.70	1.96
	Subjective Analysis *versus* Do Not Evaluate (M=0.11, SE=0.05)	0.54	0.30	0.78	4.58	34	**0.00**	0.61	1.57
	Do Not Evaluate *versus* Dynamometer	0.11	0.00	0.23	2.09	34	**0.04**	0.33	0.71
	Other *versus* Dynamometer	0.11	0.00	0.23	2.09	34	**0.04**	0.33	0.71
Proprioception	Subjective Analysis (M=0.57, SE=0.08) *versus* CTSIB (M=0.09, SE=0.04)	0.49	0.31	0.66	5.67	34	**0.00**	0.69	1.94
	Subjective Analysis *versus* Other (M=0.03, SE=0.02)	0.54	0.37	0.72	6.35	34	**0.00**	0.73	2.17
	Do Not Evaluate (M=0.29, SE=0.07) *versus* Other	0.26	0.08	0.43	3.01	34	**0.00**	0.45	1.03
Functional Capacity	Subjective Analysis (M=0.49, SE=0.08) *versus* ICF (M=0.23, SE=0.07)	0.26	0.10	0.41	3.43	34	**0.00**	0.50	1.17
	Subjective Analysis *versus* Other (M=0.06, SE=0.04)	0.43	0.24	0.62	4.55	34	**0.00**	0.61	1.56
	Subjective Analysis *versus* Do Not Evaluate (M=0.11, SE=0.05)	0.37	0.13	0.61	3.19	34	**0.00**	0.47	1.09
	ICF *versus* Other	0.17	0.02	0.33	2.24	34	**0.03**	0.35	0.76

M: mean; D: mean difference; SE: standard error; CI: confidence interval; t: t-test; df: degrees of freedom, sig: p value, r: r value, d: Cohen's D

5.7. Discussion

Difference in HPOT practices between England and Brazil.

This study targeted PT's working with HPOT in the UK and in Brazil. The number of respondents across the two countries suggest that HPOT is much more known and practiced in Brazil than it is in the UK, as there was 24 Brazilian PT's who responded against only 11 in the UK.

Debuse, Chandler and Gibb, (2005) reported in their survey that there were 21 UK PTs that would be qualified to conduct HPOT. The CPTRH could not confirm if this number is still the same, either if they were all working with HPOT specifically and with CP children. In the UK, only in 2017 the Association of Chartered Physiotherapists in Therapeutic Riding was recognized by the Chartered Society of Physiotherapy (CSP) and became the Chartered Physiotherapists in Therapeutic Riding and Hippotherapy (CPTRH). Completion of their qualification course enables a PT to work within any area of EAT from riding for disabled to vaulting, the course is also not entirely accessible to all PTs and it demands an extra amount of time, as its modules (4) are run only every six months. In addition, PTs need to be a member of CSP and hold a Health and Care Professions Council registration (HCPC), together with a year of relevant experience and a record of Equine skills acquired prior to the course (CPTRH, accessed in May, 2017). All these requirements could help to understand why it might be so difficult to find qualified PTs working with HPOT and with CP children only.

When ANDE, the Brazilian Association of HPOT was contacted they stated that around 1000 PTs have completed at least one of their hippotherapy courses, however, they did not have the number of how many of those do actually practice HPOT and work with participants with CP. The access to the HPOT qualification in Brazil is much more straightforward than in the UK, as they offer a range of courses from basic HPOT to specializations. The requirement to do a basic HPOT course and start working it is only having a Bachelor in Physiotherapy recognized by the Brazilian Government, and the course only takes 4 days. If the PT wishes to do the specialization course (1 year duration), than the requirements will be stricter as they will need complete the prior HPOT courses, Bachelor in Physiotherapy course and have experience in research and practice working with HPOT (Associação Nacional de Equoterapia, 2015). Furthermore, ANDE have stated that there were 255 centres registered in their database, number in which we based our calculations considering that each centre would have at least on PTs. When looking for every centre, only 82 were eligible, as they were working with HPOT and CP.

Although 82 centres were identified not all of them, as reported on the results section, were able to be contacted and/or have a physiotherapist working within the centre at the time of the study, as in Brazil, other PTs such psychologist or OTs can also receive HPOT training and work with children with CP.

As stated previously, Debuse, Chandler and Gibb, (2005) reported that HPOT hasn't been practiced in the UK for long and it is quite unknown in the country. Previous literature reviews (Sterba, *et al.*, 2007; Zadnikar and Kastrin, 2011; Herrero Gallego, *et al.*, 2012; Tseng, Chen and Tam, 2013) gathered studies only published in English, but these did not include any that were actually produced in the UK. In the literature review presented in this thesis (Chapter 3), again although only gathering studies published in English, did not include any studies that were conducted in the UK, but did included two papers produced in Brazil that were published in English (Antunes, *et al.*, 2016; Moraes, *et al.*, 2016). In addition, from the 319 studies that were found during the review process (Chapter 3), 58 were excluded because they were not published in English, from those it is interesting to report that 5 were in Portuguese and 14 in German, indicating as well a bigger engagement and interest of these countries with HPOT, as reported by Debuse, Chandler and Gibb (2005) and by this present study.

Despite those differences, both the CPTRH and ANDE do follow the definitions and guidelines about HPOT and EAT given by AHA. Because of this, it is anticipated that there would not generally be a disagreement between the answers of both groups with respect to the conduct and effect of HPOT. Nevertheless, as reported in our results, this hypothesis was retained for some of the questions, but not for others. The details will be discussed separately and per section.

Section I: Hippotherapy Guidelines and Equipment

The pre-coded questions of this section were based, first in the AHA guidelines (American Hippotherapy Association, accessed in May 2017) to investigate whether PTs were complying with these guidelines, and secondly on some studies done in sports riding (Greve, Murray and Morgan, 2012; Diaz, 2014; Dyson, 2015; Dyson, Carson and Fisher, 2015) to investigate why they use saddle and/or HPOT pad (due to proposed differences in the positioning of the subject).

The results demonstrated that 100% of the PTs are complying with AHA guidelines, all of them used a HPOT pad and the majority also used saddle in their practice. As reported, most chose to use a saddle based only where the safety of the patients would be of concern on a pad, however, UK PTs, have stated they also use a saddle to progress a patient into activities supported by the Riding for the Disabled Association. This charity provides therapeutic riding for disabled children, which can make the access to therapeutic riding easier by the patients than it would be in Brazil. As for the HPOT pad, the most chosen reason was to focus on proprioception and balance, as the pad would allow the therapist to move the patient easily and also to enhance the contact between the patient and the horse. In addition, without the hard structure of the saddle, and the support it offers, the patients would need to work hard and constantly engage on activating balance reactions to keep themselves on the horse.

It is important to highlight that children with CP most likely will have an increase on muscle tone and spasticity on lower limb, the width of the horse helps to stretch and as spasticity respond to slow stretch, just by sitting passively in the horse already may help normalize the tone on hip adductors (Tseng, Chen and Tam, 2013; del Rosario-Montejo, *et al.*, 2015; Stergiou, *et al.*, 2017b). Because of the spasticity, some PTs may choose to use a saddle to try increase this stretch, however, if the child has a very rigid (MAS 3 or 4) that may be very uncomfortable and painful for the child.

Moreover, these results also implicate that PT's are choosing to use HPOT pad or saddle according to patients needs and to focus in a specific type of exercise to target outcomes such as balance, proprioception or stabilization. Among equestrian veterinarian researchers and athlete riders it is recognised that the use of a saddle may affect a rider position (Morgan, 2012; Diaz, 2014; Dyson, Carson and Fisher, 2015; Greve, Murray and Dyson, 2015), however, and in spite the fact that in practice PT's seen to be concerned on the choice of one or another, there are no studies looking specifically on the effect of using a HPOT pad or a saddle and whether this could have an effect on improving balance, posture control or proprioception. Clayton, *et al*., (2011) have investigated the range of CoP of children with CP, by using a pressure mat under a saddle, and compared the results with children without physical disabilities, still, no comparisons or discussion were made considering the interference of saddle. This could be considered as much needed research pathway in the field, with the aim of highlighting which equipment would be most effective in improving the quality of therapy for a specific outcome.

Section II: The Characteristics of HPOT sessions

This section elucidated answers to some questions regarding the duration and frequency of the sessions and what type of exercises the PTs were focusing their sessions on. The pre-coded questions about duration and frequency were based on the methodology of previous studies that were investigating HPOT and CP, that have their results summarized in previous systematic literature reviews (Sterba, *et al*., 2007; Zadnikar and Kastrin, 2011; Herrero Gallego, *et al*., 2012; Tseng, Chen and Tam, 2013). The studies carried out sessions from once a week to three times a week, and from 5 to 60 minutes a session. The PTs were also given the choice to state a different answer if that was the case.

As reported, and with the expectation that there would be no differences between PT's from Brazil and the UK on the frequency and duration of HPOT sessions, it was found that most of the PT's report carrying out the session once a week for 30 minutes. The choice of doing it for 30 minutes was also significantly more chosen than any other. Although 30 minutes of HPOT has been reportedly used in several HPOT studies (Kwon, *et al*., 2011; Hyun Jung, *et al*., 2012; Kang, Jung and Yu, 2012; Moraes, *et al*., 2015; Moraes, *et al*., 2016) this consensus goes against what have been reported in the published literature reviews (Sterba, *et al*., 2007; Zadnikar and Kastrin, 2011; Herrero Gallego, *et al*., 2012; Tseng, Chen and Tam, 2013) as the authors in these reviews concluded that there were no consensus in regard duration or frequency. Nevertheless, only Herrero, *et al*., (2012), Zadnikar and Kastrin (2011) and Sterba, *et al*., (2007) discussed briefly these differences on their results, stating that the heterogeneity among the studies in regard these outcomes contributes to the difficulty of concluding that there a good evidence of the HPOT benefits. Furthermore, Tseng, Chen and Tam, (2013) and Zadnikar and Kastrin (2011) produced a meta-analysis in studies providing different frequencies and duration of treatment, which could lead to some bias on their analysis.

Likewise, there is also a lack about discussion on why PTs or researchers would choose to carry out a therapy session for 30 minutes, 45 or 60 minutes either the frequency/duration of the treatment This discussion seen to be far from being elucidated, as the most recent guideline from the National Institute for Health Care and Excellence there a recommendation of individual tailored rehabilitation treatment, carried out by a multidisciplinary team, focusing on spasticity management, but no recommendation regard duration of sessions, frequency or duration of treatments is given (NICE, 2017a). A recent report from Action CP, has reported that about 72% of any type of physiotherapy treatment for children with CP is commissioned by Clinical Commissioning Groups, that services provided are highly variable across England and that there is extremely limited information about children with CP in the country and they type of rehabilitation they have been receiving and/or for how long (Action Cerebral Palsy, 2016).

The Action CP report cohoborate with the guidance given by NICE and adds that children on early stages of childhood shall receive longer hours of physiotherapy/physical rehabilitation treatments (Action Cerebral Palsy, accessed in November, 2016).

Based on the answers given by participants, it is possible to conclude that most PTs do HPOT 30 minutes, once a week. This is likely to be due to policies of the centre or due to cost-benefits of expenses-effectiveness of the treatment. HPOT centres in the UK or in Brazil are, mostly, charity centres, with or without the support of National Health System (NHS) or Brazilian Universal Health Service, which make those centre highly dependable of fund strategies and cost-benefit policies to deliver their services (Associação Nacional de Equoterapia, accessed in June, 2015; CPTRH, accessed in April, 2017)

A study published on CELL in 2014 discussed the integrative biology of exercise (Hawley, *et al*., 2014) and highlighted that exercise provokes a variety of changes and adaptations from the cells, to the tissues, organs and muscles. They discussed that endurance and strength exercises may generate changes on the muscle fibre, increasing its capacity. The physiological responses of the muscle to exercise cause a subsequent cascade of adaptations, which will be specific to the mode of exercise, its volume, intensity and frequency (Egan and Zierath, 2013; Hawley, *et al*., 2014; Heinonen, *et al*., 2014).

It is possible to hypothesize that maybe not an ideal or a most recommended duration of exercise, but rather the most efficient one to achieve the aims for a specific individual.

Nevertheless, the findings of this survey could be used as a guide for further studies involving HPOT that might be carried out in the United Kingdom, in Brazil or somewhere else as the results which relate to HPOT practice somewhat contrast with the method used in published research studies. They therefore indicate that there is need for researchers and practitioners to build a bridge between research and practice, and in doing it so could help translate positive research results to the clinical service and thereby enhance the credibility of the therapy. Moreover, using the same protocol with regard to duration and frequency of treatment may have the benefit of reducing bias when comparing different studies and could improve the quality of future meta-analyses to enhance and help support the effectiveness of HPOT treatment. Nevertheless, it is important to emphasise that it was not the aim of this study to evaluate what is the most efficient protocol for HPOT, but rather to understand what is the most used or recommended by practitioners.

As for the focus of exercises performed in practice, the results reported a significant difference between UK and BR in their preference for exercises aimed at enhancing flexibility, posture and balance. All UK PTs and the majority of Brazilian (70.8%) performed exercises focusing on posture, this difference was however significant. As for flexibility and balance, the difference in practice was even bigger, as those two types of focus for exercise represent the least chosen by Brazilians PTs and the most chosen (after posture) by the UK PTs. Debuse, Chandler and Gibb (2005), despite investigating the perception of PTs about HPOT effects, did not investigate the type of exercises PTs were doing in the UK and as we were not able to find any study published in the UK involving HPOT and CP, it is difficult to explain while this difference appears. Furthermore, although the studies do report the evaluation protocol in detail, only a few actually report what type of exercises they do while the child is on the horse (Antunes, *et al*., 2016; Moraes, *et al*., 2016), this is probably due to two reasons: i) there is a massive variety of patients that are being included in the studies (Herrero Gallego, *et al*., 2012; Tseng, Chen and Tam, 2013; Moraes, *et al*., 2015) , and ii) and most importantly because the therapy should be specific to the patients' needs (World Health Organization, 2007), therefore, the type of exercises is varies to some extent for every one of them.

Section III: Measuring the Physical Effects of Hippotherapy

The variety of types of evaluation methods used to investigate physical effects of HPOT have been strongly criticized by authors of the main systematic literature reviews in the area (Sterba, *et al*., 2007; Zadnikar and Kastrin, 2011; Herrero Gallego, *et al*., 2012; Tseng, Chen and Tam, 2013; Moraes, *et al*., 2015)**,** as some of the studies do not use validated or gold standard measures, or justify their choice of methods to evaluate a specific effect. Furthermore, it is also clear from the literature that even for the same outcome, studies use different methods, with some using only clinical scales and others using software to analyse motion, making it quite challenging to draw a comparison from the studies' results.

For this reason, the questions in this section first tried to elucidate what type of evaluation PTs are doing, across four different options. Here it was shown that for the anamneses (the first evaluation of the patient), UK PTs mainly chose to use clinical observation and Brazilians reported to use published and validated methods. However, when asked how they evaluate patient's progress and treatment effectiveness "published validated measures" was reportedly and significantly chosen by all PTs.

In this study participants were asked specifically about 10 physical outcomes that have been studied in the literature when investigating the physical effects of HPOT in patients with physical disabilities: Balance (Kwon, *et al*., 2011; Kang, *et al*., 2012; Silkwood-Sherer, *et al*., 2012; Lee, *et al*., 2014); Posture (Kuczyński and Słonka, 1999; El-Meniawy and Thabet, 2012; Shurtleff and Engsberg, 2012); gross motor function (Chang, *et al*., 2012; Park, *et al*., 2014; Known, *et al*., 2015; Champagne, Corriveau and Dugas, 2016); spasticity (Lechner, *et al*., 2003); muscle strength (Benda, McGibbon and Grant, 2003; McGibbon, *et al*., 2009); functional capacity (Frevel and Maurer, 2014); joint angles mobility, gait (Manikowska, *et al*., 2013; Kwon, *et al*.,2011; McGee and Reese, 2009); proprioception (Silkwood-Sherer and Warmbier, 2007) and motor control.

In agreement with what has being reported in the literature (Tseng, Chen and Tam, 2013; Moraes, *et al*., 2015) balance, posture, gross motor function, motor control and gait are among the most expected outcomes. Debuse, Chandler and Gibb (2005) had a similar question in their study, where they asked respondents to elucidate and rank 3 possible effects (physical or psychological) and UK respondents have rated regulation of muscle tone as high as psychological effect, followed by postural control. This difference may be explained by the different type of questions that were asked, in Debuse, Chandler and Gibb (2005) study the questions were open, and then categorized by the authors, while in this study, the question was already stated for the therapist to choose which of the outcome they could see a bigger improvement.

For some of the outcomes there was a significant difference between the choices of evaluation between UK and BR. Balance was one of them, as Brazilians reportedly use more Berg balance scale and UK more paediatric Berg Balance Scale. Effectively, the paediatric Berg Balance Scale is a derivation of the Berg Balance Scale, as it is a version of this scale to focus in children (Franjoine, Gunther and Taylor, 2003) so although there is a difference in the choice, this difference is not critical to clinical evaluation, as both scales are validated and measure the same variables. Posture was also an outcome where UK and BR PT's diverged. Although in both groups the majority of PTs reported evaluating posture with subjective analysis, the countries diverged on the option "other", which was chosen by 54% of UK PT.

UK PTs seem to not evaluate spasticity as often as the Brazilians. As for the Brazilian group, the report using the Modified Ashworth Scale or subjective analysis, with no significant difference between both choices. The same was seen for joint mobility, while the majority of BR PTs were evaluating this outcome with subjective analysis, the majority of UK PTs reported do not evaluate it at all.

As for any other outcome, there was not a significant difference between the choices of BR and UK physiotherapists. For all of the outcomes subjective analysis was reportedly and significantly the choice of evaluation in both countries.

This study does not investigate why PTs do, or do not use a certain type of evaluation. It is possible to imagine that most PTs may not have enough available time to use validated clinical scales in their daily practice, as it can be costly and very time-consuming. Interestingly, Brazilian respondents reported using more validated methods than UK PTs. This is surprising and intriguing, as all resources are first validated in English to than be translated and validated in other languages.

These results agree with what has been discussed in the literature about the variation of scientific validated methods to evaluate the effectiveness of HPOT in children with CP. It is important to highlight that during practice it is often difficult to apply certain types of validated scales and tests, due to the need for training to be used, and the time that the tests require to perform, which can be often challenging to fit within the schedules of the PTs, the children and the centres. In addition, when considering use of software for motion analysis and biomechanics equipment, those tools are often very expensive to acquire not a realistic acquisition for therapy centres that are in most cases charities or funded by public health services.

Finally, the majority of respondents, in both countries, seem to agree that HPOT improves the synergism between the muscle groups of the lower limb (adductor-abductor/flexor-extensor) and all of them believe HPOT has an effect on decreasing the variability of gait components (e.g. stride length), which agree with some studies published in the literature (McGee and Reese, 2009; Kwon, *et al*., 2011; Manikowska, *et al*., 2013) that indicate improvement on walking speed and hip and knee range of motion.

All of the respondents also agreed HPOT treatment should be carried out until the patient no longer physically improves following the treatment, which was demonstrated in one study (Shurtleff, *et al*., 2012) that followed up a child that had improvements on head and trunk control after 12 weeks of HPOT (Shurtleff, *et al*., 2010) did not present any further improvement after adding 24 weeks more of treatment, indicating what the authors called as a "plateau".

The question of for how long HPOT treatment should be carried out is not easy to be answered, as shown above, effects can be seen in different times among different patients, and although this study supports the view that it should stop when a child has reached a "plateau" level of improvement, there is no indication of when that would be, neither is there a consensus in the literature about how long HPOT should be carried out. Furthermore, as addressed by the ICF and WHO the longer-term goal for children with CP is to become active members of the society, reaching maximum individual capacity including gaining functional independence. Enhancing or achieving functional independence may happen in different times for different individuals within different levels of the condition, which maybe could indicate that HPOT could be recommend for longer than the protocols presented here, as long as it is still being effective on enhancing body function for the individual (Frank, *et al.*, 2011; WHO, accessed in 2016).

Based on these findings, it is recommended that i) more studies using only validated measures need to be carried out, ii) those studies need to describe in more details their protocols, their evaluations and their finding, iii) there is a need to enhance the connection between what is being done in practice and research and as well to increase the access of PTs to practice based on evidence, iv) HPOT associations and physiotherapy associations might consider promoting training on types of evaluations based on what is considered gold standard in the scientific literature. The use of standard evaluations would also facilitate communication among PTs, clients, researchers and public services, which could lead to a greater awareness of the benefits of the therapy and its accessibility.

At this study it was not possible to recruit all respondent needed based on population size calculation. Nevertheless, as discussed on methods, the numbers for UK PTs were based on a study published in 2005 and the numbers for BR PTs based on the number of centres registered. Those number, are most likely, a good approximation to the reality, however, there is no guarantee that they are exactly the values supposed in this study. Furthermore, it is important to highlight, that in spite not reaching the target number, the results presented have had significant difference and large effect sizes, which indicate that the significant findings were of large magnitude for the population and/or outcome that were being analysed.

5.8. Limitations of the Survey

The population gathered to complete this survey was not enough to meet the confidence interval of 95%. Therefore, the answers gathered on this study may not be true representation of the perception of all PTs working with HPOT and children with CP. Nevertheless, due to the unique characteristics of this study and due to the fact, one could not be sure about how many PT were working with HPOT and children at CP in Brazil and in the UK at the moment of the data collection, the results present here bring great insight to the characteristics of HPOT practice.

In addition, all the questions were closed questions, which could lead to an approximation of the reality, so to say, the most adequate answer for a specific participant could not be precisely represented due to the limited number of responses possible. Furthermore, and in spite of having some open questions, it was not the aim of the study to qualitatively analyse the answers, as their purpose was to provide better understanding of the practice so it could be applied further on in the thesis. This could have skewed the participants' answers towards what was most similar to them, instead of being really representative of their practice. Nevertheless, care was taken to give the opportunity to PTs to write down the answers in case something was not like their practice.

5.9. Conclusions

Based on the answers gathered it appears that there is an agreement regarding the frequency and duration of HPOT, as most practitioners seem to conduct HPOT once a week, for 30 minutes, for at least 6 weeks; and also regard its effects, as most therapists seem to agree HPOT could be indicate to improve outcomes such as gross motor function, balance and spasticity. This study also demonstrated a belief from the PTs in England and in Brazil that HPOT has a positive effect on enhancing posture, balance, motor control, gross motor function and gait. Nonetheless, it has brought an awareness about the way PTs are evaluating their patients, which is not a valid and reproducible method. PTs seem to not look sufficiently at evaluation measures, and it make it difficult to create clinical evidence of the effectiveness of HPOT on the rehabilitation process of children with CP. All of them have claimed treatment should be carried out until patients is no longer improving physically, which should be evaluated using a valid and standardized method due to possible variance in subjective assessment.

Moreover, it is important to highlight an implication about protocol of evaluations. Even though there is a case to be made about the need to researchers reproduce the same methods and protocols to enhance and back up the effectiveness of a specific treatment, this is not always possible to be done in practice, as PTs must provide and individual centred and specific tailored treatment, to achieve the aims and improve quality of life and function, as preconized by the WHO and NICE.

5.10. Implications for Future Work

This work has some implications that may be considered for future research work and that will be used to guide the design of the experimental studies presented in this thesis, such as time and frequency of therapy, outcomes that will be evaluated and outcomes measurement. This could be used by researchers on designing studies evaluating HPOT effectiveness, as it would lead to a better approximation of research and practice. Furthermore, the indication of lack of valid measurement on evaluations also should encourage researchers to investigate the association of validated clinic measurements with laboratory measurements and to create accessible protocols of evaluation that could be easily and costless applied in clinical practice.

This survey has helped to identify the key gap in knowledge and several points that can guide on the design of protocols for future research, as such:

- There is an opportunity to investigate how physiotherapists carry out HPOT in other countries such as USA, Poland, Spain or Korea, in an attempt to straighten the relationship between HPOT schools and enhance the evidence of this technique around the World;
- There is an opportunity to investigate the perception of parents and individuals that undertake HPOT treatment and compare to the views of physiotherapists;
- There was an important difference between the type of exercises carried out in HPOT sessions by PTs in Brazil and in the UK, which may be due to the school of HPOT and the perception of the therapists investigated in this survey;

- The survey has brought evidence that PTs in Brazil and in the UK carried HPOT sessions for 30 minutes, once a week (in majority) which is going to be the same protocol used in the experimental studies of the thesis, in an attempt to reduce the gap between research and practice;
- The survey has brought evidence that over 90% of PTs in the UK and in Brazil agreed to the use of HPOT pad as best to improve proprioception and balance of children with CP and all PTs have stated to follow the guidelines given by AHA, both things will guide the protocol used on the experimental studies, where HPOT sessions and evaluations will be carried out with HPOT pads and following the AHA guidelines for safety;
- Balance was the outcome that is most expected to improve by PTs in Brazil and in the UK and it is the main outcome of investigation on the experimental studies;
- Gross motor function and spasticity are expected to improve by more than 65% of the PTs in both countries and will also be investigates in the experimental studies;
- The survey has brought that most PTs in both countries tend to use subjective analysis when evaluating their patient, which highlight a gap in knowledge of demonstrating the applicability of clinical scales;
- All of PTs have agreed that HPOT treatment should be carried out until the individual reach a plateau;

The experimental studies will tackle the gap in knowledge regard the evaluation methods and regard the outcomes expected to improve after HPOT treatment and it will use the evidence gathered regard the duration and frequency of sessions, the use of AHA guidelines and the outcomes expected to be improved by HPOT.

6. Chapter 6: Methodology of the Experimental Study Presented on Chapter 7

The checklist of the what should include in the reports of this study can be found on appendix 9.

6.1. General Methodology

Ethical Considerations

The ethical considerations for the remaining chapter were submitted to, reviewed and approved by the Faculty of Science and Technology Research Ethics Panel at Anglia Ruskin University (FST/FREP/15/553).

Risk assessments were also performed, considering all possible hazards of providing HPOT treatment for disabled children, and all possible actions were taken to ensure child safety, following AHA guidelines for HPOT sessions. Measures taken to ensure safety included not attaching any equipment while the child was riding, use of helmets and selecting a horse that was suitable for all children involved in the study.

A participant information sheet (PIS) and consent form was presented to each parent/guardian prior to beginning of the study so that informed consent could be given on behalf of the child. The PIS contained information about all the stages of the study, the treatment sessions and the evaluations. A copy of the signed PIS was kept secure in the Reach Centre, a copy was given to the parents and a copy was kept securely with the researcher. All parents were advised that they could withdraw their child from the study at any given moment and without any prejudice. A specific consent form and PIS was given to each child and care was taken to ensure they gave their assent to sitting on the horse and to all the evaluations. Enough time was given for parents/guardian and children ask questions about the study.

Location and Recruitment

This is a cohort study, including children with Cerebral Palsy. Data collection took place at the Reach Centre, in Brentwood, Essex. All the HPOT treatment sessions were carried out by the Physiotherapist Louise Barrett, head of Reach Centre and vice-chair of the CPTRH. Data was not collected during the HPOT sessions themselves instead participants were invited to allocated dates and time during the weekend prior to the treatment starts, after 6 weeks and after 12 weeks of treatment.

Children with CP that attend the Reach Centre (and were thus already clients of the centre) were recruited, through a formal invitation sent to parents/guardians that were involved with the Centre's activities, with the help of the gate-keeper and physiotherapist Louise Barrett. Those who decided to engage with the studies received a summary of information about the study and were requested to sign the consent form. The individuals with CP had HPOT treatment once a week and agreed to engage with the 12 treatment sessions and to the three extra days of evaluations when data was collected to assess changes in the parameters under study that may indicate whether the therapy is beneficial. The specific characteristics of the subjects will be presented in the results session of this chapter.

Inclusion Criteria

The inclusion criteria were any child with CP between 3-10 years of age that was attend the Reach Centre for HPOT sessions, once a week. The child needed have availability to attend to 12-week session treatment and 3 sessions of evaluations i) prior to treatment, ii) after 6 weeks and at iii) the end of the treatment.

Exclusion Criteria

The exclusion criteria were any child that has CP who attended Reach Centre for any other type of equine assisted therapy; children with other types of CP; children with another type of neurological disorder (e.g. Down syndrome); children that had a surgery or Botox® application during the study; or any child that would meet the inclusion criteria but could not attend all sessions of the study.

Protocol of the Study

Eleven children aged between 3 and 8 years with spastic CP were recruited for the study. Every child had scheduled HPOT treatment over a 12-week period and were evaluated 3 times; prior to the HPOT treatment starts, after 6 weeks of HPOT and the third after 12 weeks of HPOT (Figure 6.1). The sessions were directed by an experienced physiotherapist qualified and registered by the CPTR and the gross motor function evaluation was carried out by a qualified physiotherapist who was the lead researcher (FRB).

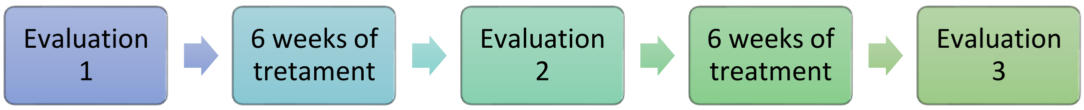


Figure 6.1· Flow of evaluation and treatment.

Every session of HPOT was designed by the physiotherapist in charge and based on the needs and rehabilitation aims of each child. The sessions would focus on balance, strength, coordination training. The author of this thesis was blind to the intervention to do not create any bias during the evaluation of the outcomes. The physiotherapist was a licensed hippotherapist and followed the HPOT guidelines in the UK (CPTRH, 2017).

6.2. Methodology of Gross Motor Function Evaluation

Aim

To increase knowledge and understanding on the effects of 12 weeks of HPOT treatment on the gross motor function of children with spastic CP.

Evaluation of Participants: Gross Motor Function

The GMFM-88, a scale with pre-determined motor activities divided in 5 dimensions, was used to evaluate the gross motor function of the children with CP and the GMFCS to classify the children motor capacity.

Gross Motor Function Classification System – The Classification of the Child with CP Based on their Motor Ability.

The GMFCS assessment results for each participant reported their motor disorder, the anatomic position of the impairment (Appendix 4), which was used according to the age of the participants, between 2 and 4 years of age for 9 of the participants and between 6 and 12 years of age for the other 2. The GMFCS was not used to evaluate the effect of HPOT, but to classify and divide the children into two groups, according with their ability to walk, with or without aid, with levels I and II being called “GMFCS 1” and those have the ability to walk, with or without aid and levels III, IV and V as “GMFCS 2”, which was formed by children who did not the ability of walking even with an aid (Table 6.1).

Table 6.1. Example of GMFCS Classification System Applied to Children with CP with 2 to 4 Years Old.

Level	Motor impairment
I	Children floor-sit with both hands free. Movements in and out of floor sitting are performed without assistance. Walk without aid or assistance.
II	Children floor-sit but may have difficulties with balance when both hands are free. Movements in and out of floor sitting are performed without assistance. Children pull to stand in a stable surface and crawls on hands and knees with reciprocal pattern. Cruise hold on to furniture and walk using an assistive mobility device as preferred method of mobility.
III	Children maintain floor-sitting often adopting “W” sitting and may require some assistance. They creep on their stomach or crawl on hands and knees as primary methods of mobility. They may pull to stand on stable surface and cruise hold short distances. May walk indoors/short distance with mobility device or assistance.
IV	Children floor-sit when placed but have difficulties on keep alignment and balance without hands for support. Often require adaptive equipment for sitting and standing. Self-mobility for short distances may be achieved by rolling, creeping on stomach or crawling on hands and knees without reciprocal leg movement.
V	Physical impairments restrict voluntary control of movement and the ability to maintain head and trunk control. All areas of motor function are limited. There are no means of independent mobility and are transported by wheelchair.

Source: Palisano, *et al.*, (1997) and Bower, (2009).

Gross Motor Function Measure – The Scale to Evaluate the Ability of a Child with CP to Achieve a Pre-Determined Motor Activity.

This scale has 5 categories. Category A: lying and rolling (17 items); category B: sitting (20 items); category C: crawling and kneeling (14 items); category D: standing (13 items) and category E: walk, run and jump (24 items). In this version each item is scored on a four-point scale (0-3) where 0 refers to cannot do the action at all; 1 refers to initiation of the task (<10% of the task); 2 equals to partially complete the task (10 to <100% of the task); and 3 indicates that the child is able to complete the action completely (Russel, *et al.*, 1989; Palisano and Rosenbaum, 1997; Moraes, *et al.*, 2016; Queiroz, 2016). The % scores for each category were calculated for analysis (Palisano and Rosenbaum, 1997; Alotaibi, *et al.*, 2013; Harvey, 2017).

For this scale, the higher the score obtained the more positive was the impact of HPOT on the gross motor function.

The GMFM-88 was used because it is more widely used among HPOT studies and it is more sensitive to evaluate children above 5 years old (Russell, *et al.*, 2000; Alotaibi, *et al.*, 2014; Harvey, 2017, Prieto, *et al.*, 2018). In addition, the characteristic of the scale means it is possible to evaluate every child on a variety of gross motor activities and to evaluate the child's ability and will to complete a pre-determined action.

Data Extraction: Gross Motor Function

In each category of GMFM the sum of the points was taken for each participant. All categories were summed together to give the total GMFM-88 score. The scores across participants were used to statistical analysis and the baseline scores, obtained prior to the treatment were compared with the ones obtained at 6 and 12 weeks. The scores between 6 and 12 weeks were also compared. For this scale, the higher the scored obtained the more positive was the impact of HPOT in the gross motor function.

6.3. Methodology of Balance Evaluation

Aim

To increase knowledge and understanding on the effects of 12 weeks of HPOT treatment on dynamic and static balance of children with spastic CP.

Protocol Evaluation of Balance Study

The assessment consisted of evaluating the child's balance, by looking in the CoP sway path, velocity and range of motion, using a pressure mat (while passively sitting on the horse) and sitting on the force platform. The protocol of HPOT sessions were described in chapter 5. Every child received HPOT treatment for 12 weeks and were evaluated 3 times; prior to the treatment, after 6 weeks of treatment, and after 12 weeks of treatment.

Procedure and Data Collection

To evaluate dynamic balance, the Pliance® system was used. Every child sat on the horse passively for 5 minutes and during this time three trials of 10 seconds each were collected while the horse was moving in a straight line. The same procedure was repeated for every child and in all evaluation points (0 weeks, 6 weeks and 12 weeks).

To evaluate static balance, every child was invited to sit in the most comfortable position and without any support for at least 10 seconds (the position was recorded and repeated in every evaluation) on the force place. Three trials of 10 seconds were collected. This evaluation was repeated at all evaluation points (0 weeks, 6 weeks and 12 weeks) and before and after sitting passively on the horse for 5 minutes. The data collected allowed for the calculation of sway path and velocity of the CoP for dynamic balance on the horse and for quiet sitting balance.

The horse used for the evaluation was the same for every child and it was a cob cross 13.3 hand pony, with a flat longer strided gait with medium width. The horse has gentle withered and a roundish barrel and it is suitable for children with increased tone and been doing HPOT for 2 years.

Time was given to the horse warm up and get habituated with it before every trial without a participant mounting, just wearing the pad and the Pliance® system. The equipment would then be calibrated to zero, to discount the weight of the HPOT pad.

The child would mount in the horse, through the stairs, for those that were able to walk, or positioned by the therapist for the children GMFCS Levels III-V. The mounting was conducted by the lead physiotherapist with the help of the centre's volunteers. The child was instructed to keep the hands on the handle of the pad and to sit as straight as they could, looking towards the horizon and keep the trunk erect. Those instructions are important for children with CP as they may lack control of head and trunk and may have difficulties on keeping the body up straight. The same instructions were given to the control that although physically able did not have the experience of riding before the trials.

A trained horse leader conducted the horse during the entire evaluation. The physiotherapist walked by the child's side giving support and a side walker walked on the other side giving support and ensuring child's safety. The arena was rectangular (20m x 40m) and the horse was led alongside the middle line of the arena. Two cones were positioned to mark a start line for the trial with it starting when the fore limb crossed the cone line (Figure 6.2).

Figure 6.2. Example of a Data Collection Trial.

Pliance® System – Dynamic Balance Evaluation

The effect of the movement of the horse on the lower torso of a participant was examined using the Pliance®. This equipment is able to record the pressure distribution and calculate the centre of pressure range of motion and velocity of each participant while on the horse and at same time give a video record of the movement (Nevison and Timmis, 2013). A HPOT Pad was placed on the top of the cotton pad. The full-size pad Christ Lammfelle Bareback pad or 'Fellsattel'® by Christ Lammfelle, this pad is to ensure extra comfort for the horse and the participant, with no pressure points and it has been used by Riding for the Disabled Association (RDA) in the UK[12].

The pressure sensor mat (Pliance type S2086; Novel GmbH, Munich, Germany) (Figure 6.7) was positioned on the horse's trunk, with the middle line of it being aligned to the horse's spine and below a specific design thin cotton pad. This cotton pad is part of the equipment and is where the Pliance® analyser box (Figure 6.3) and multi-box adapter will be securely attached. The analyser box is the piece of equipment responsible for translating the signals received from the mat to the computer and the multi-box to connect the pad and the analyser box to power. On the top of this pad a HPOT pad was placed (Figure 6.4).

[12] More information about the pad: http://www.horsedream.co.uk/proddetail.asp?prod=6301%2F772%2FWB

dimensions (mm)	150 x 100 x 40
weight (g)	400
number of sensors (ma	256 (1,024)
measurement frequency	20,000 sensors/second
storage type	2 GB SD card
computer interface	fiber optic/USB and Bluetooth®
operating system	current Windows OS
sync option	fiber optic/TTL, in and out
power supply	NIMh battery

pliance®-xf analyser for mobile measurements

Figure 6.3. Pliance Analyser Box.

Figure 6.4. Pliance on the Horse.

Every individual experienced have one lap of habituation (Figure 6.4) on the horse then three trials were recorded and if the participant was unacceptably unbalanced (in a manner that could affect their safety) the subject was assisted and that trial would be repeated. Every participant sat passively on the horse for a total of 5 minutes.

Figure 6.5. Pliance Placed under the HPOT Pad.

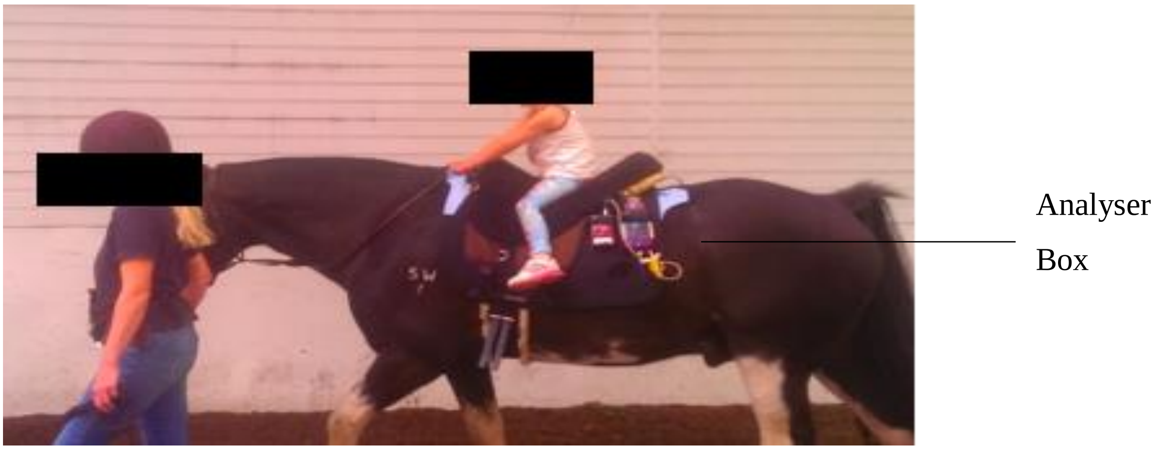


Figure 6.6. Child Ride the horse while Being Recorded with the Pliance.

Force Plate – Static Balance Evaluation

In this study, a piezoelectric force plate (Kistler type 9865, Kistler AG, Winterthuh, Switzerland), a gold standard equipment was used to assess CoP sway path AP, ML and total and it is velocity in the three conditions for 10 seconds, with a sampling frequency of 100 Hz during quiet sitting for every participant.

Every child GMFCS level I, II and III was allowed to keep their shoes, orthosis. This decision was taken to translate the most common situation of standing for the children as they use the orthosis and specific shoes that help them to keep the balance and the ankle/foot positioned in more adequate manner.

The children GMFCS level IV and V (not able to walk) that used body suit could maintain them, as requested by the parents. Those children were allowed to sit on the force plate in their most comfortable position which was in "W" (tights rotated internally, knees bent, sitting between their feet) or with legs-crossed. This was considered for three reasons:

1. The children were very small and they would fit entirely on the force plate in one of those two positions;
2. Using the force plate in a chair/bench or asking for the child to sit with their legs extended was not something the children with those levels of motor capacity were able to achieve;
3. The child was able to sit by themselves for at least 10 seconds for the measure to be considered for the analysis. The sitting position was repeated for every measure.

The measurements were taken before and after the child mounted the horse passively for 5 minutes, at 0 weeks, 6 weeks and 12 weeks of HPOT treatment.

Data Processing: Calculating Centre of Pressure Components

For data analysis of the CoP components using the Pliance® system and the Force Plate, the first second of each trial was deliberately discounted, to ensure that the horse was walking on straight line and the next 10 seconds were considered. To calculate sway path (mm) and velocity (mm/s^2) in anterior-posterior (AP) on the X direction, medial-lateral (ML) on Y direction data were exported to Excel® from Pliance software® in a. fgt format with the force (N) and displacement on X and Y direction (mm) being presented every two milliseconds. The Pliance® system gave the values automatically, for the force plate the equations explained below were inputted into Excel®.

To calculate the sway path (SP) in the X and Y direction, the change in position of the CoP was calculated between each sample. This difference was then rectified (to avoid negative values) and then summed to provide the sway path in X (AP) and Y (ML) as on the equation 6.1 below:

Equation 6.1. Calculation of Sway Path on X and Y Plans (mm).

$$Sway\ Path\ (X,Y)\ =\sum\sqrt{(\Delta x,y)n}$$

Where Δ = the difference between two given points every two milliseconds and *n* equals to the number of times this operation was repeated between the 2^{nd} second and the 11^{th} second. This equation was used to calculate sway path in X plane (anterior-posterior) and in the Y plane (medial-lateral).

The sway path total was calculated by the summation of the square root of the summation of the any given point at every two milliseconds to square in X and Y as described in the equation 6.2 below:

Equation 6.2. Calculation of Sway Path Total (mm).

$$Sway\ Path\ (total) = \sum\sqrt{((\Delta x)n)^2 + ((\Delta y)n)^2}$$

Where Δx = the difference between two given points every two milliseconds in the X plan, Δy = the difference between two given points every two milliseconds in the Y plan and *n* equals to the number of times this operation between the 2^{nd} second and the 11^{th} second.

Newton's equation (equation 6.3) was used to calculate the velocity of sway path AP, ML and total. Summation of every given point every two milliseconds the SP divided by 1/50 as shown on equation 6.4. The same equation was used to calculate Total Velocity and Velocity in the X and Y plains.

Equation 6.3. Newton's Equation for Velocity of a Uniform Straight Movement.

$$Veloc = \frac{\Delta s}{\Delta t}$$

Where Δs = the distance variation from point A to point B and Δt = the time variation from point A to point B.

Equation 6.4. Velocity Calculation (mm/s).

$$Velocity = \sum \frac{(\Delta sp)n}{{}^{1}/_{50}}$$

Where Δsp = the difference between two given points every two milliseconds in the sway path total, sway path AP and sway path ML, *n*= equals to the number of times this operation between the 2nd second and the 11th second.

Data Extraction: Balance Evaluation

Variables for Comparison

Pliance®

The data from the Pliance® was shown in real time while the participant sitting passively on the horse for 5 minutes and then extracted in. fgt format. Three measurement blocks of evaluation were collected within the 5 minutes' session. The first second was not considered, and the subsequent 10 seconds (from 2nd till 11th second) were considered to the analysis. The data extracted was sway path total, sway path anterior-posterior (X) and medial-lateral (Y) and the sway velocity total and in X and Y.

Force Plate

AP and ML coordinates of the CoP were extracted for each trial. Data were collected at 50 Hz. The following variables were calculated to characterise the CoP movement while in quiet sitting:

1- Sway Path Total, AP and ML
2- Sway Velocity Total, AP and ML

The calculation of the variables has been previously described above. The software used to obtain the variables was Kistler Mars®. Data were extracted from the software to Excel®.

6.4. Methodology of Spasticity Evaluation

Aim

To increase knowledge and understanding on the effects of 12 weeks of HPOT treatment on spasticity of children with spastic CP.

Protocol of Spasticity Evaluation

Evaluations of spasticity were made at baseline and after 6 and 12 weeks of treatment to assess the long-term effect of HPOT on spasticity. To evaluate the short-term effect, participants were assessed before and after passively riding for 5 minutes, at baseline, 6 weeks and 12 weeks with the MAS. The muscle groups that were evaluated to investigate both the short and long-term effect of HPOT in spasticity can be found on Table 6.2. All muscles were evaluated bilaterally, before and after riding for 5 minutes, at baseline, after 6 and 12 weeks.

Table 6.2. Group of Muscles that were Evaluated

Upper Limb	**Lower Limb**
Biceps	Quadriceps
Triceps	Hamstrings
Shoulder Flexors	Gastrocnemius
Shoulder Extensors	Tibialis Anterior
Shoulder internal rotators	Hip Adductors
Shoulder External Rotators	Hip Abductors
Shoulder Abductors	
Shoulder Adductors	

Modified Ashworth Scale

For all measures the child was positioned supine on a mattress, without any orthosis or shoes. Body support was allowed as just the limbs were being evaluated.

For muscles whose primary action is flexing the joint, the joint was placed in the maximally flexed position and moved to a position of maximum extension for approximately one second (counted "one thousand one"). If primary purpose of activating the muscle was to extend the joint, then the joint would be placed on the maximum extension position and moved to a position of maximum flexion. The same protocol was used for assessing the all muscle groups as advised by Bohannon (1987). The score given was based on the resistance felt when doing the evaluation. This resistance is velocity dependent and was graded (Table 6.3) following the guidelines of MAS, with zero indicating no increase in the muscle tone and 4 indicating the affected limb is completely rigid in flexion and/or extension.

All the evaluations were carried out by the same examiner. The muscle groups are not considered independent variables, as they do not affect the level nor the presence of spasticity. Spasticity is what going to affect one or all of the muscle groups listed above on table 6.2. Each muscle group will be analysed separately, and the spasticity (evaluated by the MAS) is the characteristic of the muscle condition that is going to be evaluated, it is the dependent variable, or, in other words, what it is expected to change over the course of 12 weeks of HPOT treatment.

Data Extraction: Spasticity Evaluation

In order to facilitate the analysis, I have used a consecutive number scheme within the MAS scale as shown on the table 6.3 below, as previously done by Lechner, et al., 2003.

Table 6.3. MAS and Analysis Label

Modified Ashworth Scale		Label to analysis
Number	**Description**	**Number**
0	No increase in muscle tone	0
1	Slight increase in muscle tone, manifested by a catch at the end of the range of motion (RoM) when the affected part(s) is moved in flexion of extension	1
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the RoM.	2
2	More marked increase in muscle tone through most of the RoM, but affected parts easily moved.	3
3	Considerable increase in muscle tone, passive movement difficult.	4
4	Affect parts rigid in flexion or extension.	5

6.5. Methodology on Quality of Life Evaluation

Aim

To increase knowledge and understanding on the effects of 12 weeks of HPOT treatment on quality of life of children with spastic CP.

Evaluation of Quality of Life: PedsQL® Scale

The scale PedsQL® has 23 items and it is divided in four categories: Physical, Social, School and Emotional function. It takes less than four minutes to complete, it is flexible and has age appropriate questionnaires (2-4; 5-7; 8-12; 13-18). The questionnaire (Appendix 7) was given to each parent/guardian in each of the assessments, according to the age of the child being assessed. PedsQL® uses a Likert scale, and for each task parents were asked how difficult was for the child to complete that specific element. Parents have the choice to choose from "that was never a problem to the child to complete that task", giving zero to "almost always a problem", giving four. For this specific questionnaire, a higher the score is considered an indicative of lower QoL.

Data Extraction: Quality of Life

In each category of PedsQL® the sum of the points was taken for each participant. All categories were summed together to give the total PedsQL® score. The scores of all participants were used in statistical analysis. Those scores obtained prior to the treatment were compared with the ones obtained at 6 and 12 weeks. For this scale, the smaller the score obtained indicates a positive impact of HPOT on their QoL, which indicates that the child had less problem doing a determined activity on the scale when values at 6 weeks was compared to values at 0 weeks and when values at 12 weeks was compared to values at 6 and 0 weeks.

6.6. Statistical Analysis of the Data

All the statistical analyses were performed using Stata®, version 15.1 (StataCorp LLC). To investigate the hypothesis presented in the thesis regard the effect of HPOT in children with CP (GMFM, PedsQL, static and dynamic test and spasticity) the test used to analyse all variables of this study was the Friedman's test of multiple comparisons with pairwise signed-ranks tests. This is a non-parametric test used to compare observations on the same subjected that are repeated through a period of time, as it was proposed in this cohort study.

Normality tests (shapiro-wilk normality test) were run in all variables (Appendix 10). Only the data from the quality of life variable presented normal distribution, however, due to the small sample size it was decided to apply Friedman's test to all variables, as it is an alternative for ANOVA when the assumption of normality is not met. In this test the original variables are ranked within all cases possible, the mean ranks are computed and p-value <0.05 refuse the null hypothesis of equal population distributions (SPSS-tutorial, https://www.spss-tutorials.com/spss-friedman-test-simple-example/; accessed on 28/12/2020). Friedman Test of multiple comparisons with pairwise signed-ranks tests. Friedman was chosen as it is a non-parametric test.

The literature brings that using nonparametric tests, such as Friedman's test are recommended for small sample sizes, as such, the one presented in this study (Dwivedi, Mallawaarachchi and Alvarado, 2016). Paraphrasing Siegel (1956), the use of non-parametric tests has a bunch of advantages, among them the fact that they are "distribution-free", by all means, not assuming normality from a determined population (as the variables presents in this thesis) and that they are useful to test small samples sizes, as such the one presented in this study.

Siegel (1956) also explained that the Friedman's test can be used when studying the same group of subjects under each X condition and when the measure of the variable is at an ordinal scale, such as the variables analysed at this thesis (Siegel, 1956).

The data presented has two independent variables (HPOT treatment and GMFCS), the interaction between these two variables on the dependent variable will also be demonstrated (Hawkins, 2014). The data will be presented in tables and graphs.

To facilitate the report of the results please consider the following:

- GMFM – 88 is the dependent variable
- GMFCS is the other independent variable for GMFM. GMFCS Levels I and II will be called GMFCS 1, and GMFCS Levels III, IV and V will be called GMFCS 2.
- PedsQL® is the dependent variable
- Dependent Variable of spasticity evaluation (what is expected to vary or change in result of the independent variable):
    - MAS score is the dependent ordinal variable. It is the dependent variable because it measures the spasticity which is the outcome expected to change due to HPOT treatment (which will be the independent variable);
- Independent variables for spasticity evaluation (the factor that will cause a variation on the dependent variable):
    - Long-term evaluation is one of the independent variables. Evaluation 1 is the pre-treatment, Evaluation 2 is the evaluation after 6 weeks of HPOT treatment and Evaluation 3 is the evaluation after 12 weeks of HPOT

treatment. It is an independent variable because it marks the period of HPOT treatment, and it is then one of the things it is expected to affect the spasticity (evaluated by MAS).

- Short-term evaluation is also an independent variable. Evaluation pre-horse is the evaluation made before the child mount the horse passively for 5 minutes. Evaluation post-horse is the evaluation made after the child mount the horse passively for 5 minutes. In this case, it is an independent variable because it is expected that sitting the horse passively for 5 minutes will generate a short-term variation on spasticity (evaluated by MAS).

- The data gathered here has six dependent variables for balance evaluation (static and dynamic): sway path anterior-posterior, medio-lateral and total and sway velocity anterior-posterior, medio-lateral and total. This for each, dynamic and static balance. For each child and for each of these dependent variables there are three trials for the same evaluation, as exemplified below.

Dependent variables - Balance		**Independent Variables – HPOT/evaluation points**		**Trials for analysis**
Dynamic Balance	Sway Path Anterior-Posterior	0 weeks		3 trials – 10 seconds each
		6 weeks		3 trials – 10 seconds each
		12 weeks		3 trials – 10 seconds each
Static Balance	Sway Path Anterior-Posterior	0 weeks	Pre-horse	3 trials – 10 seconds each
			Post-horse	3 trials – 10 seconds each
		6 weeks	Pre-horse	3 trials – 10 seconds each
			Post-horse	3 trials – 10 seconds each
		12 weeks	Pre-horse	3 trials – 10 seconds each
			Post-horse	3 trials – 10 seconds each

Figure 6.7. Example of how data was collected for analysis for each type of balance being evaluated.

- Evaluation is one of the independent variables for all analysis. Evaluation 1 is the pre-treatment, Evaluation 2 is the evaluation after 6 weeks of HPOT treatment and Evaluation 3 is the evaluation after 12 weeks of HPOT treatment.

6.7. Bias

This was a cohort study, where every subject was followed through a period of time and was their own control. Cohort study is a primary investigation, and it is considered level II of scientific evidence (John Concato, 2000). This type of study brings evidence and help to build the body of the literature bringing the challenges and possible results of testing a specific type of intervention.

Cohort studies bring important results, and as discussed in the literature they do not systematically over-estimate the magnitude of associations between the intervention and the outcome and also that there is little evidence that treatment effects in observational studies are different than those brought on clinical trials (John Concato, 2000; Benson and Hartz, 2000). This is only a small short-term cohort study, but it followed the period of treatment that is most used in the literature as discussed in the systematic review and also the treatment term that is most used on practice in Brazil and in the UK. In addition, with the new analysis of the data, using only non-parametric test and being more conservative in the assumptions, the statistical differences are more trustable. A recommendation was made for bigger cohort studies, following a bigger sample of children with cerebral palsy to establish the results presented here. Randomized clinical trials are also recommended, with the important consideration that the type of exercises done in the HPOT sessions are not delimited and control, every child should still have their sessions tailored to them, as recommended by the WHO.

In the UK there were, at the time, only two centres doing HPOT. The reach centre and another centre in Wales. The logistics of going to Wales were not possible at the time, and an executive decision was made to do the treatment and analysis at only one centre. The fact that the therapy was done by only one physiotherapist, brings less bias to the treatment given, as it was ensured this therapist was properly qualified in HPOT and doing it as accordingly do the AHA and ACPTR guidelines.

Amalgamation of Chapters 5-8: Now chapter 7 to 10.

7. Results Chapter 7: The Effect of Hippotherapy on Gross Motor Function, Spasticity, Balance and Quality of Life in Children with Spastic Cerebral Palsy

The work in this chapter was presented as a talk at the following events:

1. Charter of Physical Therapists in Therapeutic Riding Eastern Region Training Day at the Reach Centre, Brentwood – UK on March 17th, 2017.
2. 7th Annual Research Conference of Faculty of Science and Technology – Anglia Ruskin University, Chelmsford – UK on May 10th, 2017.
3. 11th Annual Research Student Conference – Anglia Ruskin University, Cambridge – UK on July 7th, 2017. This work received a Highly Commended Award at this Conference.

7.1. General Hypothesis of the Study

It is hypothesised that 12 weeks of HPOT would physical components (gross motor function, balance and spasticity) and quality of life of children with CP.

Sub-hypothesis of the Experimental Study:

GMFM – 88 scores

It is hypothesised that 12 weeks of HPOT would significantly improve the GMFM-88 scores of children with CP and that children GMFCS levels I and II would respond differently to HPOT treatment when compared to children levels III, IV and V.

Balance

It is hypothesised that HPOT treatment will influence certain components of balance, such as the sway path and sway velocity of the CoP of children with CP, by making the sway path and sway velocity smaller after HPOT treatment while riding and/or sitting passively on the force plate.

Spasticity

It is hypothesized that a short period sitting passively on the horse walking in a straight line for 5 minutes and 12 weeks of HPOT treatment will reduce spasticity of the upper and lower limbs of children with CP.

7.2. Results: Effect of HPOT in the GMFM – 88 scores

Participant Characteristics

Table 7.1 presents the general characteristics of the participants, their CP classification according to severity, topography and movement disorder and gross motor function classification according to GMFCS levels. The guardians/parents of participant 2 withdrew the child from the study after the first evaluation for personal reasons. Patient 11 only did 6 weeks of therapy and had 2 assessments as she was recruited only in time to the start of the second block of therapy (Table 7.1).

Table 7.1. Demographic Characteristics of the Participants.

	Gender	Age (in years)	Height (cm)	Weight (Kg)	CP classification	GMFCS
Participant 1	Female	8	137	33.47	Spastic Diplegic	I
Participant 2	Female	3	97	10.56	Spastic Quadriplegic	V
Participant 3	Female	4	99	11.02	Spastic Quadriplegic	V
Participant 4	Male	4	102	18.61	Spastic Diplegic	IV
Participant 5	Male	4	101	14.60	Spastic Quadriplegic	V
Participant 6	Female	4	106	17.75	Spastic Diplegic	III
Participant 7	Female	4	104	10.79	Spastic Hemiplegic	I
Participant 8	Female	4	100	13.67	Spastic Quadriplegic	IV
Participant 9	Female	8	133	28.76	Spastic Hemiplegic	I
Participant 10	Female	4	111	22.59	Spastic Diplegic	III
Participant 11	Female	4	105	15.3	Spastic Diplegic	II
Mean ± SD		4.64±1.69	108.64±13.60	17.92±7.55		

CP: cerebral palsy; GMFCS: gross motor function classification system. Height in centimetres, Age in years and Weight in kilograms.

Effect of Hippotherapy on Gross Motor Function Measure Scores

The GMFM-88 total score has improved in all participants after 12 weeks of HPOT sessions. When looking specifically into the children GMFCS levels I and II, the GMFM-88 total scores have improved after 6 weeks of HPOT treatment and they reached the maximum scores on categories A, B and C also after 6 weeks of therapy. For children GMFCS levels III, IV and V, three children have reached maximum scores on category A after 6 weeks of HPOT, however no one has reached maximum scores in the other categories after 12 weeks. This information is displayed on Table 7.2.

Table 7.2. GMFM-88 Scores after 6 and 12 weeks of HPOT.

	GMFM																	
	88-1%	88-2%	88-3%	A-1%	A-2%	A-3%	B-1%	B-2%	B-3%	C-1%	C-2%	C-3%	D-1%	D-2%	D-3%	E-1%	E-2%	E-3%
Patient1	85,98	93,56	96,21	92,16	100,00	100,00	98,33	100,00	100,00	80,95	100,00	100,00	82,05	100,00	100,00	76,39	76,39	86,11
Patient3	15,91	15,91	19,70	37,25	37,25	50,98	28,33	28,33	31,67	14,29	14,29	16,67	0,00	0,00	0,00	0,00	0,00	0,00
Patient4	42,42	44,70	46,97	80,39	82,35	84,31	68,33	73,33	76,67	35,71	35,71	40,48	10,26	10,26	10,26	15,28	18,06	19,44
Patient5	15,53	23,48	27,27	50,98	56,86	72,55	20,00	48,33	48,33	7,14	9,52	14,29	0,00	0,00	0,00	0,00	0,00	0,00
Patient6	57,58	59,85	60,98	96,08	100,00	100,00	98,33	98,33	98,33	61,90	71,43	71,43	23,08	23,08	23,08	12,50	12,50	16,67
Patient7	93,18	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	97,62	100,00	100,00	100,00	100,00	100,00	76,39	100,00	100,00
Patient8	44,32	47,35	49,62	88,24	100,00	100,00	71,67	75,00	81,67	57,14	57,14	57,14	12,82	12,82	12,82	0,00	0,00	2,78
Patient9	90,91	100,00	88,64	100,00	100,00	100,00	98,33	100,00	50,00	90,48	100,00	100,00	100,00	100,00	100,00	73,61	100,00	100,00
Patient10	56,44	56,82	63,26	76,47	76,47	96,08	95,00	96,67	96,67	76,19	76,19	85,71	23,08	23,08	25,64	16,67	16,67	19,44

A, B, C, D and E: categories of GMFM-88; 1-evaluation pre-treatment; 2-evaluation after 6 weeks; 3-evaluation after 12 weeks.

The data analysis has shown a significant difference the distribution of values on treatment – baseline, 6wks, 12wks and GMFCS comparison, as Friedman test = 8.083, p=0.018. Table 7.3 shows where the statistical difference is found. Mean and standard deviation of the scores is presented, however, it is important to point it out that the comparison is based on the mean of the rank of the values.

The analysis demonstrated that GMFM – 88 total of walkers are significantly different than non – walkers, meaning that the walkers have better motor capacity. The analysis also demonstrated that the non-walkers improved significantly with the HPOT treatment.

Table 7.3. Friedman test for GMFM - total

Group	Total score Mean (sd)			p value*
	Pre-treatment	6 weeks	12 weeks	
Walkers (G1)	90.02 (3.68)	97.85 (3.72)	94.95 (5.79)	PreTreat = 6 wks (p=0.109) Pretreat = 12 wks (p=0.285) 6 wks. = 12 wks. (p=0.781)
Non-walkers (G2)	38.70 (18.83)	41.35 (17.86)	44.63 (17.71)	**PreTreat ≠ 6 wks (p=0.034)** **PreTreat ≠ 12 wks (p=0.028)** **6 wks. ≠ 12 wks. (p=0.027)**
p values**	**G1 ≠ G2 (p=0.020)**	**G1 ≠ G2 (p=0.019)**	**G1 ≠ G2 (p=0.020)**	

*level of statistical significance according to pairwise signed-ranks tests; ** level of statistical significance according to Mann-Whitney test

No significance was found in the distribution of values in the different moments or groups when looking into Dimension A (Friedman's test= 4.750, p=0,093), dimension B (Friedman test=5.083, p=0.079), dimension C (Friedman test=4.333, p=0.115), dimension D (Friedman test=3.250, p=0.197) and dimension E (Friedman test=5.250, p=0.072). The figure 7.1 shows the scores for every child evaluated in all points.

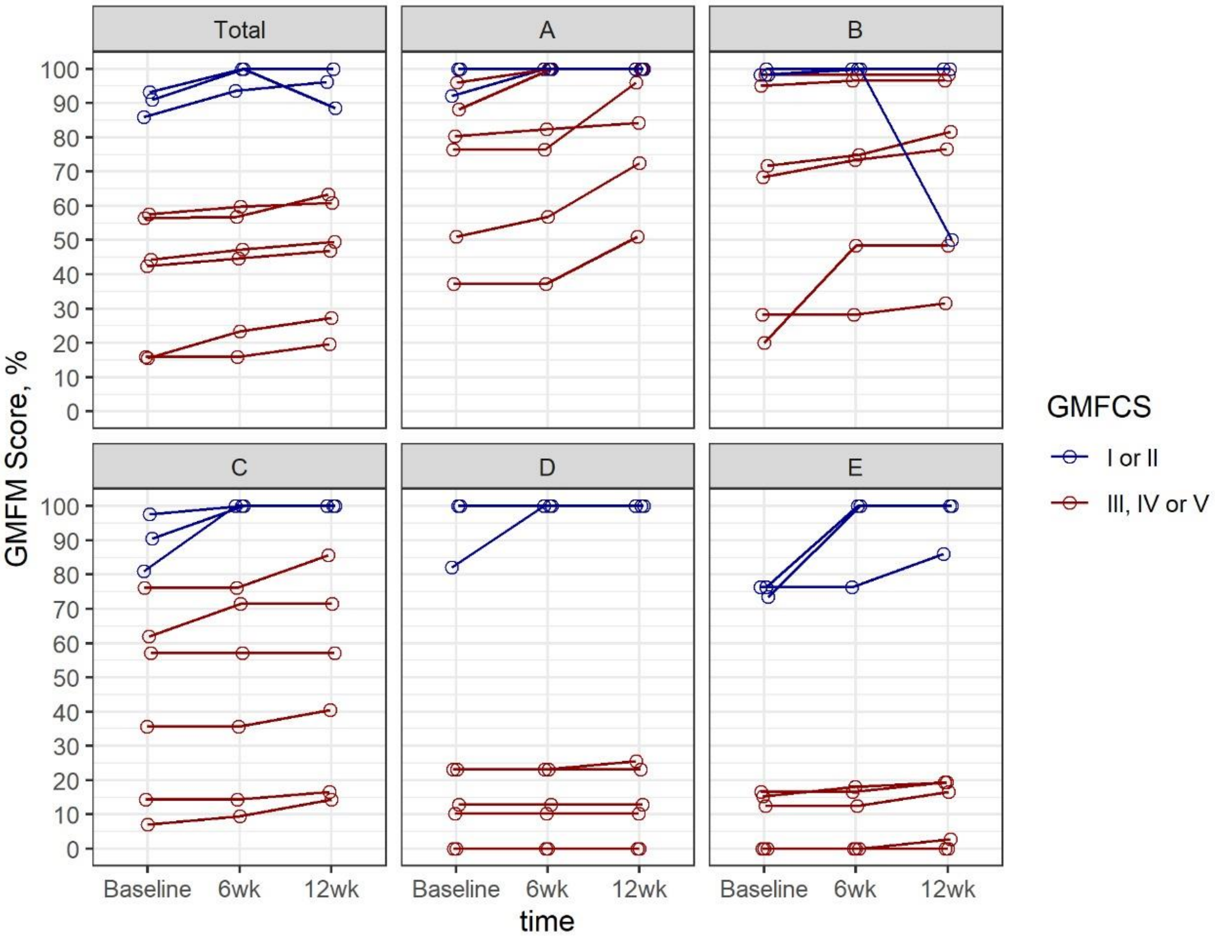


Figure 7.1.GMFM – 88 Total scores and its Dimensions.

GMFCS level I and II: children with CP that were classified at these levels; GMFCS levels III, IV and V: children with CP that were classified at these levels.

7.3. Results: Dynamic and Static Centre of Pressure Variation in Children with Spastic Cerebral Palsy after Hippotherapy Treatment

Pliance® System – Dynamic Balance

Sway Path of the Centre of Pressure

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and GMFCS comparison when looking to sway path anterior-posterior (Friedman test=16.111, p=0.024), sway path medio-lateral (Friedman test=15.000, p=0.036) and sway path total (Friedman test=17.889, p=0.012). No difference was found according to pairwise signed-ranks tests for any of the comparisons as shown on Table 7.4.

Sway Velocity of the Centre of Pressure

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and GMFCS comparison when looking to velocity anterior-posterior (Friedman test=16.556, p=0.020), sway velocity medio-lateral (Friedman test=15.111, p=0.035) and velocity total (Friedman test=16.333, p=0.022). Sway velocity medio lateral and velocity total were found to be significantly different according to pairwise signed-ranks tests when 12 weeks of treatment was compared to 6 weeks, indicating an improvement as shown on table 7.4

Table 7.4. Sway Path of the CoP after 12 Weeks of HPOT Treatment.

	Mean (sd)			
Variables	**Time 1 (n=8)**	**Time 2 (n=9)**	**Time 3 (n=9)**	**p values***
Sway Path AP	1749.5 (618.6)	2068.8 (970.0)	1567.7 (653.5)	Time 1 = Time2 (p=0.161) Time 1 = Time 3 (p=0.093) Time 2 = Time 3 (p=0.051)
Sway Path ML	1755.1 (526.0)	1805.7 (557.1)	1426.3 (543.3)	Time 1 = Time2 (p=0.484) Time 1 = Time 3 (p=0.161) **Time 2 ≠ Time 3 (p=0.038)**
Sway Path Total	2746.9 (847.4)	3045.0 (1144.2)	2344.2 (853.1)	Time 1 = Time2 (p=0.263) Time 1 = Time 3 (p=0.161) Time 2 = Time 3 (p=0.051)
Sway V Total	274.4 (84.8)	286.7 (99.7)	235.0 (84.5)	Time 1 = Time2 (p=0.575) Time 1 = Time 3 (p=0.161) **Time 2 ≠ Time 3 (p=0.028)**
Sway V AP	174.8 (61.9)	194.2 (82.4)	157.4 (64.7)	Time 1 = Time2 (p=0.327) Time 1 = Time 3 (p=0.093) Time 2 = Time 3 (p=0.051)
Sway V ML	175.3 (52.6)	170.1 (54.2)	142.8 (54.1)	Time 1 = Time2 (p=0.263) Time 1 = Time 3 (p=0.161) Time 2 = Time 3 (p=0.086)

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

In the figure 7.2 it is possible to observe the distribution of the sway path of the CoP for all participants, accordingly to their ability to walk. It is possible to notice the downwards trend for both GMFCS 1 and 2, however, even more prominent on the GMFCS 1 groups. In red the GMFCS 1 (level I and II) are demonstrated and in blue the GMFCS 2 (levels III, IV and V). Each line represents one patient.

In the figure 7.3 it is possible to observe the distribution of the sway velocity of the CoP for all participants, accordingly to their ability to walk. It is possible to notice the downwards trend for both GMFCS 1 and 2, however, even more prominent on the GMFCS 1 groups. In red the GMFCS 1 (level I and II) are demonstrated and in blue the GMFCS 2 (levels III, IV and V). Each line represents one patient.

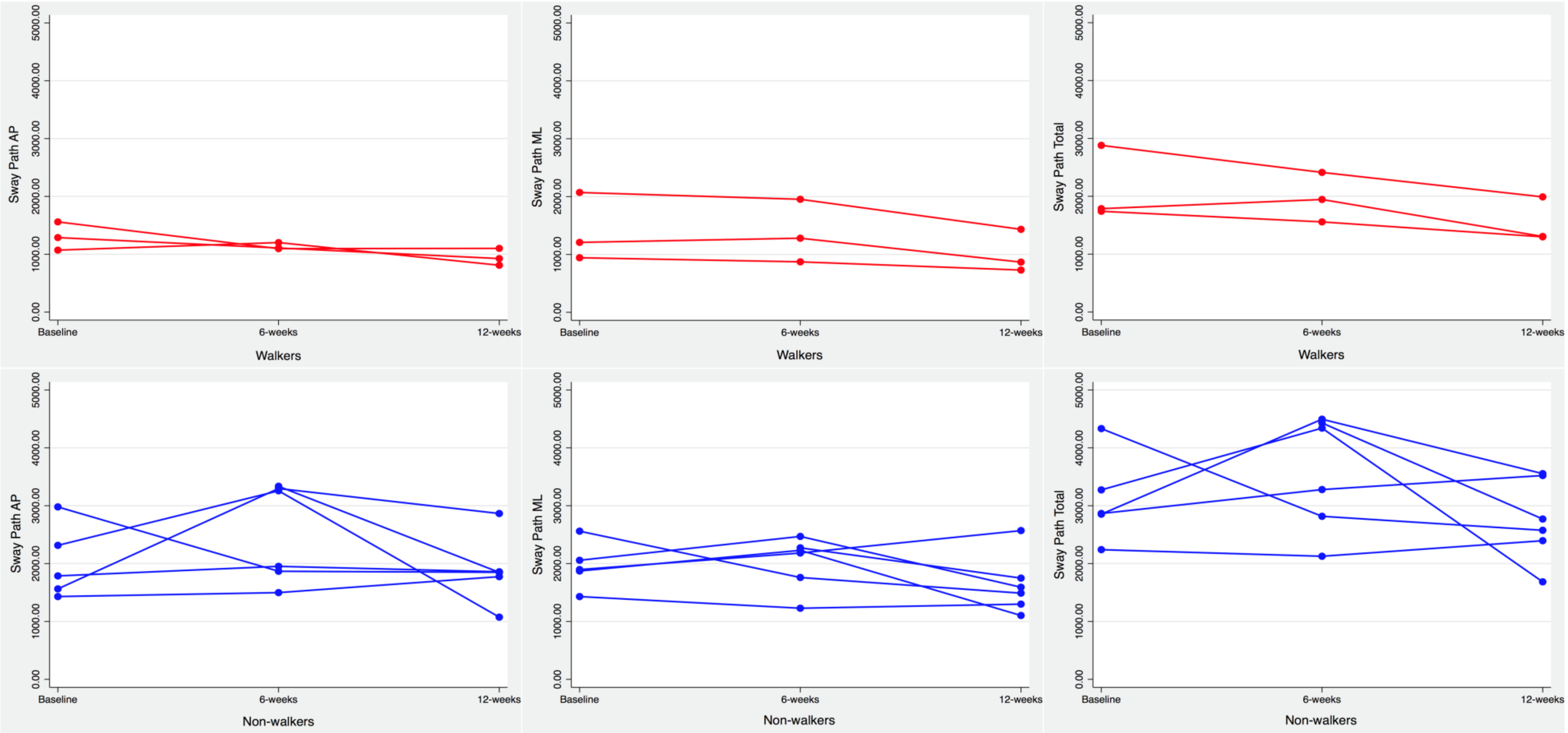


Figure 7.2. Sway Path of CoP.

AP: anterior-posterior; ML: medio-lateral; mm: millimetres; 1,2 and 3: 0, and 12 weeks' evaluations respectively. Walkers: GMFCS levels I and II – able to walk; Non-walkers: GMFCS levels III, IV and V – unable to walk.

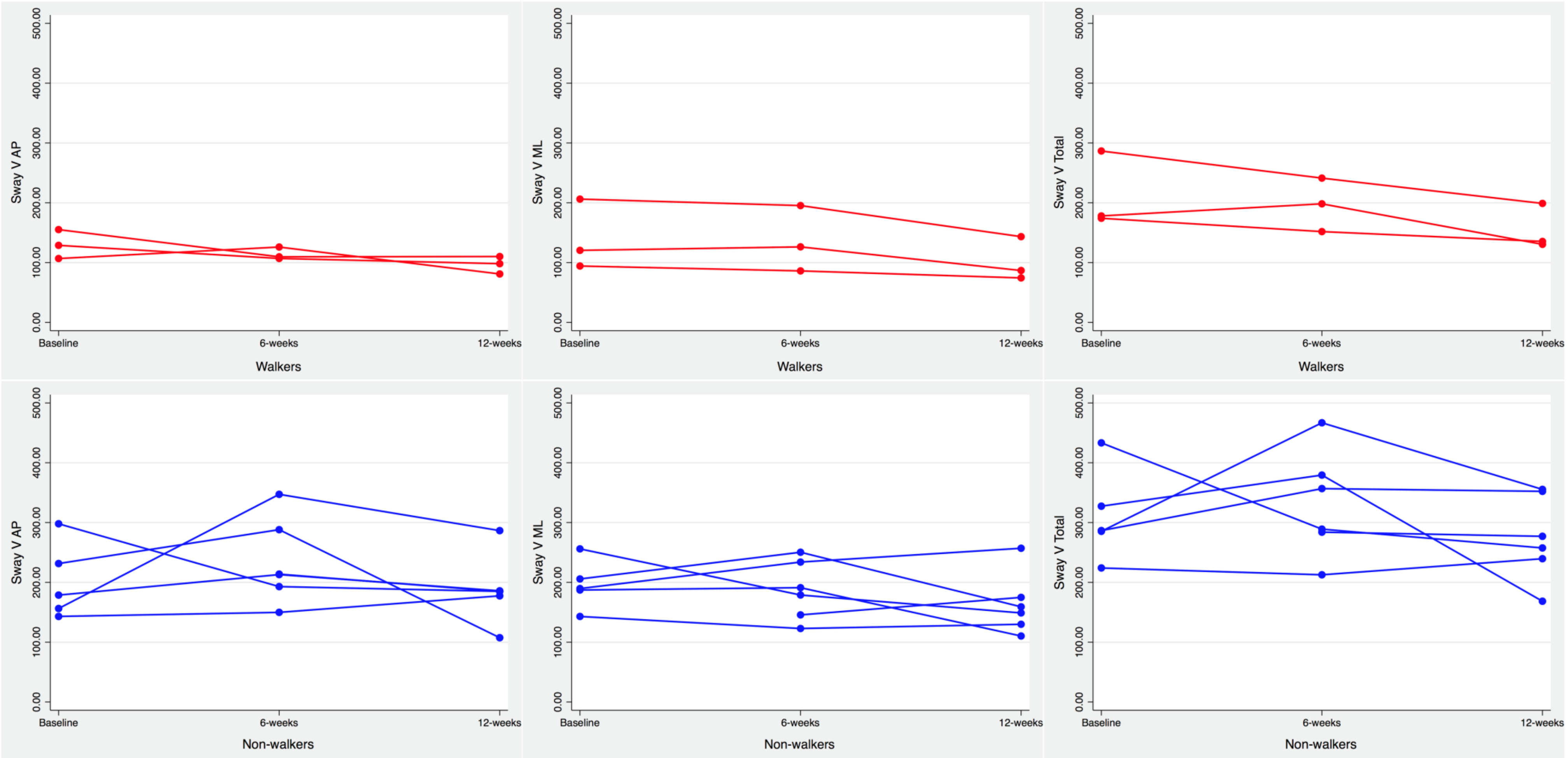


Figure 7.3. Sway Velocity of CoP

AP: anterior-posterior; ML: medio-lateral; mm: millimetres; 1,2 and 3: 0, and 12 weeks' evaluations respectively. Walkers: GMFCS levels I and II – able to walk; Non-walkers: GMFCS levels III, IV and V – unable to walk.

Force Plate – Static Balance

Sway Path of the Centre of Pressure

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and GMFCS comparison when looking to sway path anterior-posterior (Friedman test=6.000, p=0.049) and sway path total (Friedman test=6.000, p=0.049). No difference was found for sway path medio-lateral (Friedman test=4.667, p=0.097). No difference was found according to pairwise signed-ranks tests for any of the comparisons as shown on Table 7.5.

Sway Velocity of the Centre of Pressure

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and GMFCS comparison when looking to velocity anterior-posterior (Friedman test=6.000, p=0.049) and velocity total (Friedman test=6.000, p=0.049). No difference was found for velocity medio-lateral (Friedman test=3.000, p=0.083). No difference was found according to pairwise signed-ranks tests for any of the comparisons as shown on Table 7.5.

Table 7.5. Sway Path and Velocity – Static Balance

Variables	**Mean (sd)**			**p values***
	Time 1 (n=8)	**Time 2 (n=4)**	**Time 3 (n=8)**	
Inter Sway AP	258.9 (78.9)	194.1 (77.2)	270.7 (69.8)	Time 1 = Time2 (p=0.285) Time 1 = Time 3 (p=0.735) Time 2 = Time 3 (p=0.273)
Inter Sway ML	190.9 (62.7)	224.1 (177.7)	233.1 (142.0)	
Inter Sway Total	357.5 (98.6)	327.8 (196.1)	433.0 (160.7)	Time 1 = Time2 (p=1.000) Time 1 = Time 3 (p=0.128) Time 2 = Time 3 (p=0.144)
Inter Veloc AP	25.7 (7.9)	19.4 (7.7)	27.3 (6.7)	Time 1 = Time2 (p=0.285) Time 1 = Time 3 (p=0.735) Time 2 = Time 3

				(p=0.144)
Inter Veloc ML	19.1 (6.2)	16.0 (12.0)	22.9 (14.4)	
Inter Veloc Total	35.8 (9.9)	32.8 (19.7)	43.4 (16.1)	Time 1 = Time2 (p=1.000) Time 1 = Time 3 (p=0.128) Time 2 = Time 3 (p=0.144)

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

7.4. Results: Short- and Long-Term Effect of Hippotherapy on Ashworth Scale Scores when Evaluating Upper and Lower Limbs of Children with Spastic Cerebral Palsy.

Effect of 12 weeks of Hippotherapy Treatment on Spasticity on the Upper Limb

Biceps

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right biceps (Friedman test==26.667. p<0.001) and left biceps (Friedman test=18.256, p=0.019). For the right biceps, spasticity before riding (pre-horse) was significantly smaller when 12 weeks was compared to baseline (p=0.028). It was also found that after riding for 5 minute (post-horse) spasticity was significantly smaller when 6 weeks was compared to baseline (p=0.015) and when 12 weeks was compared to baseline values (p=0.017), as shown on Table 7.6. For the left biceps spasticity was significantly smaller when 12 weeks was compared to baseline on the post-horse comparison (p=0.017). Post-horse was also found to be significantly smaller at 6 weeks and 12 weeks when comparted to pre-horse for the right biceps and at 12 weeks for left biceps. All values and comparisons can be found on table 7.6.

Table 7.6. Effect of HPOT on Spasticity of Biceps

Right Biceps				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.30 (1.16)	1.80 (1.32)	1.11 (0.93)	Time 1 = Time 2 (p=0.188) **Time 1 ≠ Time 3 (p=0.028)** Time 2 = Time 3 (p=0.164)
Post-horse	1.90 (0.99)	1.20 (1.03)	0.67 (0.71)	**Time 1 ≠ Time 2 (p=0.015)** **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.217)
	Pre = Post (p=0.084)	**Pre ≠ Post (p=0.014)**	Pre = Post (p=0.084)	
Left Biceps				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.00 (1.25)	1.50 (0.85)	1.22 (0.97)	Time 1 = Time 2 (p=0.202) Time 1 = Time 3 (p=0.132) Time 2 = Time 3 (p=0.083)
Post-horse	1.30 (0.95)	1.00 (0.82)	0.44 (0.73)	Time 1 = Time 2 (p=0.343) **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.056)
	Pre = Post (p=0.143)	Pre = Post (p=0.059)	**Pre ≠ Post (p=0.028)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Triceps

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right triceps (Friedman test=26.244. p=0.001) and left triceps (Friedman test=16.067, p=0.041). For the right triceps, spasticity before riding (pre-horse) was significantly smaller when 12 weeks was compared to baseline (p=0.057). It was also found that after riding for 5 minute (post-horse) spasticity was significantly smaller when 6 weeks was compared to baseline (p=0.047). For the left triceps spasticity was significantly smaller when 6 weeks was compared to baseline on the post-horse comparison (p=0.027). Post-horse was also found to be significantly smaller at all time (baseline, 6 weeks and 12 weeks) when comparted to pre-horse for this muscle group. All values and comparisons can be found on table 7.7.

Table 7.7. Effect of HPOT on Spasticity of Triceps

Group	Mean (sd) Time 1	Mean (sd) Time 2	Mean (sd) Time 3	p value*
Right Triceps				
Pre-horse	2.10 (1.10)	1.80 (1.13)	1.33 (1.00)	Time 1 = Time 2 (p=0.507) **Time 1 ≠ Time 3 (p=0.047)** Time 2 = Time 3 (p=0.083)
Post-horse	1.10 (0.74)	0.90 (0.88)	0.44 (0.73)	Time 1 = Time 2 (p=0.522) **Time 1 ≠ Time 3 (p=0.047)** Time 2 = Time 3 (p=0.083)
	Pre ≠ Post (p=0.006)	**Pre ≠ Post (p=0.010)**	**Pre ≠ Post (p=0.017)**	
Left Triceps				
Pre-horse	2.00 (0.82)	1.20 (0.79)	1.22 (0.97)	**Time 1 ≠ Time 2 (p=0.027)** Time 1 = Time 3 (p=0.084) Time 2 = Time 3 (p=0.564)
Post-horse	1.00 (0.82)	0.60 (0.52)	0.44 (0.73)	Time 1 = Time 2 (p=0.165) Time 1 = Time 3 (p=0.084) Time 2 = Time 3 (p=0.564)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.026)**	**Pre ≠ Post (p=0.028)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Wrist Flexor

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right wrist flexor (Friedman test=25.267. p=0.001) and left wrist flexor (Friedman test=19.311, p=0.013). For the right wrist flexor, no significance was found when baseline was compared to 6 and 12 weeks. For the left wrist flexor, it was found that for the values pre-horse (pre-riding for 5 minutes) was significantly smaller when 6 weeks was compared to baseline (p=0.026) and when 12 weeks was compared to baseline (p=0.017) and on post-horse (after riding for 5 minutes) when 12 weeks was compared to baseline (p=0.028).

Post-horse was also found to be significantly smaller at all time (baseline, 6 weeks and 12 weeks) when comparted to pre-horse for the left wrist flexor and at baseline and 6 weeks for the right wrist flexor. All values and comparisons can be found on table 7.8.

Table 7.8. Effect of HPOT on Spasticity of wrist flexor

Right wrist flexor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.80 (1.40)	1.40 (1.35)	1.00 (0.87)	Time 1 = Time 2 (p=0.102) Time 1 = Time 3 (p=0.164) Time 2 = Time 3 (p=0.895)
Post-horse	1.20 (1.13)	0.90 (0.99)	0.56 (1.01)	Time 1 = Time 2 (p=0.083) Time 1 = Time 3 (p=0.257) Time 2 = Time 3 (p=0.615)
	Pre ≠ Post (p=0.014)	**Pre ≠ Post (p=0.025)**	Pre = Post (p=0.102)	
Left wrist flexor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.10 (0.88)	1.50 (0.85)	1.00 (1.12)	**Time 1 ≠ Time 2 (p=0.026)** **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.164)
Post-horse	1.10 (0.74)	0.80 (0.79)	0.22 (0.44)	Time 1 = Time 2 (p=0.246) **Time 1 ≠ Time 3 (p=0.028)** Time 2 = Time 3 (p=0.084)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.008)**	**Pre ≠ Post (p=0.028)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Wrist Extensor

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right wrist extensor (Friedman test=29.433. p<0.001) and left wrist extensor (Friedman test=19.256, p=0.014). For the right wrist extensor, spasticity at 12 weeks was significantly smaller than baseline (p=0.025). For the left wrist extensor, it was found that for the values pre-horse (pre-riding for 5 minutes) was significantly smaller when 12 weeks was compared to baseline (p=0.014), both at pre-horse values.

Post-horse was also found to be significantly smaller at all time (baseline, 6 weeks and 12 weeks) when comparted to pre-horse for the left wrist extensor and at baseline and 6 weeks for the right wrist flexor. All values and comparisons can be found on table 7.9.

Table 7.9. Effect of HPOT on Spasticity of wrist extensor

Right wrist extensor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.60 (0.97)	1.30 (1.06)	0.89 (0.93)	Time 1 = Time 2 (p=0.083) **Time 1 ≠ Time 3 (p=0.025)** Time 2 = Time 3 (p=0.317)
Post-horse	0.80 (0.63)	0.70 (0.67)	0.56 (1.01)	Time 1 = Time 2 (p=0.317) Time 1 = Time 3 (p=0.427) Time 2 = Time 3 (p=0.666)
	Pre ≠ Post (p=0.009)	**Pre ≠ Post (p=0.014)**	Pre = Post (p=0.180)	
Left wrist extensor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.90 (1.37)	1.50 (1.08)	0.89 (1.05)	Time 1 = Time 2 (p=0.165) **Time 1 ≠ Time 3 (p=0.014)** Time 2 = Time 3 (p=0.194)
Post-horse	0.90 (1.20)	0.80 (0.79)	0.22 (0.44)	Time 1 = Time 2 (p=0.609) Time 1 = Time 3 (p=0.083) Time 2 = Time 3 (p=0.084)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.015)**	**Pre ≠ Post (p=0.047)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Shoulder Flexor

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right shoulder flexor (Friedman test=30.056. p<0.001) and left shoulder flexor (Friedman test=23.244, p=0.003). For the right shoulder flexor, spasticity at 6 weeks when compared to baseline (p=0.027) and at 12 weeks was significantly smaller than baseline (p=0.028) for pre-horse values and 12 weeks was smaller than baseline (p=0.027) at post-horse. For the left shoulder flexor, it was found that for the values pre-horse (pre-riding for 5 minutes) was significantly smaller when 6 weeks was compared to baseline (0.027) 12 weeks was compared to baseline (p=0.048), both at pre-horse values.

Post-horse was also found to be significantly smaller at all times (baseline, 6 weeks and 12 weeks) when comparted to pre-horse for the right and left shoulder flexor. All values and comparisons can be found on table 7.10.

Table 7.10. Effect of HPOT on Spasticity of Shoulder Flexor

Right shoulder flexor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.00 (1.25)	1.30 (0.95)	1.22 (1.09)	**Time 1 ≠ Time 2 (p=0.027)** **Time 1 ≠ Time 3 (p=0.028)** Time 2 = Time 3 (p=0.655)
Post-horse	1.10 (0.88)	0.70 (0.67)	0.44 (0.73)	Time 1 = Time 2 (p=0.084) **Time 1 ≠ Time 3 (p=0.027)** Time 2 = Time 3 (p=0.157)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.026)**	**Pre ≠ Post (p=0.028)**	
Left shoulder flexor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.00 (1.05)	1.30 (0.82)	1.11 (1.05)	**Time 1 ≠ Time 2 (p=0.027)** **Time 1 ≠ Time 3 (p=0.048)** Time 2 = Time 3 (p=0.157)
Post-horse	0.90 (0.74)	0.90 (0.99)	0.56 (1.01)	Time 1 = Time 2 (p=0.825) Time 1 = Time 3 (p=0.194) Time 2 = Time 3 (p=0.289)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.045)**	**Pre ≠ Post (p=0.047)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Shoulder Extensor

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right shoulder extensor (Friedman test=23.911. p=0.002) and left shoulder extensor (Friedman test=17.678, p=0.024). For the right shoulder extensor, spasticity at 6 weeks when compared to baseline (p=0.047) for pre-horse values and 6 weeks was smaller than baseline (p=0.016) at post-horse. For the left shoulder extensor, it was found that for the values post-horse (after riding for 5 minutes) was significantly smaller when 12 weeks was compared to baseline (0.045).

Post-horse was also found to be significantly smaller at baseline and 12 weeks when comparted to pre-horse for the right and left shoulder extensor. All values and comparisons can be found on table 7.11.

Table 7.11. Effect of HPOT on Spasticity of Shoulder Extensor

Right shoulder extensor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.30 (1.16)	0.80 (0.63)	1.11 (1.05)	**Time 1 ≠ Time 2 (p=0.047)** Time 1 = Time 3 (p=0.353) Time 2 = Time 3 (p=0.569)
Post-horse	0.90 (0.88)	0.55 (0.53)	0.22 (0.44)	Time 1 = Time 2 (p=0.084) **Time 1 ≠ Time 3 (p=0.016)** Time 2 = Time 3 (p=0.083)
	Pre ≠ Post (p=0.045)	Pre = Post (p=0.083)	**Pre ≠ Post (p=0.017)**	
Left shoulder extensor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.30 (0.82)	1.00 (0.67)	0.89 (0.78)	Time 1 = Time 2 (p=0.083) Time 1 = Time 3 (p=0.083) Time 2 = Time 3 (p=0.564)
Post-horse	0.70 (0.48)	0.70 (0.48)	0.22 (0.44)	Time 1 = Time 2 (p=1.000) **Time 1 ≠ Time 3 (p=0.045)** Time 2 = Time 3 (p=0.102)
	Pre ≠ Post (p=0.047)	Pre = Post (p=0.083)	**Pre ≠ Post (p=0.027)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Shoulder Abductor

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right shoulder abductor (Friedman test=19.489. p=0.012). No significance was found for the left shoulder abductor (Friedman test=7.167, p=0.519). For the right shoulder abductor, spasticity at 6 weeks when compared to baseline (p=0.031) and at 12 weeks when compared to baseline (p=0.017) for pre-horse values and 6 weeks was smaller than baseline (p=0.045) and 12 weeks when compared to baseline (p=0.014) at post-horse.

Post-horse (after ridding for 5 minutes) was also found to be significantly smaller at baseline and 12 weeks when comparted to pre-horse for the right shoulder abductor. All values and comparisons can be found on table 7.12.

Table 7.12. Effect of HPOT on Spasticity of Shoulder Abductor

Right shoulder abductor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.70 (1.16)	0.90 (0.74)	0.78 (0.83)	**Time 1 ≠ Time 2 (p=0.031)** **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.317)
Post-horse	0.80 (0.63)	0.40 (0.52)	0.11 (0.33)	**Time 1 ≠ Time 2 (p=0.045)** **Time 1 ≠ Time 3 (p=0.014)** Time 2 = Time 3 (p=0.083)
	Pre ≠ Post (p=0.029)	**Pre ≠ Post (p=0.025)**	**Pre ≠ Post (p=0.047)**	
Left shoulder abductor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.40 (0.52)	1.20 (0.63)	0.89 (0.78)	No difference
Post-horse	0.70 (0.48)	0.40 (0.52)	0.11 (0.33)	No difference

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Shoulder Abductor

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right shoulder adductor (Friedman test=19.789. p=0.011). No significance was found for the left shoulder adductor (Friedman test=11.700, p=0.165). For the right shoulder adductor, spasticity at 6 weeks when compared to baseline (p=0.047) for pre-horse values and 6 weeks was smaller than baseline (p=0.026) and 12 weeks when compared to baseline (p=0.016) at post-horse.

Post-horse (after ridding for 5 minutes) was also found to be significantly smaller at baseline and 12 weeks when comparted to pre-horse for the right shoulder adductor. All values and comparisons can be found on table 7.13.

Table 7.13. Effect of HPOT on Spasticity of Shoulder Adductor

Right shoulder adductor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.70 (1.16)	0.90 (0.74)	0.78 (0.83)	**Time 1 ≠ Time 2 (p=0.031)** **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.317)
Post-horse	0.80 (0.63)	0.40 (0.52)	0.11 (0.33)	**Time 1 ≠ Time 2 (p=0.045)** **Time 1 ≠ Time 3 (p=0.014)** Time 2 = Time 3 (p=0.083)
	Pre ≠ Post (p=0.029)	**Pre ≠ Post (p=0.025)**	**Pre ≠ Post (p=0.047)**	
Left shoulder adductor				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.10 (0.74)	1.10 (0.74)	0.89 (0.78)	No difference
Post-horse	0.50 (0.53)	0.40 (0.52)	0.11 (0.33)	No difference

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Shoulder Internal Rotator

No significance was found for the right (Friedman test=14.722. p=0.065) left shoulder internal rotator (Friedman test=14.433, p=0.071).

Shoulder External Rotators

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right shoulder external rotator (Friedman test=15.533. p=0.049) and left shoulder external rotator (Friedman test=21.700, p=0.005). For the right shoulder external rotator, spasticity at 6 weeks when compared to baseline (p=0.025) and 12 weeks (p=0.045) for pre-horse values and 12 weeks was smaller than baseline (p=0.027) at post-horse.

Post-horse was also found to be significantly smaller at baseline and 12 weeks when comparted to pre-horse for the right and left shoulder external rotator. All values and comparisons can be found on table 7.14.

Table 7.14. Effect of HPOT on Spasticity of Shoulder External Rotator

Right shoulder external rotator				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.40 (0.84)	0.90 (0.57)	0.89 (0.78)	**Time 1 ≠ Time 2 (p=0.025)** **Time 1 ≠ Time 3 (p=0.045)** Time 2 = Time 3 (p=1.000)
Post-horse	0.70 (0.95)	0.60 (0.97)	0.33 (0.71)	Time 1 = Time 2 (p=0.084) **Time 1 ≠ Time 3 (p=0.027)** Time 2 = Time 3 (p=0.083)
	Pre ≠ Post (p=0.047)	**Pre ≠ Post (p=0.047)**	**Pre ≠ Post (p=0.028)**	
Left shoulder external rotator				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.20 (1.13)	1.10 (1.20)	0.89 (0.78)	Time 1 = Time 2 (p=0.564) Time 1 = Time 3 (p=0.158) Time 2 = Time 3 (p=0.569)
Post-horse	0.70 (0.95)	0.60 (0.97)	0.33 (0.71)	Time 1 = Time 2 (p=0.564) Time 1 = Time 3 (p=0.083) Time 2 = Time 3 (p=0.180)
	Pre ≠ Post (p=0.047)	**Pre ≠ Post (p=0.047)**	**Pre ≠ Post (p=0.047)**	

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

Figure 7.3 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left shoulder flexor. The figure shows the mean and the standard error for all children with CP evaluated.

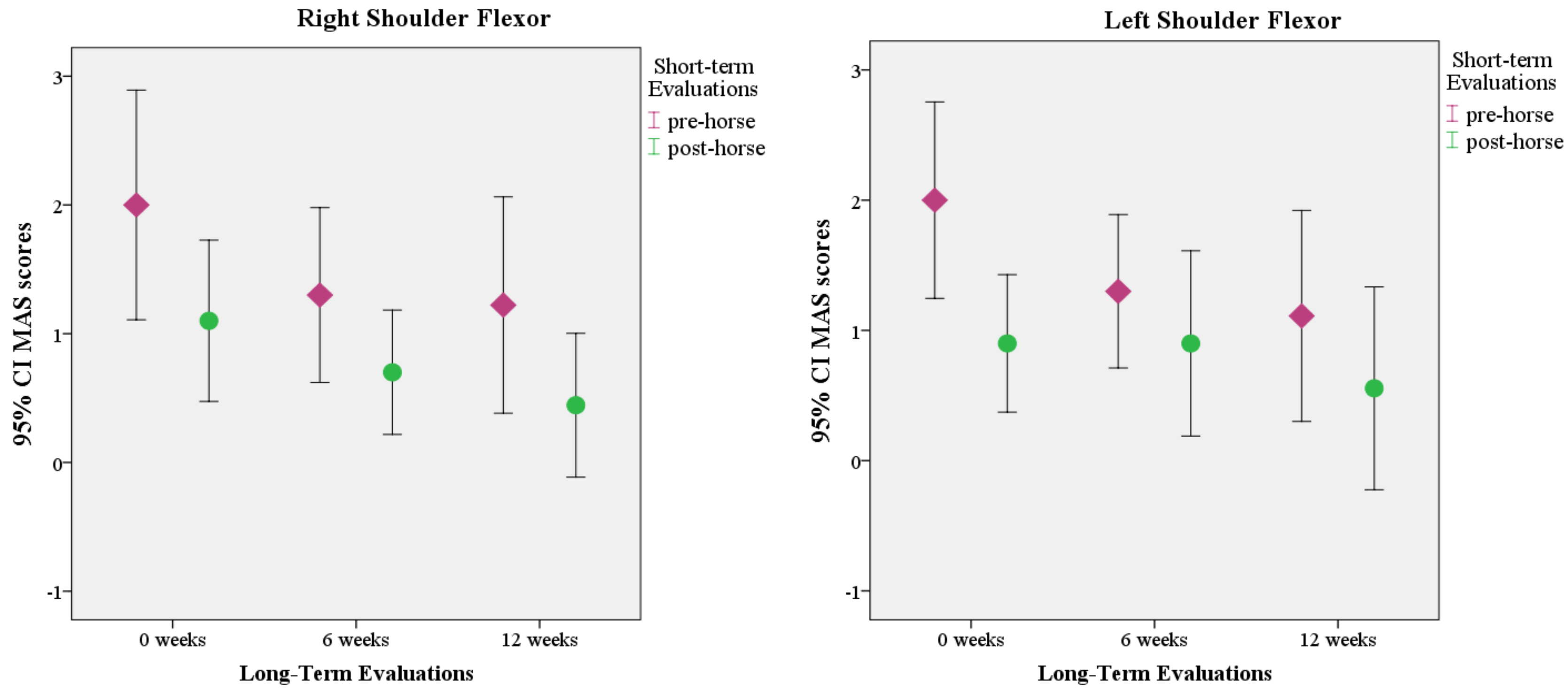


Figure 7.4. Spasticity on shoulder flexors after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity.

Figure 7.4 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left shoulder extensor. The figure shows the mean and the standard error for all children with CP evaluated.

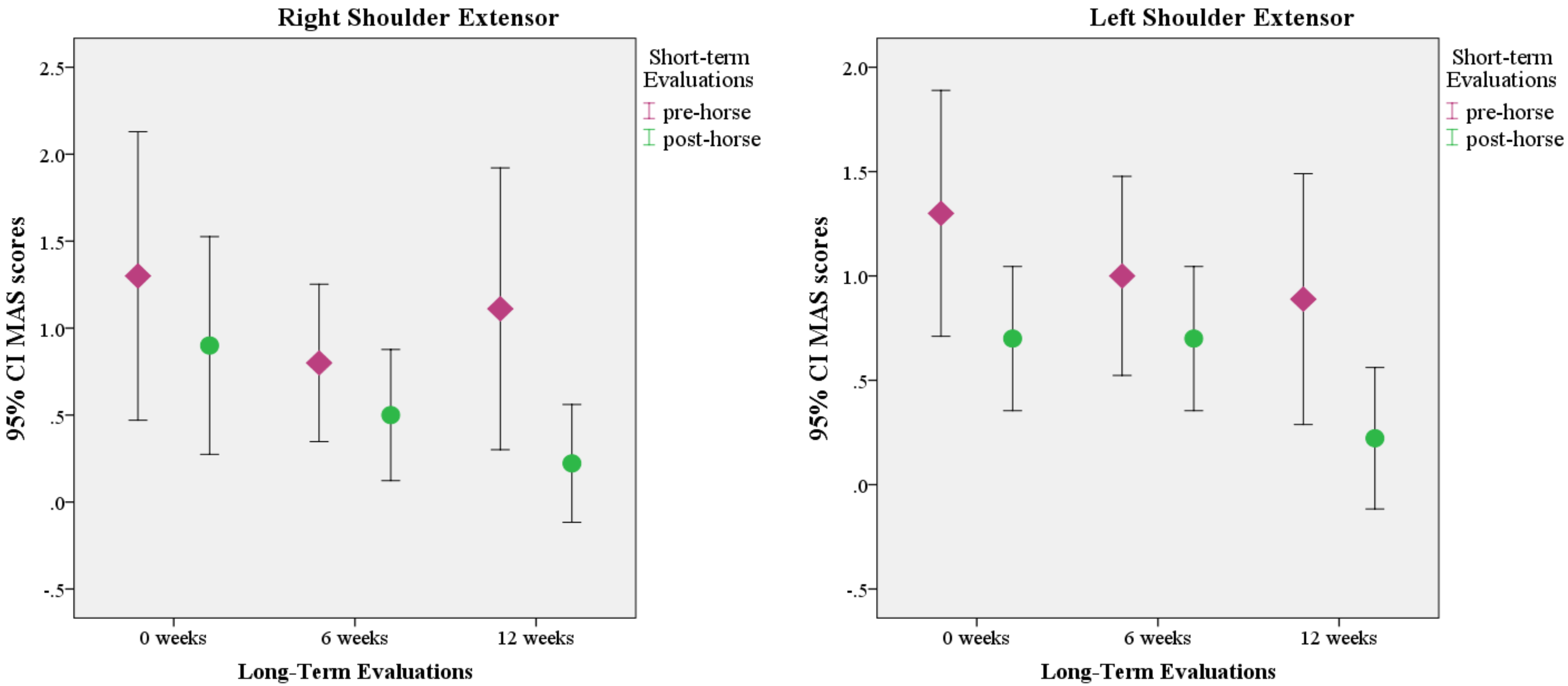


Figure 7.5. Spasticity on shoulder extensors after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity.

Figure 7.5 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left shoulder external rotators. The figure shows the mean and the standard error for all children with CP evaluated.

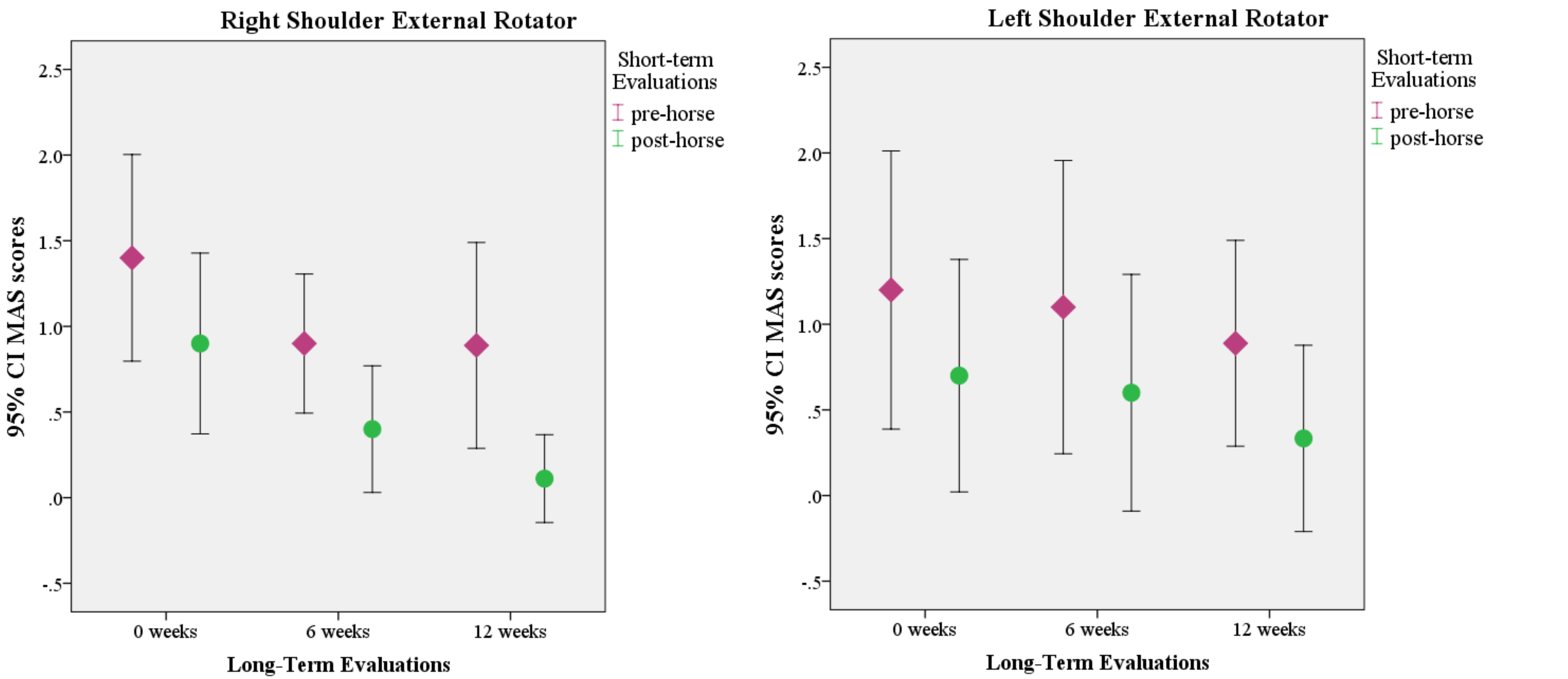


Figure 7.6. Spasticity on shoulder external rotators after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.6 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left shoulder external rotators. The figure shows the mean and the standard error for all children with CP evaluated.

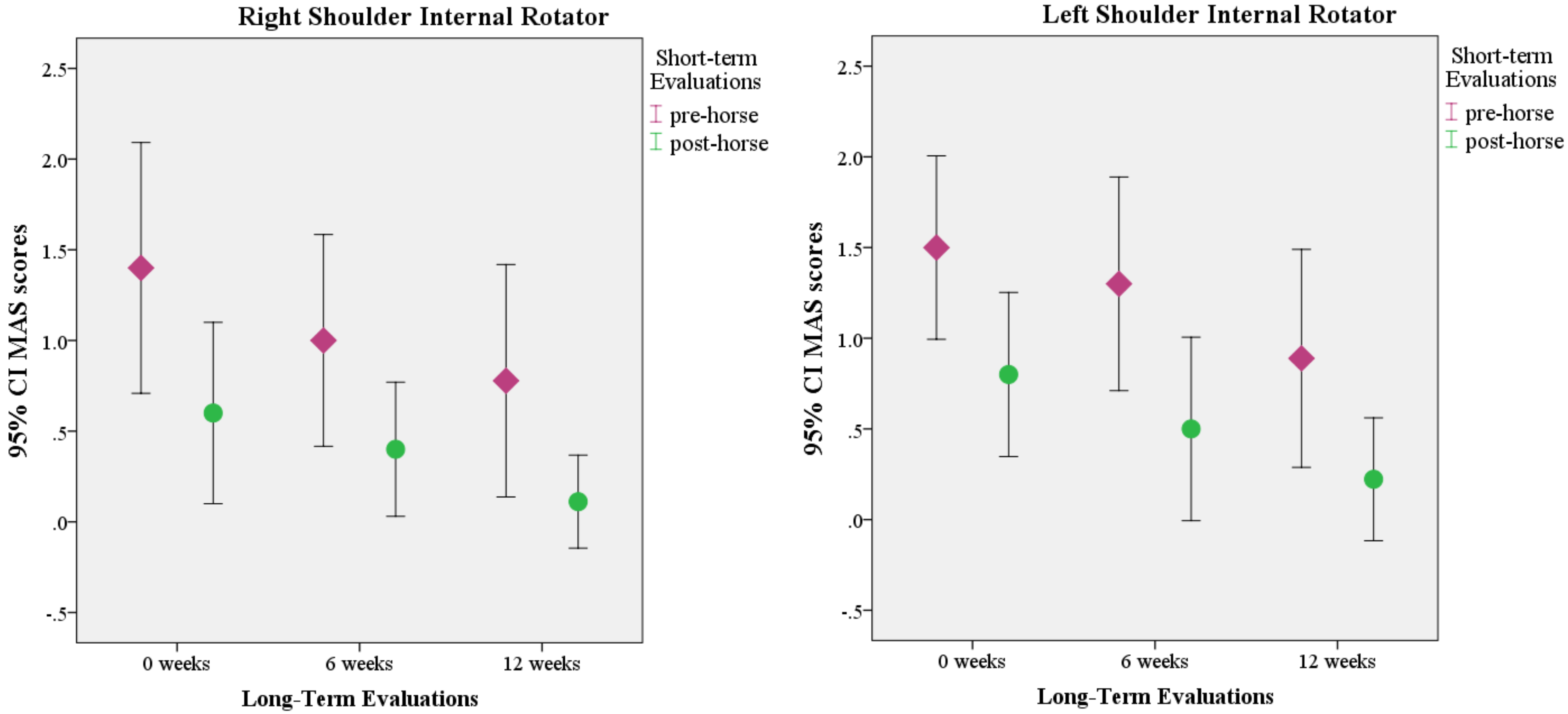


Figure 7.7. Spasticity on shoulder internal rotators after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.7 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left shoulder adductor. The figure shows the mean and the standard error for all children with CP evaluated.

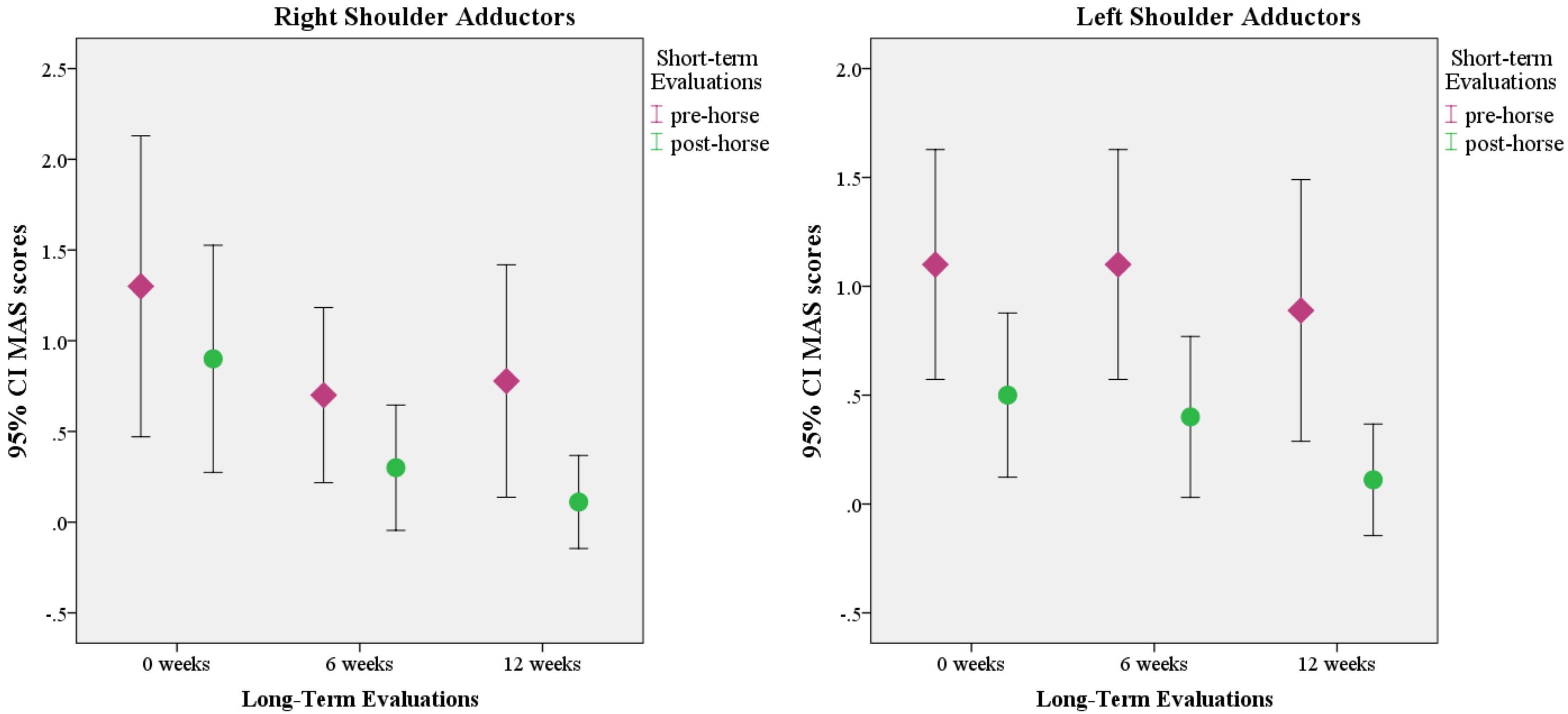


Figure 7.8. Spasticity on shoulder adductors after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.8 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left shoulder abductor. The figure shows the mean and the standard error for all children with CP evaluated.

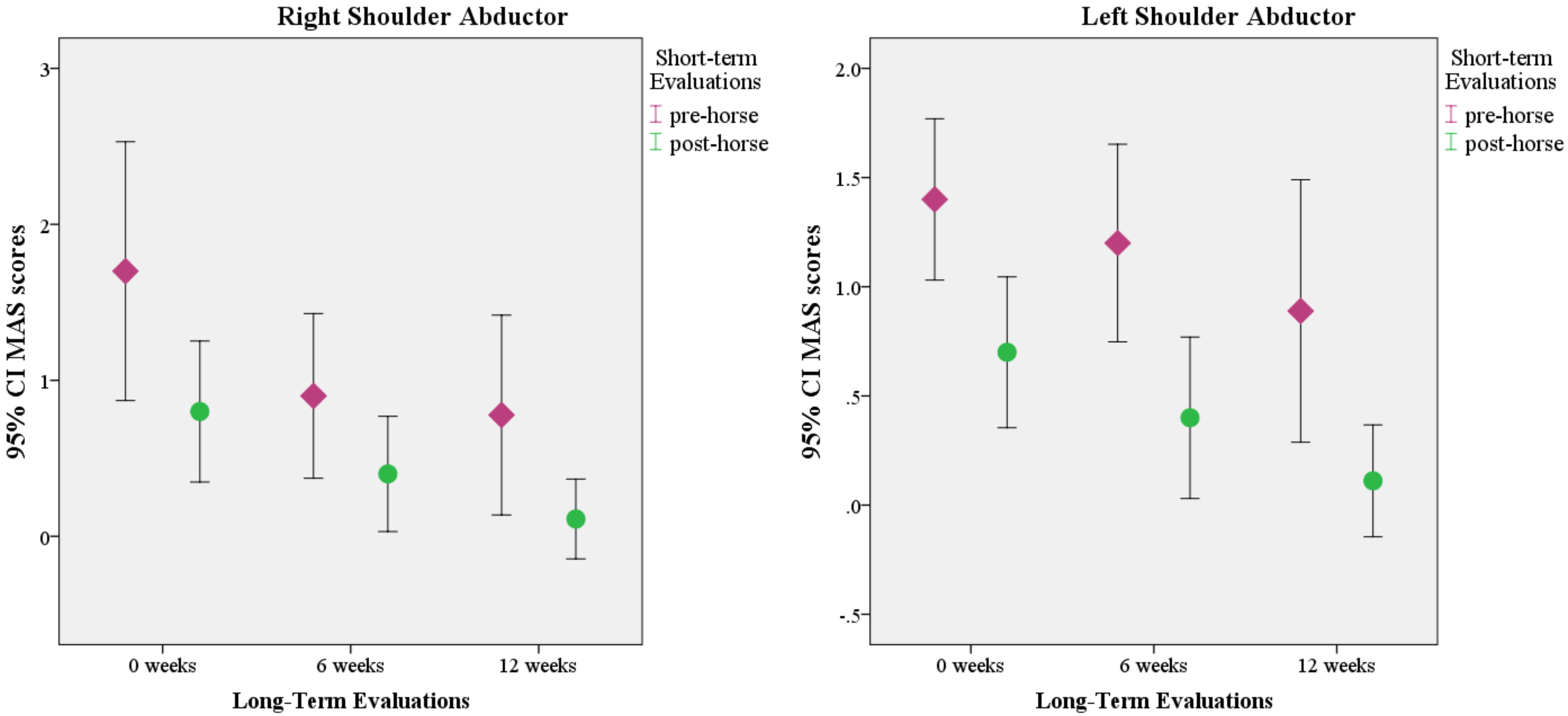


Figure 7.9. Spasticity on shoulder abductors after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Effect of 12 weeks of Hippotherapy Treatment on Spasticity on the Lower Limb

Quadriceps

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right quadriceps (Friedman test=31.789, p<0.001) and left quadriceps (Friedman test=18.322, p=0.019). For the right quadriceps, spasticity was smaller at 6 weeks when compared to baseline (p=0.010) and 12 weeks (p=0.041) for pre-horse values and 6 weeks (p=0.014) and 12 weeks was smaller than baseline (p=0.027) at post-horse. For the left quadriceps spasticity was smaller at 6 weeks when compared to baseline (p=0.011) at pre horse and at post-horse (p=0.047).

Post-horse was also found to be significantly smaller at baseline, 6 weeks and 12 weeks when comparted to pre-horse for the right and left quadriceps. All values and comparisons can be found on table 7.15.

Table 7.15. Effect of HPOT on Spasticity of Quadriceps

Right quadriceps				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	3.00 (1.41)	1.90 (1.29)	1.67 (1.12)	**Time 1 ≠ Time 2 (p=0.010)** **Time 1 ≠ Time 3 (p=0.041)** Time 2 = Time 3 (p=0.382)
Post-horse	1.70 (0.95)	1.10 (0.88)	1.00 (0.87)	**Time 1 ≠ Time 2 (p=0.014)** **Time 1 ≠ Time 3 (p=0.027)** Time 2 = Time 3 (p=0.655)
	Pre ≠ Post (p=0.020)	**Pre ≠ Post (p=0.011)**	**Pre ≠ Post (p=0.016)**	
Left quadriceps				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	2.60 (1.71)	1.30 (1.06)	1.44 (0.73)	**Time 1 ≠ Time 2 (p=0.011)** Time 1 = Time 3 (p=0.117) Time 2 = Time 3 (p=0.761)
Post-horse	1.30 (1.06)	0.60 (0.70)	0.89 (0.60)	**Time 1 ≠ Time 2 (p=0.047)** Time 1 = Time 3 (p=0.489) Time 2 = Time 3 (p=0.289)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.015)**	**Pre ≠ Post (p=0.025)**	

*level of statistical significance according to pairwise signed-ranks tests

Hamstrings

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right hamstrings (Friedman test=29.111, p<0.001) and left hamstrings (Friedman test=29.322, p<0.001). For the right hamstrings, spasticity was smaller at 6 weeks when compared to baseline (p=0.026) for pre-horse values and 6 weeks (p=0.009) and 12 weeks was smaller than baseline (p=0.047) at post-horse. For the left hamstrings spasticity was smaller at 6 weeks when compared to baseline (p=0.027) at post-horse.

Post-horse was also found to be significantly smaller at baseline, 6 weeks and 12 weeks when comparted to pre-horse for the right and left hamstrings. All values and comparisons can be found on table 7.16.

Table 7.16. Effect of HPOT on Spasticity of Quadriceps

Right quadriceps				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	3.00 (1.41)	1.90 (1.29)	1.67 (1.12)	**Time 1 ≠ Time 2 (p=0.010)** **Time 1 ≠ Time 3 (p=0.041)** Time 2 = Time 3 (p=0.382)
Post-horse	1.70 (0.95)	1.10 (0.88)	1.00 (0.87)	**Time 1 ≠ Time 2 (p=0.014)** **Time 1 ≠ Time 3 (p=0.027)** Time 2 = Time 3 (p=0.655)
	Pre ≠ Post (p=0.020)	**Pre ≠ Post (p=0.011)**	**Pre ≠ Post (p=0.016)**	
Left quadriceps				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	2.50 (1.51)	1.70 (1.25)	1.67 (0.87)	Time 1 = Time 2 (p=0.079) Time 1 = Time 3 (p=0.077) Time 2 = Time 3 (p=0.708)
Post-horse	1.40 (1.07)	0.70 (0.67)	1.00 (0.71)	**Time 1 ≠ Time 2 (p=0.027)** Time 1 = Time 3 (p=0.164) Time 2 = Time 3 (p=0.180)
	Pre ≠ Post (p=0.007)	**Pre ≠ Post (p=0.010)**	**Pre ≠ Post (p=0.014)**	

*level of statistical significance according to pairwise signed-ranks tests

Hip Adductors

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right hip adductors (Friedman test=24.156, p=0.002) and left hip adductors (Friedman test=24.911, p=0.002). For the right hip adductors, spasticity was smaller at 6 weeks when compared to baseline (p=0.031) and 12 weeks to baseline (p=0.0017) for pre-horse values. For the left hip adductors spasticity was smaller at 6 weeks when compared to baseline (p=0.033) and 12 weeks when compared to baseline (p=0.027) at pre-horse; and 6 weeks when compared to baseline (p=0.0045) at post-horse.

Post-horse was also found to be significantly smaller at baseline and 6 weeks when comparted to pre-horse for the right and left hip adductors. All values and comparisons can be found on table 7.17.

Table 7.17. Effect of HPOT on Spasticity of Hip Adductors

Right hip adductors				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	2.00 (1.25)	1.10 (0.99)	1.22 (0.97)	**Time 1 ≠ Time 2 (p=0.031)** **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.706)
Post-horse	0.80 (0.42)	0.60 (0.70)	1.00 (0.87)	Time 1 = Time 2 (p=0.317) Time 1 = Time 3 (p=0.317) Time 2 = Time 3 (p=0.164)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.047)**	Pre = Post (p=0.317)	
Left hip adductors				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	1.80 (1.03)	1.10 (0.99)	1.22 (0.97)	**Time 1 ≠ Time 2 (p=0.033)** **Time 1 ≠ Time 3 (p=0.027)** Time 2 = Time 3 (p=0.706)
Post-horse	1.00 (0.67)	0.60 (0.70)	0.89 (0.60)	**Time 1 ≠ Time 2 (p=0.045)** Time 1 = Time 3 (p=0.564) Time 2 = Time 3 (p=0.180)
	Pre ≠ Post (p=0.016)	**Pre ≠ Post (p=0.047)**	Pre = Post (p=0.180)	

*level of statistical significance according to pairwise signed-ranks tests

Hip Abductors

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right hip abductors (Friedman test=28.267, p<0.001) and left hip abductors (Friedman test=29.056, p<0.001). For the left hip abductors, spasticity was smaller at 6 weeks when compared to baseline (p=0.031).

Post-horse was also found to be significantly smaller at baseline and 12 weeks when comparted to pre-horse for the right and left hip abductors. All values and comparisons can be found on table 7.18.

Table 7.18. Effect of HPOT on Spasticity of Hip Abductors

Right hip abductors				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	1.80 (1.32)	1.10 (1.20)	1.56 (0.73)	Time 1 = Time 2 (p=0.115) Time 1 = Time 3 (p=0.472) Time 2 = Time 3 (p=0.382)
Post-horse	0.90 (0.57)	0.70 (0.82)	1.00 (0.71)	Time 1 = Time 2 (p=0.317) Time 1 = Time 3 (p=0.317) Time 2 = Time 3 (p=0.179)
	Pre ≠ Post (p=0.016)	Pre = Post (p=0.102)	**Pre ≠ Post (p=0.025)**	
Left hip abductors				
Group	Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Pre-horse	2.00 (1.25)	1.10 (1.20)	1.56 (0.88)	**Time 1 ≠ Time 2 (p=0.031)** Time 1 = Time 3 (p=0.262) Time 2 = Time 3 (p=0.353)
Post-horse	0.90 (0.74)	0.70 (0.82)	0.89 (0.60)	Time 1 = Time 2 (p=0.157) Time 1 = Time 3 (p=1.000) Time 2 = Time 3 (p=0.317)
	Pre ≠ Post (p=0.010)	Pre = Post (p=0.102)	**Pre ≠ Post (p=0.014)**	

*level of statistical significance according to pairwise signed-ranks tests

Gastrocnemius

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right gastrocnemius (Friedman test=33.822, p<0.001) and left gastrocnemius (Friedman test=28.167, p<0.001). For the right gastrocnemius, spasticity was smaller at 12 weeks to baseline (p=0.0017) for pre-horse values; for post-horse values 6 weeks was smaller than baseline (p=0.025) and 12 weeks was smaller than baseline (p=0.017). For the left gastrocnemius spasticity was smaller at 6 weeks when compared to baseline (p=0.027) and 12 weeks when compared to baseline (p=0.008) at pre-horse; and 6 weeks when compared to baseline (p=0.0047) and 12 weeks compared to baseline (p=0.017) at post-horse.

Post-horse was also found to be significantly smaller at baseline, 6 weeks and 12 weeks when comparted to pre-horse for the right gastrocnemius and baseline and 6 weeks for the left. All values and comparisons can be found on table 7.19.

Table 7.19. Effect of HPOT on Spasticity of Gastrocnemius

Right gastrocnemius				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	3.10 (1.52)	2.60 (1.50)	2.00 (1.00)	Time 1 = Time 2 (p=0.084) **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.353)
Post-horse	2.10 (1.52)	1.60 (1.71)	1.11 (1.17)	**Time 1 ≠ Time 2 (p=0.025)** **Time 1 ≠ Time 3 (p=0.017)** Time 2 = Time 3 (p=0.164)
	Pre ≠ Post (p=0.006)	**Pre ≠ Post (p=0.006)**	**Pre ≠ Post (p=0.009)**	
Left gastrocnemius				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	1.80 (1.03)	1.10 (0.99)	1.22 (0.97)	**Time 1 ≠ Time 2 (p=0.033)** **Time 1 ≠ Time 3 (p=0.027)** Time 2 = Time 3 (p=0.706)
Post-horse	1.00 (0.67)	0.60 (0.70)	0.89 (0.60)	**Time 1 ≠ Time 2 (p=0.045)** Time 1 = Time 3 (p=0.564) Time 2 = Time 3 (p=0.180)
	Pre ≠ Post (p=0.016)	**Pre ≠ Post (p=0.047)**	Pre = Post (p=0.180)	

*level of statistical significance according to pairwise signed-ranks tests

Tibialis Anterior

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and pre-horse/post-horse comparison when looking to right tibialis anterior (Friedman test=31.622, p<0.001) and left tibialis anterior (Friedman test=27.956, p<0.001). For the right tibialis anterior, spasticity was smaller for post-horse values at 12 weeks was smaller than baseline (p=0.048). For the left tibialis anterior spasticity was smaller at 6 weeks when compared to baseline (p=0.045) and 12 weeks when compared to baseline (p=0.048) at post-horse.

Post-horse was also found to be significantly smaller at baseline, 6 weeks and 12 weeks when comparted to pre-horse for the right and left tibialis anterior. All values and comparisons can be found on table 7.20.

Table 7.20. Effect of HPOT on Spasticity of Tibialis Anterior

Right tibialis anterior				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.60 (1.78)	2.50 (1.51)	2.11 (1.05)	Time 1 = Time 2 (p=0.654) Time 1 = Time 3 (p=0.465) Time 2 = Time 3 (p=0.569)
Post-horse	1.80 (1.62)	1.50 (1.72)	1.11 (1.17)	Time 1 = Time 2 (p=0.083) **Time 1 ≠ Time 3 (p=0.048)** Time 2 = Time 3 (p=0.289)
	Pre ≠ Post (p=0.016)	**Pre ≠ Post (p=0.006)**	**Pre ≠ Post (p=0.010)**	
Left tibialis anterior				
	Mean (sd)			p value*
Group	Time 1	Time 2	Time 3	
Pre-horse	2.70 (1.70)	2.70 (1.42)	1.89 (1.05)	Time 1 = Time 2 (p=0.413) Time 1 = Time 3 (p=0.111) Time 2 = Time 3 (p=0.147)
Post-horse	1.80 (1.62)	1.40 (1.78)	1.11 (1.17)	**Time 1 ≠ Time 2 (p=0.045)** **Time 1 ≠ Time 3 (p=0.048)** Time 2 = Time 3 (p=0.569)
	Pre ≠ Post (p=0.010)	**Pre ≠ Post (p=0.007)**	**Pre ≠ Post (p=0.016)**	

*level of statistical significance according to pairwise signed-ranks tests

Figure 7.9 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left quadriceps. The figure shows the mean and the standard error for all children with CP evaluated.

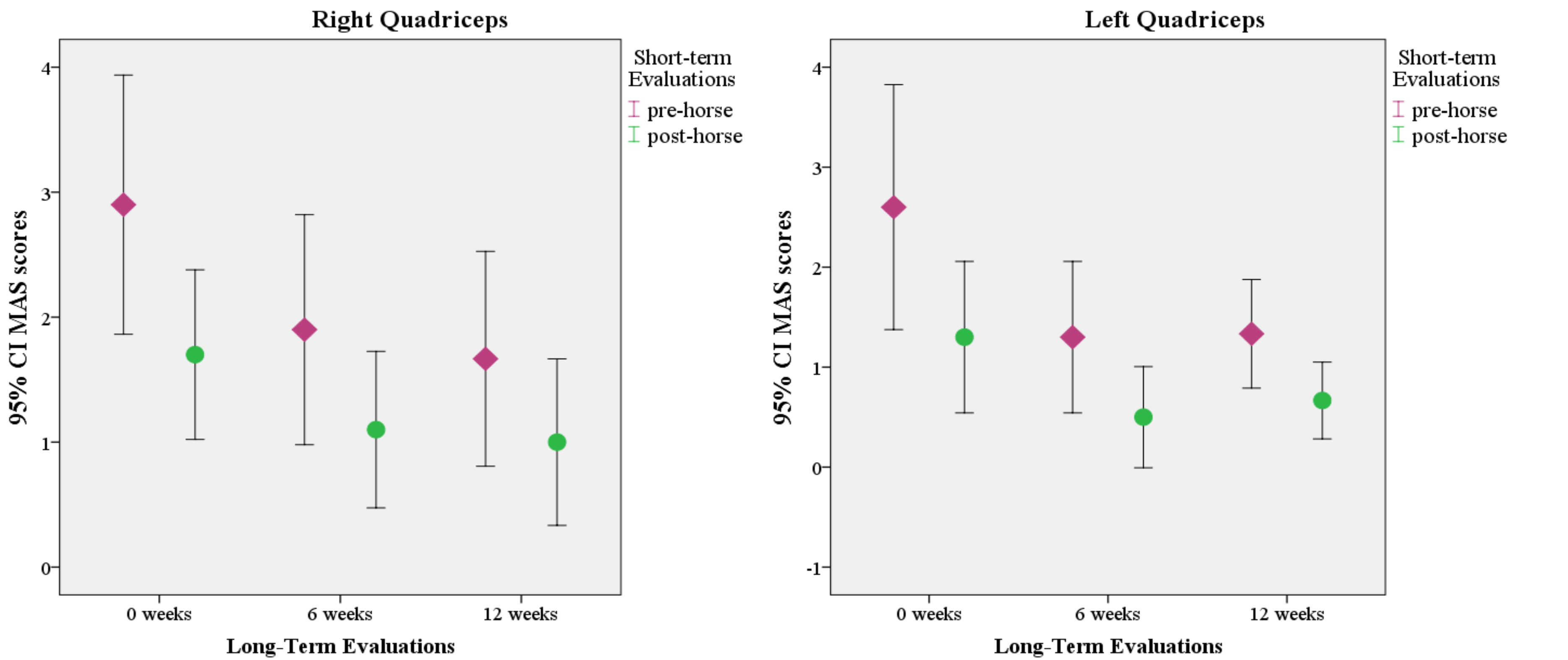


Figure 7.10. Spasticity on quadriceps after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.10 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left hamstrings. The figure shows the mean and the standard error for all children with CP evaluated.

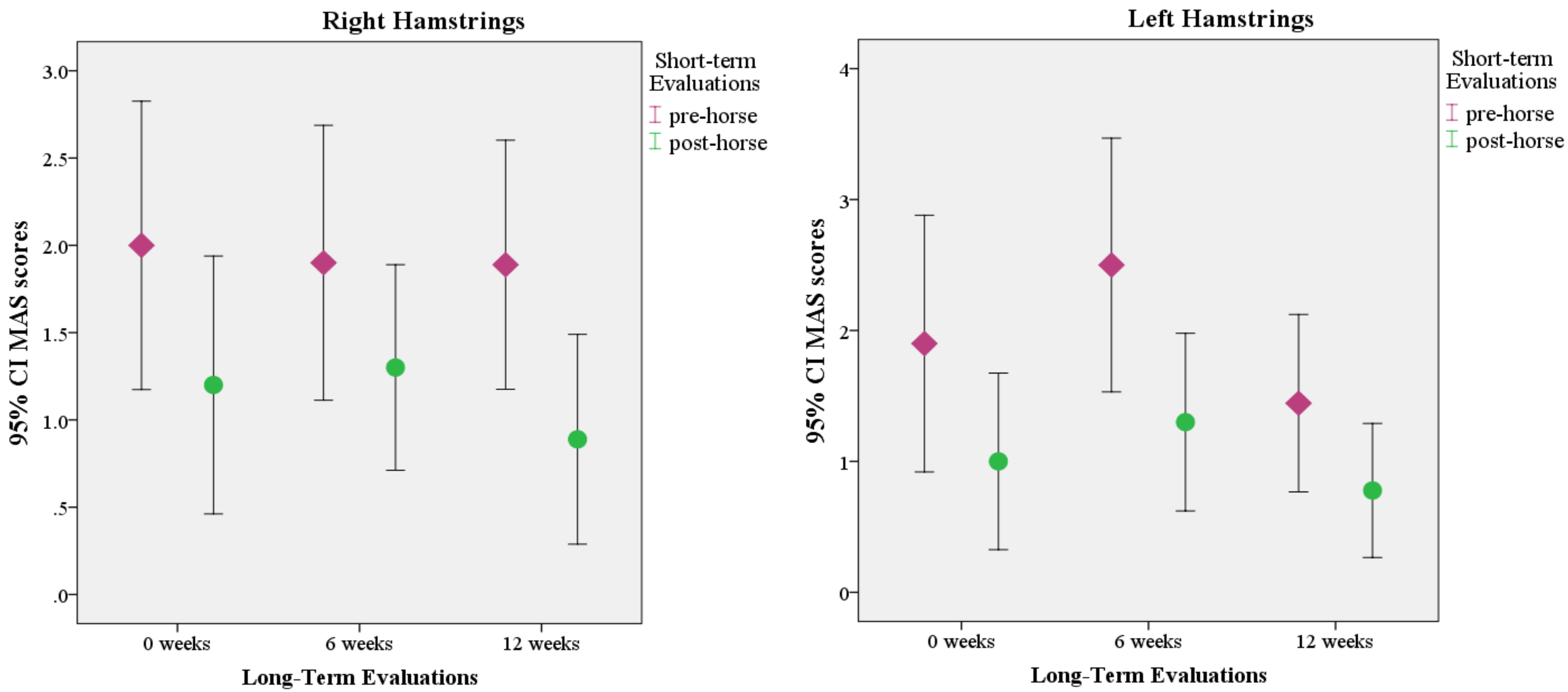


Figure 7.11. Spasticity on hamstrings after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.11 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left hip adductors. The figure shows the mean and the standard error for all children with CP evaluated.

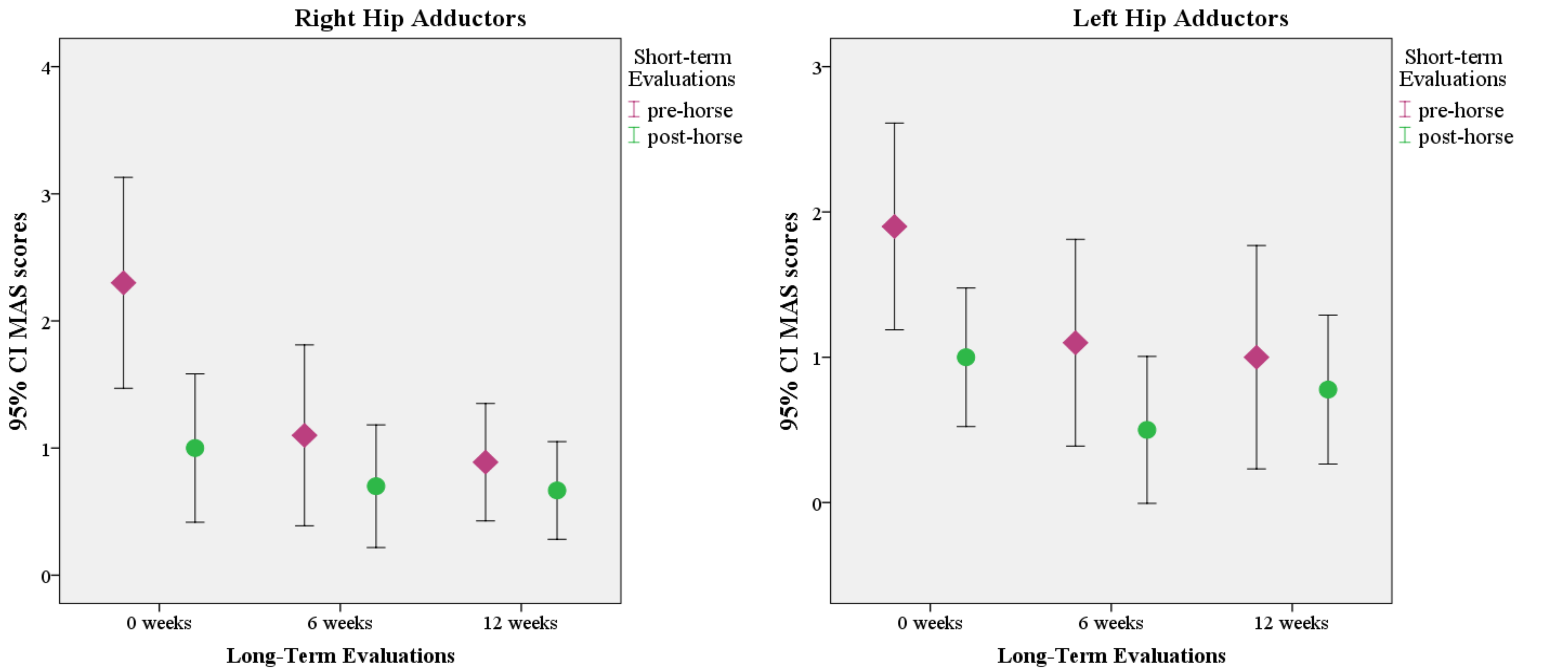


Figure 7.12. Spasticity on hip adductors after 12 weeks of HPOT Treatment. Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.12 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left hip abductors. The figure shows the mean and the standard error for all children with CP evaluated.

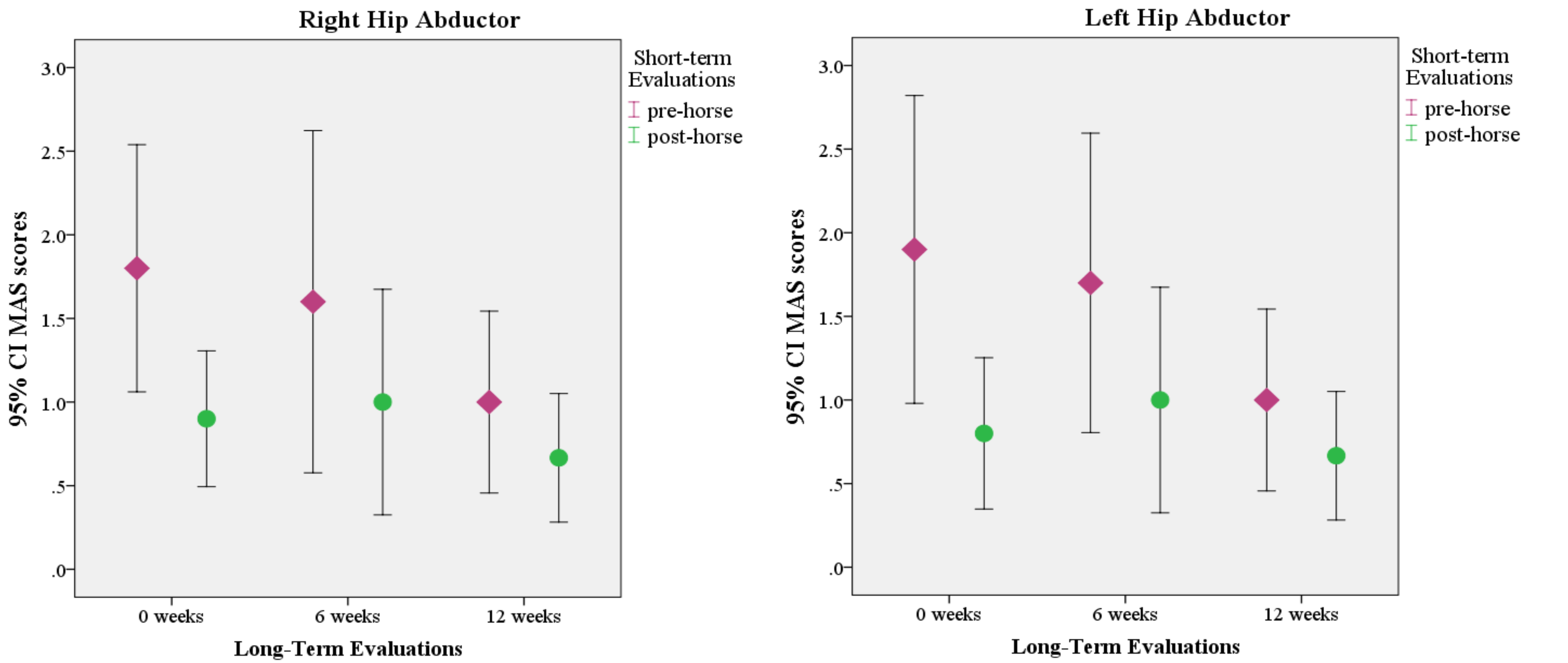


Figure 7.13. Spasticity on hip abductors after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.13 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left gastrocnemius. The figure shows the mean and the standard error for all children with CP evaluated.

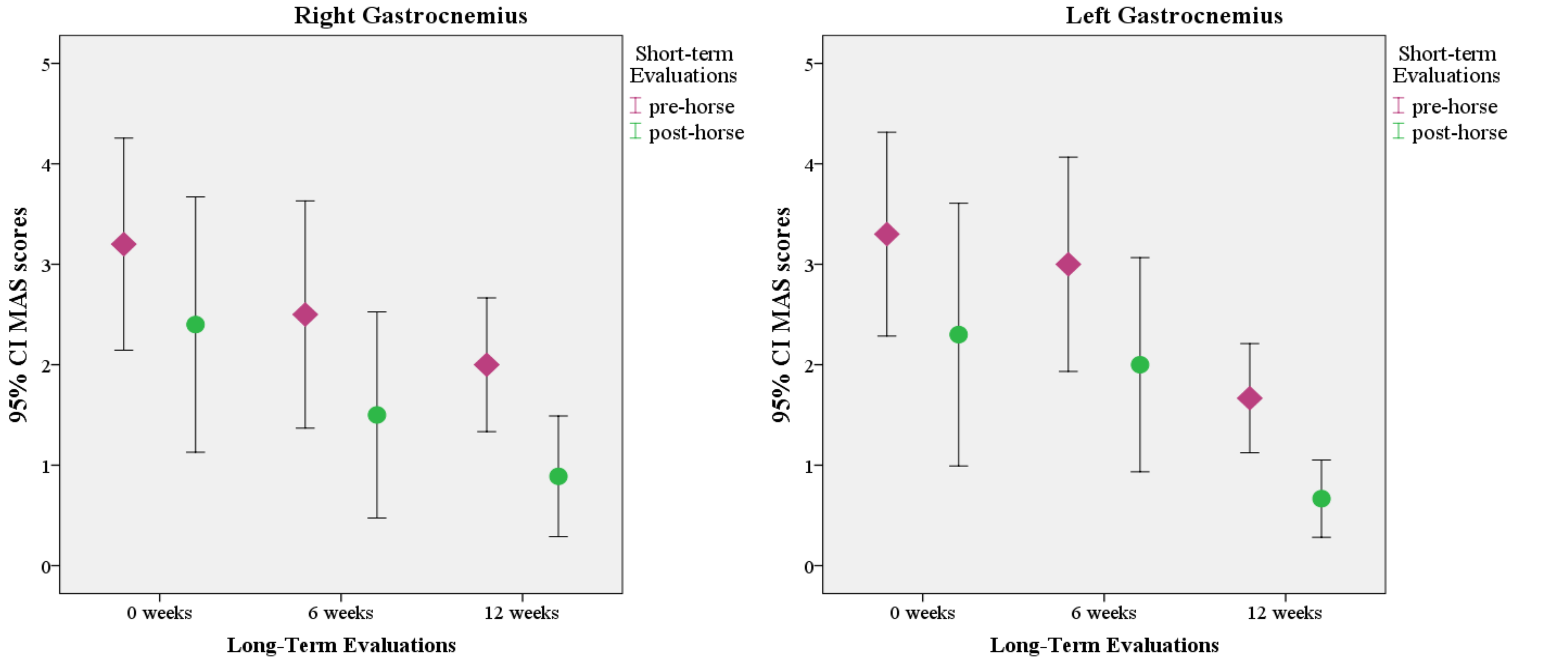


Figure 7.14. Spasticity on gastrocnemius after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

Figure 7.14 shows the significant improvement of spasticity after short-term sitting passively on the horse and after 6 and 12 weeks of HPOT for the right and left tibialis anterior. The figure shows the mean and the standard error for all children with CP evaluated.

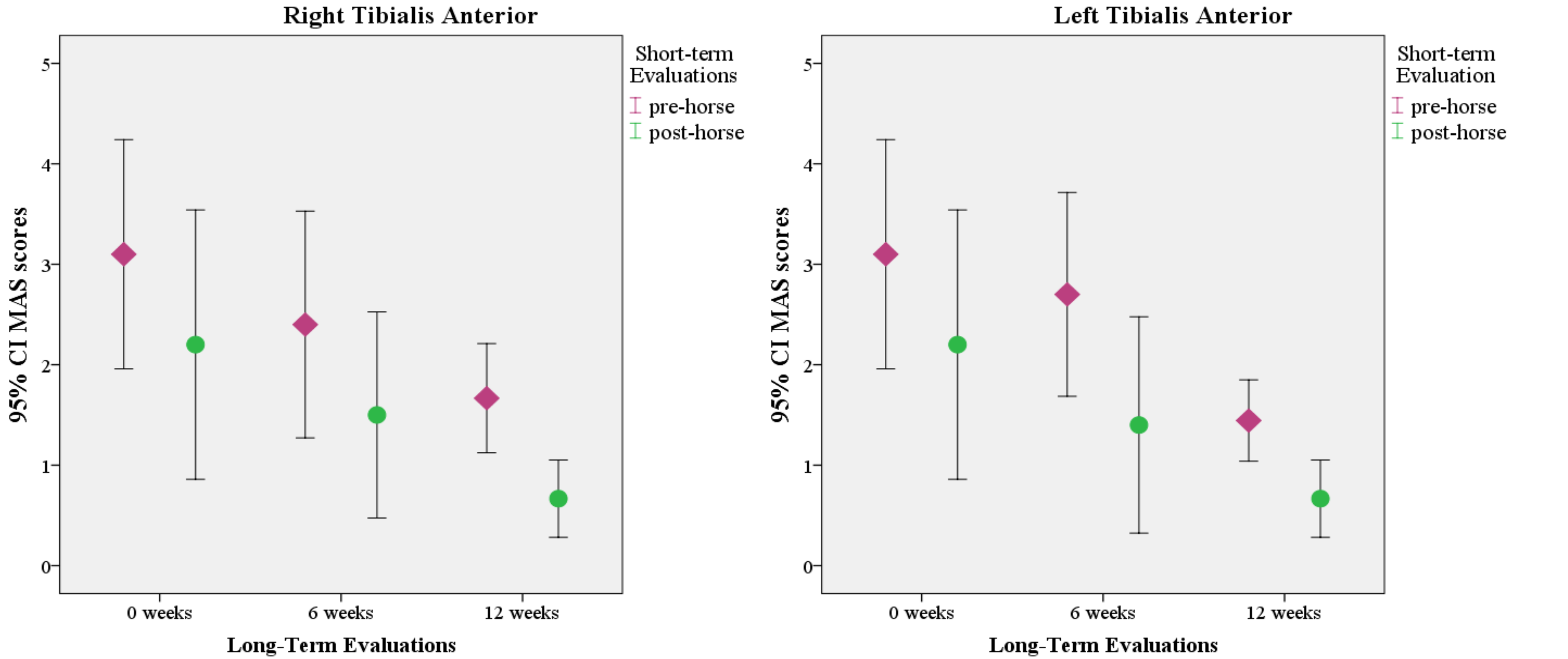


Figure 7.15. Spasticity on tibialis anterior after 12 weeks of HPOT Treatment.

Pre-horse/Post-horse: evaluations done before and after passively sitting the horse for 5 minutes. MAS scores: the evaluation of spasticity

7.5. Results: The Effect of Hippotherapy on PedsQL Scores of Children with Spastic Cerebral Palsy

The data analysis has shown a significant difference of the distribution of values on treatment – baseline, 6wks, 12wks and GMFCS comparison when looking the PedsQL total scores (Friedman test=21.267, p=0.006), physical domain Friedman test = 23.022, p=0.003), Emotional (Friedman test = 18.444, p=0.018), Social (Friedman test = 22.556, p=0.004) e School (Friedman test = 18.000, p=0.021). Table 7.21 shows the raw scores for each patient through all the evaluations.

Table 7.21. PedsQL® Scores after 6 and 12 Weeks of HPOT.

	PedsQL® Scores														
	Total1	Total2	Total3	Phy1	Phy2	Phy3	Emo1	Emo2	Emo3	Soc1	Soc2	Soc3	Sch1	Sch2	Sch3
Participant 1	43	42	38	19	19	16	11	10	9	10	10	10	3	3	3
Participant 3	47	36	30	24	18	18	9	9	4	9	6	6	5	3	2
Participant 4	58	56	54	26	25	25	9	10	9	16	15	14	7	6	6
Participant 5	42	39	33	18	16	15	7	7	5	12	11	10	5	5	3
Participant 6	49	40	34	25	22	16	6	6	6	13	9	9	5	3	3
Participant 7	27	16	15	13	8	7	5	4	4	6	3	3	3	1	1
Participant 8	62	57	53	28	26	26	14	14	10	15	13	13	5	4	4
Participant 9	40	34	31	12	14	13	12	7	7	8	8	6	8	5	5
Participant 10	48	39	39	26	25	25	9	3	3	9	6	6	4	5	5
Participant 11	33	24		20	14		2	2		7	5		4	3	

Phy: Physical function; Emo: Emotional Function; Soc: Social Function; Sch: School Function. 1 – evaluation pre-treatment; 2 – evaluation post 6 weeks; 3 – evaluation post 12 weeks of treatment. Participants in blue: those on GMFCS 1; Participants in white: Those in GMFCS 2.

Effects of Hippotherapy on PedsQL®

The data analysis has shown that for the total score of PedsQL® there was a significant lower values after 6 weeks when compared to baseline (p=0.017), for 12 weeks when compared to baseline (p=0.007) and for 12 weeks when compared to 6 weeks (p=0.009). This indicate that HPOT was able to help the children with CP to have less difficulties to do daily live activities, which, following the questionnaire, would translate in an overall better quality of life. Table 7.22 shows all the comparisons (Figure 7.15)

Table 7.22. PedsQL® Scores Analysis

Variable	Quality of life scores Mean (sd)			p value*
	Time 1	Time 2	Time 3	
Total	45.7 (10.6)	39.9 (12.1)	36.3 (11.9)	**Time 1 ≠ Time 2 (p=0.017)** **Time 1 ≠Time 3 (p=0.007)** **Time 2 ≠Time 3 (p=0.009)**
Physical	21.2 (5.9)	19.2 (5.9)	17.9 (6.4)	**Time 1 ≠ Time 2 (p=0.043)** **Time 1 ≠ Time 3 (p=0.015)** **Time 2 ≠ Time 3 (p=0.028)**
Emotional	8.5 (3.7)	7.8 (3.4)	6.3 (2.5)	Time 1 = Time 2 (p=0.393) Time 1 = Time 3 (p=0.056) **Time 2 ≠ Time 3 (p=0.028)**
Social	10.9 (3.3)	9.0 (3.7)	8.5 (3.6)	**Time 1 ≠ Time 2 (p=0.012)** **Time 1 ≠ Time 3 (p=0.008)** Time 2 = Time 3 (p=0.084)
School	5.0 (1.7)	3.9 (1.5)	3.5 (1.6)	**Time 1 ≠ Time 2 (p=0.041)** **Time 1 ≠ Time 3 (p=0.023)** Time 2 = Time 3 (p=0.158)

*level of statistical significance according to pairwise signed-ranks tests. Time 1 = baseline, time 2 = 6 weeks; time 3 = 12 weeks

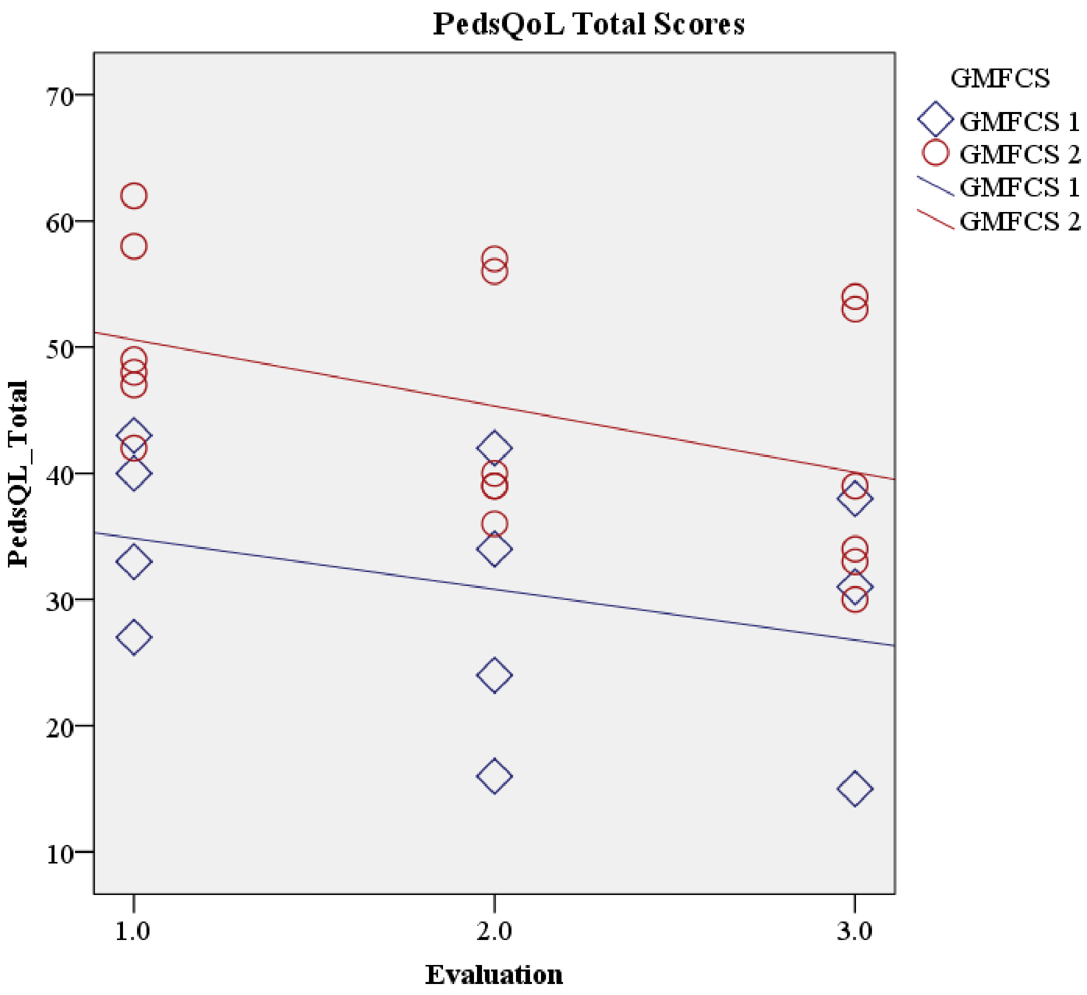


Figure 7.16. PedsQL Total scores.

GMFCS 1 - level I and II: children with CP that were classified at these levels; GMFCS 2 - levels III, IV and V: children with CP that were classified at these levels. Evaluation 1 – pre-treatment, 2 – after 6 weeks and 3 – after 12 weeks.

For the physical category, there was a significant lower values 6 weeks when compared to baseline (p=0.017), for 12 weeks when compared to baseline (p=0.007) and for 12 weeks when compared to 6 weeks (p=0.009)

For the social category 6 weeks was smaller than baseline (p=0.012) as well as 12 weeks was smaller than baseline (p=0.008). For the emotional category, there was a significant lower values when 12 weeks when compared to 6 weeks (p=0.009). For the school category 6 weeks was smaller than baseline (p=0.041) as well as 12 weeks was smaller than baseline (p=0.023) (Figure 7.16)

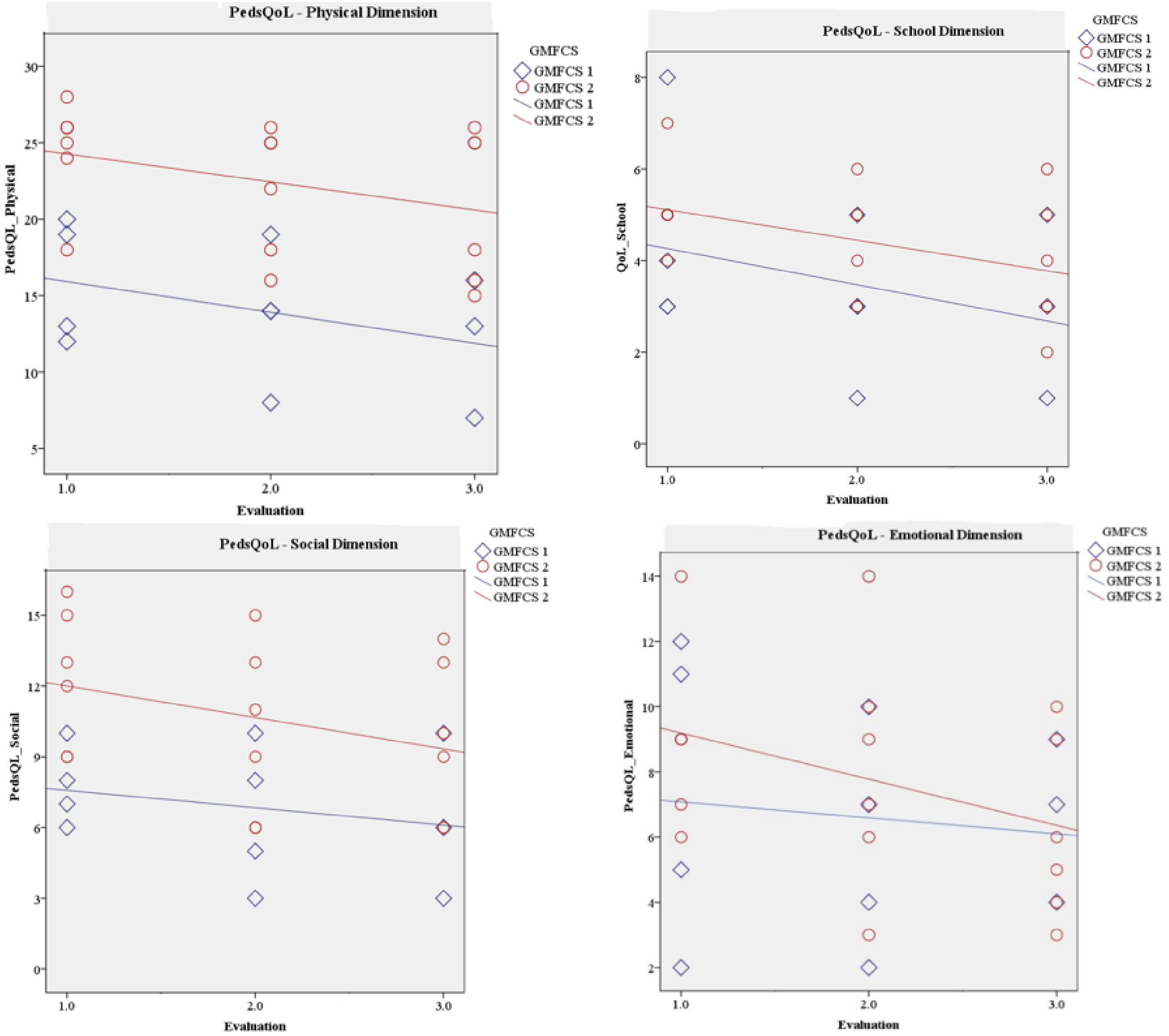


Figure 7.17. PedsQL Dimensions Scores.

GMFCS 1 - level I and II: children with CP that were classified at these levels; GMFCS 2 - levels III, IV and V: children with CP that were classified at these levels. Evaluation 1 – pre-treatment, 2 – after 6 weeks and 3 – after 12 weeks.

8. Chapter 8: Discussion Chapter: The Effect of Hippotherapy on Gross Motor Function, Spasticity, Balance and Quality of Life in Children with Spastic Cerebral Palsy

8.1. Participants Characteristics

In this study, there were three children classified as level I, one as level II, two as level III, two as level IV and three as level V. Two children were classified with the GMFCS for children between 6 to 8 years of age and 9 children from 2 to 4 years of age.

It was challenging to classify participants 6 and 10, both classified as level III and therefore included in the GMFCS 2 group. Both individuals were initiating their gait training with a walking aid, with wheels and support on trunk. In spite of their ability to walk short distances with the aid, the decision to allocate both in the GMFCS 2 group were based in the fact they were not able to have at least one gait cycle without the aid or full assistance and even with the aid they both needed help to steer and turn, and would drag at least one of their feet, not actually stepping. Furthermore, both children were on the upper limit of the classification (2-4 years old) as they were about to reach 5 years of age shortly after the end of the study. If they were to be classified with 4-6 years old scale, they would still be level III, however, at this age, they would be expected to walk with the mobility device and therefore they would be included in the GMFCS 1 group.

Despite the severity of CP, the prognosis of these children is very variable as some could even develop some degree of ambulation with an aid, while others will barely be able to control the head in the sitting position.

NICE, in its guidelines about the management of people with CP, recognized that the motor impairments the child may present with before 2 years of age can, most likely pre-determine the child’s motor ability when the child is older. They indicate that an individual with CP needs to be managed by an interdisciplinary team, and that the physical prognosis of the child needs to be made as early as possible and discussed with parents/carers to enable the child to develop their motor abilities (NICE, 2017). As for the physiotherapists, knowing about the aetiology of the insult, and the characteristics of the child's motor development and impairments are extremely relevant to the design of the therapy, following the recommendation of the WHO (World Health Organization, 2011). This opens the opportunity to expect that Patient 6 and 10, will most likely to keep the same level of classification, but in spite of it, they will keep developing on their gait abilities.

8.2. Gross Motor Function Measure Scores Variation Influenced by Gross Motor Function Classification System

The results presented here have demonstrated the 12 weeks of HPOT was able to improve the gross motor ability of children with CP across all levels of GMFCS, by improving significantly the GMFM-88 total scores and improving, numerically, all dimension scores. In addition, as hypothesised, the results have also shown that how a child with CP is classified on the GMFCS translates to how well the same child will be able to do a pre-determined activity on the GMFM-88 scale. Furthermore, the GMFCS also affects how children with CP will respond to HPOT treatment, with both variables (GMFCS and HPOT) accounting significantly to the positive changes on the GMFM-88.

Because the GMFM-88 scores evaluate the child's motor ability to achieve a pre-determined gross motor activity and the GMFCS classifies the child with CP accordingly to their motor ability, allocating children with the same classification on topography (diplegic, hemiplegic, quadriplegic), but with different GMFCS levels could bring bias to the data and reveal big variations among the participants. For that reason, the statistical method chosen, allowed us to consider all the children in the same group, but differentiating their ability to walk (levels I and II) to their lack of ability to walk (levels III, IV and V).

From the 10 studies evaluating the effect of HPOT in the GMFM, there were two studies (McGibbon, *et al.*, 1998; Casady and Nichols-Larsen, 2004) that did not report the GMFCS, although Casady and Nichols-Larsen, (2004) reports including children that were able to ambulate and children who were not able to ambulate. Two studies (Hamill, Washington and White, 2007; Frank, McCloskey and Dole, 2011) were a case study with only one child – level I and three children – level V, respectively. The remaining (McGibbon, *et al.*, 2009; Park, *et al.*, 2014) did not considered the GMFCS levels when evaluating GMFM, keeping children level I to IV in the same group. From those, only Frank, *et al.* (2011), McGibbon, *et al.* (2009) and Hamil, *et al.* (2007) did not find significant effects of HPOT in GMFM. Frank, *et al.* (2011) and Hamil, *et al.* (2007) probably due to their small sample size, and McGibbon, *et al.* (2009) probably because they have children levels II-IV in the same group, which may have caused a big variation on the GMFM, that were also not reported.

The other four (Kwon, *et al.*, 201; Hyun, *et al.*, 2012; Kwon, *et al.*, 2015 Champagne, Corriveau and Dugas, 2016) have separated their sample accordingly to the GMFCS. Champagne, Corriveau and Dugas, (2016) and Kwon, *et al.* (2011) only evaluated children who were able to walk (levels I and II). Kwon, *et al.* (2015) randomly allocated 45 children in the HPOT and 46 in the control group. In each group the number of children per level was similar, with 12 – level I, 12 level II, 11-12, level III and 10 – level IV. They reported the differences between both groups (control and HPOT) per level, per GMFM category and total values, as well the pre-intervention and post-intervention scores. As in this study, they reported improvements in all levels, when comparing pre and post intervention scores. Chang, *et al.*, (2012) did report the difference between the group that was able to walk (levels I and II) and the group that was not able to walk (III and IV), however they have only shown significant differences between both groups on categories C and D, with the non-walkers performing significantly worse than the walkers in these two classes.

In addition, the results presented have shown that children GMFCS level III, IV and V had further room for improvement on the GMFM total scores, as their raking variation was found to be significantly better when 6 and 12 weeks were compared to baseline and when 12 weeks was compared to 6 weeks. This does not mean that children level I and II benefit less of HPOT, it only means that the number of children at this level (3 children) and the fact that they have reached plato scores on the GMFM dimensions did not allow them to progress further, as they already could do most of the activities, in spite of their level of motor capacity.

Kwon, *et al.*, (2011) is the only other study demonstrating effects of HPOT that have evaluate interaction between two variables on GMFM-88 scores. They have reported significant interaction between the interventions (physiotherapy*hippotherapy). Their protocol gave 16 HPOT sessions (twice a week for 8 weeks – 30 minutes). However, the number of physiotherapy sessions (twice a week for 30 minutes) were not disclosed by Kwon, *et al.,* (2011). They included children at level I and II only and the interaction played a significant role on improving GMFM-88-dimension E. They have also reported that no significant interaction for total GMFM-88 and dimension D was found between their control group (only doing physiotherapy) and the HPOT group (physiotherapy*hippotherapy), even after 8 weeks of treatment.

Differently than the study presented here, Kwon, *et al.,* (2011) have not evaluated the categories A, B and C. However, as for the effect of HPOT on categories D (standing) and E (walking, running and jumping) for children GMFCS 1 (levels I and II able to walk), the results presented here corroborate with the results presented by Kwon, *et al.,* (2011), which adds to the body of knowledge that HPOT could be considered as an alternative therapy to improve gross motor function in children with CP.

Moreover, the results presented corroborate with the findings of Champagne, Corriveau and Dugas, 2016 and Kwon, *et al.,* 2015. Champagne, Corriveau and Dugas, (2016) have evaluated 13 children GMFCS levels I and II that have undertaken HPOT treatment for 30 minutes, once a week for 10 weeks. They investigated the GMFM-88 total scores and dimensions D (standing) and E (walking, running and jumping) reporting a significant improvement when the mean scores after 10 weeks were compared to the baseline values. They reported that the fact that HPOT was able to improve scores on dimensions D and E was due to the fact the treatment is efficient on improving balance and postural control, as the tasks required in these two dimensions (standing, walking, running and jumping) could not be achieved without the ability of keep balance and postural control. The present study has obtained significant changes at GMFM-88 total scores even after 6 weeks of treatment, which can indicate that children level I and II could still benefit even if longer periods of treatment are not available.

Kwon, *et al.,* (2015) have also shown significant improvements on category E and total GMFM-88 scores for levels I and II and category D for level II when post-intervention scores were compared to baseline. Children on this study received HPOT, twice a week for 30 minutes, for 8 weeks. The improvements were also significant when post-intervention scores were compared with control group that have only received CPT in the same variables. This study also evaluated and reported significant improvements for children level III and IV, and the authors discussed that HPOT seem to be effective for all the GMFCS levels. Nevertheless, they have not included children level V, which makes this presented study the first on evaluating the effect of HPOT on GMFM scores on children with CP GMFCS level V and how much their GMFCS interaction with the treatment accounts to the variability on the GMFM scores.

Furthermore, it is important to highlight children GMFCS level IV and V will not develop standing mobility and therefore would not have any or little improvements on GMFM categories D and E, with category E often not even been used on children classified at these levels. This also indicates that there is only so much they would be able to achieve with the GMFM scale, considering its pre-determined tasks, independently of the length of HPOT treatment. Nevertheless, important improvements were observed on the children level IV and V included in this study, as they have gained better control of trunk and head and better control of the sitting position, which are essential to improve their autonomy at home and at school, as it improves their ability to remain sit while using the arms to play or to reach for a specific object.

As for the children classified as GMFCS level III, they may benefit further with HPOT. This is because those children may be able to achieve mobility with walking aids, once they reach 6-8 years of age (considering the GMFCS). HPOT since early age could help to improve control of head and trunk, sitting and standing. As demonstrated in the results presented above, the two children level III were able to do at least some of the tasks in every category of the GMFM.

Hyun, *et al.*, 2012 has demonstrated that children level III and IV had significant improvement on categories C, D and E after 8 weeks of HPOT conducted for 30 minutes, twice a week. Their protocol has had four HPOT sessions more than in this study. This could help explained why it was not possible to demonstrate significant improvement for the children GMFCS 2. Furthermore, they have not included children level V as it was done in this study. This also affected the possibility of HPOT improving the GMFM scores on children on the GMFCS 2, as children level

V were not able to do any of the tasks on categories D and E even after 12 weeks of HPOT treatment.

Ideally, the comparisons on this study should be done in each level of GMFCS as (Kwon, *et al.*, 2015), however with the small sample size it was not possible to separate the sample in so many groups. Nevertheless, it is the first time HPOT is demonstrated effective on improving overall scores of GMFM-88 and on categories A and C for non-ambulant spastic CP after 6 and 12 weeks of HPOT treatment.

The results from this study add to the body of the literature that HPOT seems to be effective on improving GMFM scores for children classified in all levels of GMFCS when HPOT is conducted for 30 minutes, once a week for at least 6 weeks.

8.3. Discussion: The Effect of HPOT on Balance

The aims of this study were to i) identify the effects of HPOT on dynamic balance in children with CP across all levels of GMFCS after 6 and 12 weeks of HPOT and to ii) identify the effects of HPOT on static balance and in children with CP across all levels of GMFCS after 6 and 12 weeks of HPOT.

To evaluate balance, variables of the CoP, its sway, its velocity and its RoM were explored. These variables were collected with a force plate while sitting, and with a pressure mat while passively mounting the horse. These equipment are the gold standard equipment to collect CoP variables in each condition (Winter, 2009; Robertso, 2014).

Overall, the results of this study reported no difference in CoP variables at baseline evaluations, when comparing GMFCS 1 (levels I and II – able to walk) and GMFCS 2 (levels III, IV and V – unable to walk).

Effects of Hippotherapy on Dynamic Balance

Dynamic Balance: The effect of HPOT in Centre of Pressure variables after 6 and 12 Weeks of Treatment

The results of this study have shown that 12 weeks of HPOT improved balance of children with CP by significantly reducing the sway path in both the anterior-posterior, medio-lateral and total while mounting the horse passively for all children evaluated. When looking into sway velocity AP, ML and total were also found to be significantly different at all comparisons.

Although the changes on maintaining the COP path can indicate an increase on valuable inputs to the nervous system for posture, this improvement alone is not enough to promote balance in more effective mater as the proprioceptive sensors are more sensitive to velocity, seeing a change on this outcome would indicate that the child was not only being able to maintaining their balance, but also to respond quicker to changes on body position or acceleration (Silva, Nadal and Infantosi, 2012).

The methodology used in the study presented here is similar to the one used by Clayton, *et al.*, (2011), as they reported the range of motion and the sway velocity of CoP of people with and without CP. Unlike this study, they did not investigate the effect of a therapy, and have only compared CoP variables between CP individuals and individuals without disability. Participants in Clayton's, *et al.*, (2011) study were riders, and the individuals with CP were ages of 5 (n=2) and 10 (n=2), two being GMFCS level V and two level IV, while the control group had people aged 10 to 40. They have reported that the range of motion of CoP (how much the individual moved while riding) was significantly different between the two groups, with children with CP moving significantly more, however no differences were found when looking in to the sway velocity. Clayton's, *et al.*, (2011) aims were to evaluate whether the Pliance system could be used to evaluate balance of people with and without disabilities while riding, but not to evaluate any treatment or ability. They also did not report the level of experience among the riders, which could have affected the different in the results, as well as the age difference and the comparison of a group with a severe disability and a group without any physical impairment.

Nevertheless, the study by Clayton, *et al.*, (2011), was used as based to the study presented in this chapter, regard the use of the Pliance® system. Despite different aims, comparing the current results to those of Clayton, *et al.*, (2011) provides some evidence of repeatability. In addition, this study showed the effect of HPOT as a therapeutic intervention

Janura, *et al.*, (2009) in contrast to the study Clayton, *et al.*, (2011), investigated the effects of 5 HPOT sessions in CoP variables, however only in healthy people without riding experience. They have reported that there was a significant increase in the pressure given to the horse's back after the 5th HPOT sessions but a significant decrease of sway path of CoP. Therefore, Janura *et al.*, (2009) and Clayton, *et al.*, (2011), both support that a decrease in the CoP is associated with healthy or more practiced horse riding. These findings support the results of the current study where CoP sway can be reduced after HPOT treatment. Therefore, a reduction in CoP sway path is a key indicator of healthy and practiced riding, that based on the present study can be induced in children with CP GMFCS1 with HPOT. as also reported by the results presented above.

Considering that, the study presented in this thesis is an extension of what has been published by Clayton, *et al.*, (2011) and Janura, *et al.*, (2009), as we not only reinforced the fact that the Pliance seen to be a reliable tool of evaluation of balance while riding, but it seen to be also a reliable tool to investigate the effect of HPOT treatment. There was no evaluation of range of motion, however, the results presented here (considering the sway path and the sway velocity of the CoP) has shown that not only there is a difference of balance components of CoP in different levels of GMFCS but also that they respond to HPOT differently.

This is the first time the effect of HPOT in dynamic balance while riding has been measured in children with CP to evaluate the effect of HPOT. However, this is not the first time the effect of HPOT in the balance of children with CP has been evaluated. Previous research has used the paediatric berg balance scale to evaluate dynamic balance during everyday tasks (Kwon, *et al.*, 2011; Hyun Jung, *et al.*, 2012; Silkwood-Sherer, *et al.*, 2012; Lee, *et al.*, 2014b; Kwon, *et al.*, 2015; Moraes, *et al.*, 2016). The Berg balance scale measures dynamic balance, however, because of its pre-determined activities (e.g. going up and down the stairs, sitting to standing, walking) it is not a practical tool to evaluate dynamic balance of children with CP that are unable to ambulate or keep trunk and head stability while sitting and standing with aid (GMFCS levels III, IV and V). The overall finding of these studies demonstrated significant improvements on paediatric berg balance scale scores after HPOT treatment that varied between 8 to 24 weeks, although they did not divide the children in groups according to motor abilities. Although the berg balance scale is a different measure is it is important to highlight that our findings go in the same direction of previous studies investigating CoP variables and dynamic balance throughout the paediatric berg balance scale. Further highlighting the improvement in postural control as a result of HPOT.

Likewise, the results reported by Clayton, *et al.*, (2011) and Janura, *et al.*, (2009), it was demonstrated here that the CoP variables of children GMFCS 2 is significantly bigger than of children GMFCS 1 and that HPOT is able to produce a more significant positive effect in children with mild and moderate CP than in children with severe condition.

Therefore, it is highlighted that, and in spite of the limitations, it might be imperative to explore the in-depth difference of dynamic balance components, within different levels of GMFCS.

This work presents the first evaluation of CoP variables while mounting passively the horse as an effect of HPOT treatment in children with CP with all levels of GMFCS is been carried out. Clayton, *et al.*, (2011) reported an average range of motion AP of 111.5 ± 53.8 mm, range of motion ML of 49.9 ± 5.4, CoP Velocity AP 320.1 ± 159.6 and Velocity ML of 103.5 ± 13.2, with these means been significantly worse in comparison to the non-disable control group. The GMFCS 2 (levels III-V), which would be the most comparable group to the study carried out by Clayton, *et al*., (2011), had 6 participants (age 4). Range of motion was not evaluated, and the mean of the group was not calculated as it was by Clayton, *et al*., (2011), as a decision was made to statistically analyse the data considering every trial point of every participant, avoiding that the data could be skewed in one or another direction, due to the different values among the participants recruited. Nevertheless, as reported by Clayton, *et al*., (2011) there was a significant difference in the sway velocity when children classified as levels IV and V (unable to walk – more severe CP) were compared to more abled bodied children (levels I and II).

Clayton's, *et al.*, (2011) study, although pioneered and with valued information, had a very heterogeneous sample in regard age, height and weight. Those three factors are of extremely importance, as a child with 9 years old will be in different development stage, height and weight in comparison to an adult of 30 years old. Our sample is much more homogenous in that regard, as all the children in the NWG group were 4 years old with height varying from 99 cm 111 cm and weight varying from 11.02 to 22.59 kg. These ensured that the children, although varying in GMFCS levels from III to V would be in same development stage.

Effects of Hippotherapy on Static Balance

Twelve weeks of HPOT reduced sway path and velocity AP and total were significantly reduced, which indicates that the children in this study were swaying less from one side to the other while in the sitting position. However, no statically differences were found when looking to the comparisons individually. Nevertheless, this is an important acquisition, as it demonstrates that HPOT not only improved postural stability while riding the horse, but also in the fundamental act of sitting unaided. This finding supports the use of HPOT for improving function in the everyday lives of children with CP.

As being able to keep the body more centralize and within the base of support, can allow the children to not need the arms to maintain themselves in the sitting position, and therefore be able to achieve some activities such as reaching for an object or playing with something.

In addition, the results presented here have shown that only before the HPOT treatment starts the sway path anterior-posterior was significantly different between children in the GMFCS 1 and 2, being significantly smaller (indicating less sway in this plan) in children GMFCS 1. After 6 and 12 weeks of therapy, the difference between the two groups became smaller and non-significant, indicating that HPOT has helped children in the GMFCS 2 to sway less and/or closer to the amount of sway children in the GMFCS 1 would have.

Although this difference was not significant, it is an important finding, and it indicates that perhaps children in the GMFCS 2 (level III – V – unable to walk) may take longer to answer to a HPOT treatment, but that does mean that they do not benefit from it.

It is possible that the size of the sample, interfered directly on the amount of variability found on our data for force plate measures. Even children with the same GMFCS level, or within same group have had a big variability and big standard deviations when means were compared.

Previous studies evaluating the effect of HPOT in balance components of children with CP (Kang, *et al.*, 2012; Mackow, *et al.*, 2014; Moraes, *et al.*, 2016) did look into CoP or CoG variables, however in static positions, with the use of force plate. Moraes, *et al.,* (2016) looked in changes of CoP Sway Path and Velocity AP and ML after 24 weeks of treatment in quasi-static sitting position using an AMTI AccuSway Plus force platform, for 10 seconds, with eyes open at frequency of 100 Hz. They analysed the variables of 15 children levels I to IV without dividing the children according to their GMFCS. The evaluation was taken at baseline, after 12 weeks and after 24 weeks of treatment. There were significant improvements on sway path AP and ML at 12 and 24 weeks when compared to baseline and sway velocity between 24 weeks and baseline and 24 weeks and 12 weeks. The results presented by those authors are important, as it seems that HPOT was able to reduce sway path and velocity during static balance independently of the GMFCS. Differently, the study presented here, only demonstrated significant improvements on sway velocity ML. The difference in the results, may be a result of methodology regard frequency and duration of treatment, in addition, the study mentioned above provided 12 weeks more of HPOT.

Kang, *et al.,* (2012) also investigated the effect of HPOT in sitting balance in three different groups: HPOT group (CPT + HPOT), Control Group (no intervention) and CPT Group (CPT only). HPOT and CPT were offered for 8 weeks for 30 minutes and measures were taken before and after treatment. They reported that sway path and velocity of CoP significantly decreased in the HPOT group in comparison to the other two groups. The authors did not mention the GMFCS, however it was stated that the children had the ability to walk independently for more than 10 minutes. The fact the only independent walkers were evaluated, may explain why they have reported improved sway path and velocity after only 8 weeks of HPOT. As explained above, the difference of motor function and balance ability among mild CP (GMFCS I and II) and severe CP (GMFCS III, IV and V) is important, and they may respond differently to different types or intensity of treatment. The fact that the study by Kang, *et al.,* (2012) provided positive evidence of HPOT effect on static balance and the study presented here did not adds to the discussion that it is i) not only important to use a classification that can be understood by practitioners and researchers but also ii) that children with CP with different levels of motor ability may respond differently to HPOT treatment.

As the study carried out by Mackow, *et al.,* (2014) investigated the influence of HPOT in the transference of CoG in children with CP. They have involved children levels I-III that had the ability to maintain standing position unassisted, as measures were taken during quiet stance. A single 30 minutes HPOT session was offered. There were reported significant changes on the CoG in the frontal plane after the HPOT session and in CoG oscillation velocity. The study presented here did not evaluate CoG, only components of CoP, which is related to CoG. Both results, however, go in the same direction when considering HPOT to be used in the balance rehabilitation.

The studies discussed above did not divided the children according with GMFCS, have also recruited older children (4-13 years old) and have used children with less severe CP. The results presented here, in spite of a small sample, indicated that maybe evaluate changes on CoP variables in static position with a force plate could be too sensitive for this population which leads us to suggest that more studies should be carried out using force plate and with different sensory cues (with eyes open) with a bigger sample size and considering all the levels of GMFCS. Moreover, and considering the concepts discussed by (Samuel, *et al.,* 2015; Rinaldi, *et al.,* 2009; Demura, *et al.,* 2008; Donker, *et al.,* 2008) and bearing in mind the results shown by Moraes, *et al.,* (2016) that the effects on static balance could need longer course of treatment for more significant changes to be identified.

8.4. Discussion: The Effect of HPOT in Spasticity

The results presented above have demonstrated that 12 weeks of HPOT treatment, carried out once a week for 30 minutes is able to significantly contribute to reduce spasticity in muscle groups of the upper and lower limb. In addition, the results also demonstrated that sitting the horse passively for 5 minutes can also cause a significant immediate effect on spasticity in muscle groups of the upper and lower limb. This is the first time that the effects of long-term HPOT treatment and short-term passive sitting on muscle groups of the upper limb, and although there was reports of HPOT improving spasticity in the lower limb (Antunes, *et al.,* 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018) no one has described all the main muscle groups, bilaterally.

This is important as it increases the knowledge and understanding of how this type of therapy can help in the management of spasticity for the limbs as whole, not only for a single muscle group. When thinking about gait acquisition, overall mobility, daily life activities that often require a good control of upper limb, research and therapists cannot think about only one muscle group, nor think only about one of the limbs. For children with CP it is important to provide rehabilitation treatment that will have the focus to improve and enhance the functionality of the individual as whole.

Furthermore, describing how HPOT affects all the main muscle groups, increase not only the knowledge about the therapy itself, but as well, it helps build evidence of its effectiveness. In addition, it can work as great guidance for practitioners, helping to direct the focus of the HPOT sessions.

In the literature there is a clear divergence among studies regarding the effectiveness of HPOT on managing spasticity in children with CP, as some studies have reported that there is only weak evidence to its effectiveness (Novak, *et al.*, 2013) while others have reportedly concluded that HPOT treatment could be recommended to help with managing this outcome (Liporoni and Oliveira, 2010; Tseng, Chen and Tam, 2013; Oliveira, *et al.*, 2015). However, there are several limitations to these reviews, as one of them (Novak, Mcintyre, *et al.* 2013) based its conclusions on other literature reviews, and others have extensively criticized the methodology of the studies included (Zadnikar and Kastrin 2011; Herrero, *et al.*, 2012a; Tseng, Chen and Tam, 2013). This combined with the lack of evaluation of important muscle groups in the lower limb, such as gastrocnemius and quadriceps (which are essential to gait acquisition) and the lack of evaluation of the effect of HPOT on any of the muscles in the upper limb, gave the scope for the gap in knowledge that this study aimed to address.

Among the previous four studies evaluating the effect of HPOT on muscle symmetry (Benda, McGibbon and Grant, 2003; McGibbon, *et al.*, 2009) or spasticity (Antunes, *et al.*, 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018) on children with CP there was no division of analysis made between the GMFCS levels. The two most recent studies evaluated children levels I to IV and the oldest study did not report GMFCS levels for any of the subjects evaluated. This study indicates that the HPOT effect on spasticity does not relate to the gross motor function level of the child as this study was unable to report any significant differences in all assessments. This is perhaps because GMFCS levels only account for the postures and gross movement the child is able to achieve at determined age, but not how difficult or what kind of muscle activation the child uses to achieve that specific posture or movement (Bower, 2009).

Nevertheless, spasticity can influence the acquisition of motor skills negatively, and therefore compromise the level of motor ability the child may be able to achieve. In addition, it is important to consider, that spasticity can often be a compensation for muscle weakness and lack of neuro-musculoskeletal control, which is common to the CP palsy condition. This “positive” effect of spasticity would help facilitate the acquisition of up stride postures, with studies reporting that strength deficit on upper limb relates to spasticity on agonist muscles (Bohannon, *et al.*, 1987; Armutlu, 2010; Trompetto, *et al.*, 2014).

Effects of Hippotherapy on Spasticity of the Upper Limb

This study is the first presentation of the effects HPOT can have spasticity of the upper limb in children with CP. According to the results presented here, HPOT was able to have a positive influence on spasticity, by reducing its intensity and promoting muscle relaxation significantly. It was demonstrated here that spasticity was significantly reduced at all muscle groups of the upper limb for at least one comparison of treatment versus baseline, as demonstrated on results section. This indicates that HPOT treatment can cause an overall control of spasticity along time.

Interestingly the results reported for the upper limb have shown a more extensive short-term effect of HPOT in the upper limbs than long-term effects. Significant short-term effects of HPOT were observed all muscle groups for at least on time point of comparison at 6 and/or 12 weeks of treatment.

In HPOT studies involving people with SCI (Lechner, *et al.*, 2003; Lechner, *et al.*, 2007) spasticity on the upper limb was not evaluated, in spite of having people with tetraplegia. Likewise, the studies investigating effects of HPOT in other conditions such as stroke (Beinotti, *et al.*, 2010; Lee, *et al.*, 2014) and multiple sclerosis (Silkwood-Sherer, 2007; Frevel, 2014; Lindroth, Sullivan and Silkwood-Sherer, 2015) did not investigate its effects on spasticity, not even in the lower limb.

Previous studies investigating upper limb function and spasticity in children with CP, reported that children with uni- or bilateral CP will experience difficulties on performing daily living activities that request the use of one or both hands, such as putting a shirt on, zippering jeans, tightening the shoes, holding a glass or cutlery, writing and brushing the hair and teeth (Boyd, Morris and Graham, 2001; Bower, 2009; Sakzewski, Gordon and Eliasson, 2014; Lin, *et al.*, 2015).

Furthermore, the ability to use arms and hands and to develop fine motor function varies according to the type of CP and to the location of the impairment. Reduced strength has been often associated with spasticity and ability varying from just little clumsiness to the complete absence of the hand and arm function (Boyd, Morris and Graham, 2001; Sakzewski, Gordon and Eliasson, 2014). Physical and occupational therapy techniques have been recommended to rehabilitation of upper limb in children with CP, and the importance of rehabilitation of the upper limb to overall function of the patient has been highlighted plenty of times in the literature, although there is not still evidence to indicate the most efficient technique, with Occupational Therapy and botulinum toxin been considered the most efficient so far (Boyd, Morris and Graham, 2001).

The results reported on this study about the upper limb are an important contribution to the evidence of HPOT effectiveness as a holistic rehabilitation technique for children with CP. It is suggested that further investigation on upper limb function, muscle activity and spasticity after HPOT treatment should be carried out, perhaps combining clinical scales, such as MAS with sEMG and kinematic date in order to understand the trajectory of the movements of the arms while passively riding.

Effects of Hippotherapy on Spasticity on the Lower Limb

For the lower limb, a significant effect of 12 weeks of HPOT was found on the hip adductors bilaterally, which corroborate with the results presented by (Lechner, *et al.*, 2003; McGibbon, *et al.*, 2009; Antunes, *et al.*, 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018). A significant effect of 12 weeks of HPOT were also observed on the gastrocnemius and tibialis anterior, also bilaterally.

Only two other study evaluated the effect of HPOT in lower limb spasticity in children with CP using the MAS, or as the matter fact, using any other scale. This was a feasibility study carried out in the Rehabilitation Centre, in Porto Alegre, Brazil (Antunes, *et al.*, 2016; Lucena-Anton, Rosety-Rodriguez and Moral-Munoz, 2018) that enrolled 10 children with bilateral spastic CP (diplegic or quadriplegic) ages 5 to 15, GMFCS levels I-III that were randomly allocated in intervention group, with 5 doing protocol 1 (from walk to halt and for halt to walk, for 30 minutes) and the other 5 doing protocol 2 (halt – walk – walk fast – trot, and then downwards for 30 minutes). As in this study the MAS was used to investigate short term effects of HPOT in the hip adductors, with evaluation happening before and immediately after the protocol, as procedures used in this present study. They reported a significant decrease of spasticity after both protocols, but more prominent after walk-trot.

As for the other muscle groups, in children with CP, we were unable to find any evidence investigating HPOT effects on this population. In the studies involving people with SCI, 5 different muscle groups in the lower limb were evaluated, bilaterally after HPOT sessions, however the authors did not specify which muscle groups only that evaluations were done with knee flexion-extension, hip flexion-extension and hip adductor. The authors also did not report the values for each muscle group, but instead the sum of values for all the lower limb. According to the reported results HPOT was able to produce significant short-term effects, but no long term effects were identified (Lechner, *et al.*, 2007).

As previously discussed in chapter 2 and in the introduction of this present chapter, there are two studies investigating muscle asymmetry after HPOT treatment in the hip adductors of children with CP (Benda, McGibbon and Grant, 2003; McGibbon, *et al.*, 2009). Both studies were carried out by the same research group and were randomized trials. The oldest study provided one session of 8 minutes of HPOT to the intervention group and 8 minutes of barrel exercise to the control and evaluated muscle asymmetry with sEMG. Although they reported positive effects on reducing muscle asymmetry after HPOT, they have reported several limitations, as the sample size was small, they have only evaluated short term effects of HPOT, they did not report GMFCS characteristics of the children and the control group had smaller, but no significant asymmetry prior to the treatment for the oldest study. The study published in 2009 was a follow up and an updated version of the oldest, and it investigated the asymmetry of hip adductors, gross motor function and self-perception profile.

After careful analysis of the studies cited above questions such as the ones addressed in this study were raised, and the specific effect of HPOT (short and long term) in spasticity in the main muscle groups of the upper and lower limb, using a clinical quantifiable and widely used scale, the MAS, in children with CP levels I to V, with hemiplegia, diplegia and quadriplegia was addressed.

In spite of not using a quantitative measure such as sEMG, this present study took care to report specific characteristics of spasticity for every muscle group evaluated.

As for the lower limb, HPOT had significant short- and long-term effects on reducing spasticity especially for the quadriceps, the gastrocnemius and the hip adductors, bilaterally, with significant effects in the majority of the comparisons.

The results presented here corroborate with the findings in the literature and add to the body of evidence that HPOT could be recommended to facilitate the management of spasticity on persons with physical impairment. The sensory inputs given through the precise, rhythmic and repetitive movement of the horse, combined with the inhibiting sitting in stride position with the legs positioned in flexion, with hip adduction and external rotation, and with the pelvis pitching and yelling following the horse's trunk seen to be a plausible explanation to explain the neurophysiologic effects of this technique in regulating spasticity (Lechner, *et al.*, 2003; Hammer, *et al.*, 2005; Lechner, *et al.*, 2007; Alemdaroğlu, *et al.*, 2016; Antunes, *et al.*, 2016).

8.5. Discussion of Effect of Hippotherapy in Quality of Life

The results presented here demonstrated that quality of life was significantly better across all levels of GMCFS after 12 weeks of HPOT treatment, when looking into the total scores of PedsQL®. It was also demonstrated that 6 weeks and 12 weeks of HPOT was able to reduce significantly the scores of the scale in the total and physical category, across all levels of GMFCS, in addition to significant improvement at 6 and/or 12 weeks when compared to baseline for emotional, social and school categories.

There is not a study that has investigated the differences of the scores obtained on the PedsQL® parental proxy-report after HPOT considering the different levels of GMFCS. Evaluating this difference is relevant as QoL is directly connected to independence, autonomy, ability to self-care and to participate in society (Diwan, *et al.*, 2017; Maher, Toohey and Ferguson, 2016; Rosan, Braccialli and Araujo, 2016; Tan, *et al.*, 2014).

These results corroborate to what has been reported by Arnaud, et al., (2018). They have not investigated the effect of any therapy on PedsQL® but have conducted a survey involving over 800 children with CP, assessing their QoL using parent-proxy questionnaires, like the one used in this present chapter. In this study, they have considered how the GMFCS would affect the QoL of the child.

They have reported a strong relationship between the GMFCS level and the positive results on the physical domain. The results presented here corroborate with the findings of Arnaud, et al (2018) and add further evidence to the body of the literature, that the GMFCS should be considered in future research as it significantly impact the physical well-being of a child with CP (Maher, Olds et al. 2008, Varni, Burwinkle et al. 2006).

The indication the HPOT treatment affects significantly the total scores of PedsQL® was also reported by Rosan, Braccialli and Araujo, (2016), however the findings by Davis, *et al.,* (2009) do not bring any significant changes. This may be because Davis, *et al.,* (2009) used therapeutic horse riding and scales that were considered by the authors not sensitive enough. Nevertheless, they have discussed that their results go against anecdotal evidence gathered by the parents of the children involved in the study that reported they felt their children were happier and more confident because of the therapy with the horses (Davis, et al., 2009). In addition, the results here corroborate to what was reported by Rosan, Braccialli and Araujo, (2016), that the PedsQL® seems to be an appropriate measurement to evaluate the impact of HPOT on the QoL of children with CP.

An improvement was observed at all components of PedsQL® for every child after 12 weeks of treatment, also demonstrated by Rosan, Braccialli and Araujo, (2016) and Thompson, Ketcham and Hall, (2014). However, this study did not demonstrate significant improvements of the emotional and school categories of PedsQL® after HPOT treatment. Nevertheless, was possible to demonstrated that the severity of CP considering the GMFCS makes a significant contribution to the variability of the social category (34.7%), however does not necessarily affect the school and emotional components. This was also demonstrated by Rosan, Braccialli and Araujo, (2016).

Arnaud, *et al.,* (2018) have also discussed that poorer QoL of children with CP, considering their GMFCS levels without consider any type of therapy or treatment. They have reported that the severity of the condition does not necessarily relate to poorer social acceptance, school environment domains or mood and emotions. This indicates that GMFCS levels will not necessarily affect components of QoL that are not directly related to physical well-being. Those components, would, most likely be affected by the school environment itself, by the perception of the parents towards the child, especially when using parent-proxy questionnaires, such like the one used on this study, or even they can be affected by the cognitive ability of the child (Arnaud, *et al.,* 2018; Power, *et al.,* 2018).

This study used a parent-proxy questionnaire, and despite its good reliability and responsiveness to the progression of the condition (Varni, Seid and Kurtin, 2001a; Varni, 2017) one should not assume that the opinion of the parent would necessarily be the same that the child would give (Arnaud, *et al.,* 2018). It is important to highlight that in spite the indication that children with CP is capable to report their own perception using QoL questionnaires (Varni, *et al.,* 2005; Varni, *et al.,* 2006) this was only considering children that were 5 years of age or older. As most of our sample was under 4 years of age, a parent-proxy questionnaire was more appropriate at this point of the evaluation. In addition, it is important to highlight that the parental well-being can also affect how the parent perceives the child's QoL and in further research, this outcome should be considered.

9. Chapter 9: Conclusions, Implications and Limitations of the Study

9.1. Final Considerations and Implications of This Study

Gap in Knowledge Addressed

The aim of this thesis was to i) address some of the issues raised in previous literature reviews, ii) to expand and update the previous systematic reviews in order to have a better and broader understanding of the current state of knowledge in the field, iii) to understand how physiotherapists were carrying out this technique in practice in Brazil and in the UK and (iv) to investigate the effect of short and long term HPOT treatment in gross motor function, spasticity, static and dynamic balance and quality of life of children with CP.

This thesis differs from the previous published in various ways:

1. The literature review is not only an update of what is been published, but it is also an expansion of what has been done, as it adds more studies evaluating the effects of HPOT only in specific outcomes (motor function, balance, gait, functionality, etc.) in children with CP

2. It is the first time a survey compared PT practices between Brazil and UK. The survey presented in this thesis follows the study by (Debuse 2005), in which German and British PTs were surveyed about their practice with HPOT. The study within not only extended the range of questions, investigating not only the PTs perceptions of HPOT effects and how they were being measured, but also specific characteristics of the sessions, investigating type of equipment, and in concordance with the AHA guidelines for HPOT practice, the duration of sessions and treatments and a variety of physical outcomes;

3. As discussed throughout the thesis, the effects of HPOT in gross motor function has been investigated many times as the GMFM is a gold standard, validated scale to evaluate gross motor function in children with CP. However, this study brought novelty as it considered the GMFCS levels of each child, reporting significant and positive effects of HPOT across all GMFCS levels.

4. Prior to this work the evidence of the effect of HPOT in spasticity was poor. This is the first time the short and long-term effect of HPOT on spasticity has been reported for muscles in the upper limb. As for the lower limb, previous studies have brought some evidence of HPOT reducing muscle asymmetry, however, this work was not able to find any study investigating all the main groups of the lower limb and reporting significant results. The results presented here reported that HPOT not only improve spasticity on the upper and lower limbs, but also, that it does across all GMFCS levels. In addition, it was also demonstrated that short-term passive sitting on the horse can also reduce spasticity in the upper and lower limbs.

5. The thesis addressed the effects of HPOT on static and dynamic balance in children with all GMFCS levels and with the most common classifications (diplegia, hemiplegia and quadriplegia) using validated gold standard biomechanical tools to evaluate the sway path, velocity of the CoP, an important balance component that relates to the CoM. Moreover, it was the first time that the balance of children with CP while sitting passively in the horse passively was compared to the same outcomes of children without disabilities. The results reported have shown a positive effect of HPOT on dynamic balance of children with CP across all levels of GMFCS, however there is little evidence that HPOT effects static balance in these population.

6. Lastly, the impact of QoL was evaluated in children with CP. Although, other studies have evaluated this outcome before, after HPOT, it is the first time that this is done with only a CP population and only after HPOT. The results have shown that HPOT was able to improve overall QoL and the physical domain of QoL after 12 weeks of treatment, in children with CP across all levels of GMFCS.

Participants Improvement Throughout Hippotherapy Treatment

Across the chapters of this thesis, important results regard the effects of HPOT in children with CP across all levels of GMFCS were presented. With positive findings being reported for gross motor function, dynamic balance, spasticity and quality of life. To add to this evidence, below there is a descriptive report about the improvements observed for each participant. This report was based on the subjective observations of the lead researcher and are presented here to complement the evidence given in the thesis and to provide to the reader a bigger picture of the participants.

GMFCS Levels I and II – GMFCS 1 - Children that could walk

[1]*Participant 1:* This patient (♀, 8 years old) was classified as spastic diplegic – level 1. She used splints on both feet to support her ankles in an anatomical position and facilitate gait. This child was able to walk long distances with the splints on and participate in sport activities but have poor control and locomotion without the splints. As a child with diplegia, both legs were predominantly affected with some impairment on the right arm and hand, which led to a more restricted fine motor function (grasping) with the right hand, in comparison to the left hand. The right foot and leg were also more affected than the left. In the first evaluation session it was more challenging for the child to support the weight on the right leg than it was to do it so on the left leg. The child was very communicative and had no difficulty in understanding commands or initiating motor activity. By the end of the treatment the child had noticeably improved her ability to jump, run and kick, as well her ability to support the weight on both legs and to use both hands when throwing.

[7]*Participant 7:* This child (♀, 4 years old) was classified as spastic hemiplegic – level 1 and was the least physically impaired child of the group. She did not use splints, walking aids or corrected shoes and was mainly impaired in the right leg, with a right ankle with slight extension. As for the upper limb, there was a slight difficulty in grasping and keeping fingers in neutral anatomic position with the right hand. She presented the walk in semi-colon, due to stiffness on right knee. This child had fine head and trunk control when sitting and standing and was able to jump, run, kick and throw with all limbs. Between the first and the last evaluation, the child's coordination and weight shift had visually improved.

[9] *Participant 9:* This participant (♀, 7 years old) was classified as spastic hemiplegic – level I. Her left side was physically impaired, with the upper limb being more affected than the lower limb. The child did not need any aid, splints or support. She was able to communicate and follow instructions. In the first session, the child presented difficulties in standing on her left leg, on weight shift and jumping and had a semi-colon walk. By the end of the treatment she had visually improved her ability to weight shift and her semi-colon walk was visibly more normalized.

[11] *Participant 11:* This participant (♀, 4 years old) was classified as spastic diplegic – level 2. She only did one block of treatment and two evaluations. This happened because the child was included in the program just before the second block

of treatment started. With both her legs and the right arm affected, this child had the upper limb slightly more affected than the lower limbs. She had fine trunk, head and sphincter control, could walk independently although with some stiffness on the right leg. The differences between first and second session were with respect to the improvement in the child's control on standing position and walking.

GMFCS Levels III, IV and V – GMFCS 2 – Children that could not walk

[2] *Participant 2:* This child was withdrawn from the study by her guardians, as they decided to discontinue their HPOT treatment.

[3] *Participant 3:* This child (♀, 4 years old) was classified as spastic quadriplegic – level 5. The child had no ability to communicate orally, had all four limbs affected, no control of sphincter, trunk and head. The child could maintain sitting position in "W" format with her hands on the floor or over the knees to keep support. The child used splints on both feet, had equine feet and do not have any independent locomotion. In the first evaluation session the child could not maintain head straight forward, even when supported in the trunk and could not maintained 4-point support or creep. By the end of treatment, the patient's head control had improved, as she was able to keep her head straight when sitting with support for 10 seconds (extracted from GMFM) and was able to creep for some metres towards an object and maintain 4-point support when positioned by sitting in her heels without head control.

[4] *Participant 4:* This participant (♂, 4 years old) was classified as spastic diplegic – level IV. This child was particularly challenging to classify with the GMFCS for two reasons: (1) the child was starting gait training for short distances with a walker when the study started; (2) the child was four but was only three months from being 5 when the study started and less than one month when the study finished. The GMCFS used was the one from 2-4 years, in which level 3 diagnosed children still do not have the ability to walk, although that is considered a possible prognostic outcome for this individual (Bower, 2009). The child had oral communication impairments but could communicate partially, used splints on both feet and was training sphincter control. He was able to sit without help, interact with objects, creep and crawl and attempt to kneel and standing pulling towards a hard surface. By the first session, with the walking aid (with wheels and trunk support) and the splints the child was able to pull himself for very short distance. By the end of the treatment, the child's trunk control had improved

his ability as well to walk for short distances with the support device. The child was classified as level 4, due to his age and because the gait training was only starting, the child could not walk with independence during the study, however, with the child turns 5 years old and assuming improvements on gait ability he could be probably classified at level 3.

[5] *Participant 5:* This participant (♂, 4 years old) was classified as spastic quadriplegic – level 5. This child had a severe impaired oral communication, although he was able to use few simple words and phrases. He had all limbs affected, no sphincter control, no head control in the sitting position without support and poor trunk control on sitting, needing to support the weight with hands on the floor or on the knee while sitting. The child did not use splints but used a full body suit for support during the entire days and activities. In the first evaluation session, the child was able to sit with hands on the floor with poor head control, to creep towards an object, to roll, to attempt 4 points support when positioned by sitting on the heels. By the last evaluation session, the child had visibly better head and trunk control, being able to sustain head straight forward and trunk elevated through only partial support of the hands on the knees for 10 seconds (obtained from GMFM).

[6] *Participant 6:* This child (♀, 4 years old) was classified as spastic diplegic – level 3. The child was very shy, but collaborative. Her impairments were specifically in the lower limb, and she had a fine head and trunk control when in sitting position and standing with support. The child had equine feet, worse on the right foot and used corrected shoes. The child was able to crawl, but generally hopped, sit without support and interacted with objects, maintaining 4 points of support and pulled herself towards hard surface. In the first session the child could maintain standing whilst holding with both hands and with light support in the hips when positioned but was not able to attain step of cross step. By the last evaluation, the child could cross the right leg over the left leg, supporting the weight with both hands.

[8] *Participant 8:* This child (♀, 4 years old) was classified as spastic quadriplegic – level 5. The child had all four limbs impaired and used a full body suit for support. She had some control of trunk and head in the sitting position and could turn and attempt to reach objects in this position that were position near to her. In the first evaluation she could keep 4 points of contact when positioned and siting on the heels, to creep and hop. In the last evaluation session, the child's control in the sitting

position had visibly improved and she was attaining to crawl when stimulated on the hips and knees.

[10] *Participant 10:* This child (♀, 4 years old) and was classified as spastic diplegic. The child was also starting gait training with a walking aid, using a walker that did not need a trunk support, however the walker had wheels and the child was only comfortable on using the device for short distances. When walking with the aid, she needed the corrected shoes and if tired would just drag the foot around by pulling the aid using the wheels. This child was placed in the GMFCS 2 group as the walk was still in development and she could not walk without aid or support in both hands. The child could communicate and follow instructions and had full trunk, head and sphincter control. The differences between the first and third evaluations centred around improvements on gait training, on standing with the support of only one hand, and on attempting of standing in one leg when supported.

Protocol Design

The design of protocols was based in a combination of results that were gathered from the studies presented in the systematic literature review (Chapter 3) and from the data reported in the survey with PTs in Brazil and in the UK (Chapter 4).

In Chapter 3 it was reported that therapists in the UK and in Brazil typically do HPOT sessions with each patient for 30 minutes, once a week. These findings differ slightly in the literature. From the 10 studies that were identified that were investigating the effects of HPOT in the GMFM in children with CP (Casady and Nichols-Larsen, 2004 McGibbon, et al., 2009; Kwon, *et al.,* 2011; Hyun Jung, *et al.*, 2012; Kwon, *et al.*, 2015; Champagne, Corriveau and Dugas, 2016;) six were reportedly doing HPOT sessions for 30 minutes, however, only 4/10 were doing once week, with all the other studies doing HPOT twice a week.

The ultimate design of the protocol for the participant-based study was based on the survey findings. This part of the research was carried out in a HPOT centre, in the UK. The data collection was done outside of a highly controlled lab environment, and the therapy was given by an independent qualified practitioner, not by a researcher. Moreover, as the survey found that all therapists in the UK do HPOT for 30 minutes, once week, this regime was adopted for this protocol as it was close to the typical treatment regime for children that will access this treatment. Published literature reviews (Herrero, *et al.*, 2012a; Whalen and Case-Smith, 2012; Tseng, Chen and Tam, 2013) have extensively criticized the lack of consistency in the frequency and duration of HPOT sessions with only one study (Park, *et al.*, 2014) justifying their choices based on a literature review (Whalen and Case-Smith, 2012).

Our systematic literature review showed that in regard the time duration of treatment, 9/10 studies investigating the effect of HPPT on GMFM scores used a HPOT treatment regime lasting 8-10 weeks. The survey however indicated that in the UK, PT's reported that they generally carry out blocks of 6 weeks of treatment, when they often re-assess their patients' progress. The Brazilians PT's reported that the block of treatment generally goes on for 12 weeks, and it is when they re-evaluate their patient. Both countries agreed that the child should be discharged only when reaching a plateau, but there is not, to our knowledge, a consensus of when this plateau will actually be, as it will depend directly from the individual characteristics of the child. To combine findings relating to typical HPOT practice from both countries and considering that most studies investigating HPOT in GMFM lasted for at least 8-10 weeks, a decision was made to have two blocks of therapy, each of 6 weeks, with evaluations happening before the first block, between both blocks and then after 12 weeks.

Implications of the Thesis

This study highlights how importance is to instigate the possible positive effects of HPOT on physical impairments and quality of life of children with CP. Furthermore, the results reported here indicated that HPOT could be considered as an alternative therapy to help manage and improve dynamic balance, spasticity, gross motor function and QoL of children with CP. In summary, this thesis has had the following implications below.

1. The literature review and the survey have brought some discordance on protocols of HPOT treatment, regard time and duration of sessions and treatment. However, the results gathered by both studies have given the support to develop the protocol used on the experimental chapters of this thesis, protocol that can be used by other researchers and practitioners as it was demonstrated here that 12 weeks of HPOT, once week for 30 minutes

could generate positive effects on gross motor function, spasticity, dynamic balance and QoL;

2. There is still limited evidence regard who a child responds to the horse's stimuli, however the pliance® system used on chapter 7 to evaluate dynamic balance, seen to be a valid tool to help understand how the stimuli given by the horse translates itself to an improvement in a physical outcome such as dynamic balance;
3. This is the first time the effects of HPOT on spasticity of the upper limbs is evaluated. In addition, by evaluating all the major muscle groups of the lower limb, this study adds important data regard the effect of HPOT on spasticity, and more studies are recommended, perhaps evaluating muscle activity and muscle strength as well.

The effect of HPOT in QoL of children with CP has been evaluated before, as discussed on chapter 8, however, this is the first study focusing only in children with spastic CP and HPOT, as the other studies included also THR o other types of disabilities. The positives results presented here add to the body of the literature, but also indicate the PedsQL® seen to be a reliable tool to evaluate children with CP undertaking HPOT treatment. More studies with bigger samples sizes, using the same protocol of treatment and evaluation are recommended.

General Limitations of the Thesis

This study brought novelty, addressed some of the gap in knowledge related to the field and provided positive evidence about HPOT effectiveness on the management of CP that will add to the body of the literature. There are however limitations of our research and it does raise further gaps in knowledge that should be addressed in future. Due to the variability of the studies it was not possible to proceed with a meta-analysis following the systematic literature review, making it impossible to statistically analyse the results of the papers included in the review. In the survey, not every HPOT centre in Brazil responded due to contact details issues. Furthermore, some of the centres contacted did not have PTs or did not work with patients with CP, as in Brazil, other health allied professional is also allowed to conduct HPOT, such as OTs and psychologists. As for the UK therapists, the CPTRH was unable to provide a contact list for all current registered therapists, due to privacy policies, and therefore it was not possible to recruit the total sample needed for statistical power. Nevertheless, large effect sizes support the significant findings reported.

As for the experimental chapter, the biggest limitation was the size of the sample, similar sample sizes have been previously criticized in all literature reviews in the field. However, the use of a non-parametric test, indicated for this type o data helped to reduce the bias on the analysis and to bring further power to it (Siegel, 1956). Furthermore, and in spite of the homogeneity of the population considering motor disorder classification it included participants with of different levels of GMFCS classification (I-V). Nevertheless, including all the levels of classification it is a positive point, considering most studies in HPOT and gross motor function would mostly include children GMFCS levels I-II or never include a child level V. In order to overcome these issues, the children were categorized in two different groups (GMFCS 1 and 2), following their GMFCS. However, it would have been ideal to separate the children by each GMFCS level, which was not possible due the size of the sample. This could have some bias on the data, as it could have skewed the total scores of GMFM when adding children level V to the sample.

In addition, a protocol of treatment is not presented in the details in this study, as it was the decision of the researchers to follow the WHO guidelines that individuals should receive personal and individualized rehabilitation treatment. This implies that the protocol of treatment carried out in this study will not be able to be reproduce by others, however, it is important to notice that the protocol of evaluation and the scale use are easily reproducible by any study team or therapist. Every child had their treatment designed by an experienced physiotherapist that is registered and qualified to practice HPOT in the UK, according with the child needs and abilities for every session. To overcome the lack of details and also a standard protocol of treatment, the researchers defined, frequency and duration of each session, as well the duration of total treatment and have used the same horse for evaluations.

Overcoming sample size issues is a massive challenge in clinical research. Offering treatment to a large sample size is often costly, and hard to manage, due to capacity of practices, therapists and research timeline. Nevertheless, significant effects of HPOT could be reported for all outcomes evaluated and carried out detailed statistical analysis of the data, checking for the normality, the p-values and the effect sizes.

9.2. Conclusions and Implications

This research adds to the current evidence that HPOT can enhance gross motor function of children with CP. Furthermore, the results presented here demonstrate the GMFCS accounts significantly when evaluating the effect of HPOT in the scores of GMFM, which indicate that further studies should consider separating their sample by the GMFCS levels, or at least consider its accountability on their model analysis. Finally, from the results presented it was possible to observe that children with CP levels I and II included in this study answered faster and better to HPOT session than children level III, IV and V.

It is the first time that the finding in dynamic balance before and after HPOT intervention has it been reported in the literature. Those findings indicate that HPOT could be used as rehabilitation technique to improve dynamic balance in children with CP, especially in children with mild to moderate impairments. As for static balance, there is an indication that the force plate could be a too sensitive tool to evaluate this outcome.

In addition, this study has shown that HPOT may have positive significant short and long-term effects in reducing the spasticity of upper and lower limb of children with spastic CP, levels I-V with diplegia, hemiplegia and quadriplegia and therefore could be recommended to help facilitate the management of spasticity. Furthermore, this study demonstrates that HPOT is able to have a significant effect on improving total scores of PedsQL® of the children with CP included in this study. In addition, the results also demonstrated a strong and significant accountability of the GMFCS on the total and physical scores of PedsQL® indicating the importance of an individualized and well-planed course of treatment, considering not only the improvement of the physical function of the child, but also, how this improvement may affect the child's daily life and physical well-being.

The results reported here regard the effect of HPOT on Gross Motor Function Scores add to further evidence of HPOT effects on improving gross motor function in children with CP and in the future, a meta-analysis gathering this data and the data already published in the literature could perhaps define clear and strong evidence regards HPOT effect in this outcome and population.

Further studies with bigger sample sizes and with more rigorous methodology should be carried out in the future in order to fully identify the effects of HPOT on displacement and velocity of CoP during static postures. There is still scope for improvement and an opportunity to enhance the body of evidence of this technique by carrying out studies with similar protocol, but with a bigger sample size and perhaps comparing and/or combining HPOT with other common treatment.

The studies and results presented add to the literature in the field, and it gives direction for a protocol of evaluation for future studies, highlighting where are the gaps yet to be addressed and enhancing the evidence to the effectiveness of HPOT treatment.

Moreover, this study followed a clinical approach, providing a HPOT regime as close as possible to a normal HPOT practice, by having treatment offered by specialized and qualify PT. Variability of protocols has reportedly been an issue of proving HPOT effectiveness and physical rehabilitation treatment should follow the WHO and NICE recommendations and be individual-centred and tailored to the needs of each child (WHO, 2001; WHO, 2011; NICE 2012; NICE 2017a; NICE 2017b). Moreover, and despite the belief that the treatment itself should not follow a stratified protocol, this work highlights the need for methods of evaluation to follow a protocol and do need to be validated, sensitive and widely used in the literature in order to facilitate the communication among professionals, researchers, parents/guardian and children.

This thesis concludes that HPOT could be recommended as an alternative therapy to conventional techniques and that is able to produce positive and significant benefits to gross motor function, balance, spasticity, balance and quality of life. Our studies and results add to the literature in the field, and it gives direction for a protocol of evaluation for future studies, highlighting where are the gaps yet to be addressed and enhancing the evidence to the effectiveness of HPOT treatment.

It is still recommended for big cohort studies, following a bigger sample of children with CP across all levels of GMFCS. Bigger cohort studies would help to stablish the cause-effect of the therapy on the outcomes studied here. Randomized clinical trials would be also indicated, when possible., considering that the HPOT sessions should not follow only one or two types of exercises, but instead to be tailored to every child needs, as recommended by the WHO.

References

1. Action Cerebral Palsy, 2016, “Variations in Care: An analysis of cerebral palsy provision”, *Action Cerebral Palsy*, United Kingdom.
2. Alemdaroğlu, *et al.*, 2016, "Horseback riding therapy in addition to conventional rehabilitation program decreases spasticity in children with cerebral palsy: A small sample study", *Complementary therapies in clinical practice*, vol. 23, pp. 26-29.
3. Allison, Abraham and Petersen, 1996, "Reliability of the Modified Ashworth Scale in the assessment of plantarflexor muscle spasticity in patients with traumatic brain injury", *International journal of rehabilitation research. Internationale Zeitschrift fur Rehabilitationsforschung.Revue internationale de recherches de readaptation*, vol. 19, no. 1, pp. 67-78.
4. Alotaibi, *et al.*, 2014, "The efficacy of GMFM-88 and GMFM-66 to detect changes in gross motor function in children with cerebral palsy (CP): a literature review", *Disability and rehabilitation*, vol. 36, no. 8, pp. 617-627.
5. American Hippotherapy Association, 2015a, “What is hippotherapy?”, *Homepage of American Hippotherapy Association, Inc.*, [Online]. Available: http://www.americanhippotherapyassociation.org/ [30th of July 2015].
6. American Hippotherapy Association, 2015b, “10/05-last update, TERMINOLOGY”, *Homepage of American Hippotherapy Association*, [Online].
   Available: http://www.pathintl.org/images/pdf/conferences/national/2015-handouts/CCD2-Insurance-Terminology-and-Billing-For-PATH-Intl-Centers-Terminology-Final-for-PATH-PDF.pdf [26th of November 2016].
7. Anttila, *et al.*, 2008, "Effectiveness of physical therapy interventions for children with cerebral palsy: a systematic review", *BMC pediatrics*, vol. 8, no. 1, pp. 14.
8. Antunes, *et al.*, 2016, "Different horse’s paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study", *Research in developmental disabilities*, vol. 59, pp. 65-72.
9. Arı and Günel, 2017, "A Randomised Controlled Study to Investigate Effects of Bobath Based Trunk Control Training on Motor Function of Children with Spastic Bilateral Cerebral Palsy", *International Journal of Clinical Medicine*, vol. 8, no. 04, pp. 205.
10. Armutlu, 2010, “Spasticity and its Management with Physical Therapy Applications”, *New York: Nova Science Publishers, Inc.*, New York.
11. Arnaud, *et al.*, 2008, "Parent-reported quality of life of children with cerebral palsy in Europe", *Pediatrics*, vol. 121, no. 1, pp. 54-64.
12. Ashford, 2017, "Spasticity, what is the goal? Assessment, rehabilitation, and future perspectives", *Physiotherapy Research International*, vol. 22, no. 2.
13. Ashford, *et al.*, 2018, "Spasticity management with botulinum toxin: A comparison of UK physiotherapy and rehabilitation medicine

injectors", *International Journal of Therapy and Rehabilitation*, vol. 25, no. 5, pp. 215-222.
14. ANDE, 2015, "Equoterapia: O método", *Homepage of ANDE-Brasil*, [Online]. Available: http://equoterapia.org.br/articles/index/articles_list/138/81/0 [30th of July 2015]
15. Ayyappa, 1997, "Normal Human Locomotion, Part 1: Basic Concepts and Terminology.", *JPO: Journal of Prosthetics and Orthotics*, vol. 9, no. 1, pp. 10-17.
16. Back and Clayton, 2013. "Equine locomotion", *Saunders Elsevier*, Second edition, Edinburgh.
17. Barnes, *et al.*, 2017, "An international survey of patients living with spasticity", *Disability and rehabilitation*, vol. 39, no. 14, pp. 1428-1434.
18. Barnes, 2005, "Oxford Handbook of Rehabilitation Medicine", *Oxford University Press*, UK, Oxford.
19. Bar-On, *et al.*, 2015, "Spasticity and its contribution to hypertonia in cerebral palsy", *BioMed research international*, vol. 2015.
20. Barlett, 2006-last update, "Use of the Gross Motor Function Classification System to Optimize Rehabilitation Management of Children with Cerebral Palsy", *Homepage of CanChild*, [Online]. Available: https://canchild.ca/en/resources/86-use-of-the-gross-motor-function-classification-system-to-optimize-rehabilitation-management-of-children-with-cerebral-palsy [16th of March 2017].
21. Barlett, *et al.*, 2014, "Determinants of gross motor function of young children with cerebral palsy: a prospective cohort study", *Developmental Medicine & Child Neurology*, vol. 56, no. 3, pp. 275-282.
22. Becker, 2000-last update, "Effect Size Calculators", *Homepage of University of Colorado*, [Online]. Available: http://www.uccs.edu/~lbecker/ [26th of May 2017].
23. Beckung, *et al.*, 2007, "The natural history of gross motor development in children with cerebral palsy aged 1 to 15 years", *Developmental Medicine & Child Neurology*, vol. 49, no. 10, pp. 751-756.
24. Beckung and Hagberg, 2002, "Neuroimpairments, activity limitations, and participation restrictions in children with cerebral palsy", *Developmental Medicine & Child Neurology*, vol. 44, no. 5, pp. 309-316.
25. Beinotti, *et al.*, 2010, "Use of hippotherapy in gait training for hemiparetic post-stroke", *Arquivos de Neuro-Psiquiatria*, vol. 68, no. 6, pp. 908-913.
26. Benda, McGibbon and Grant, 2003, "Improvements in muscle symmetry in children with cerebral palsy after equine- assisted therapy (hippotherapy)", *Journal of Alternative and Complementary Medicine*, vol. 9, no. 6, pp. 817-825.
27. Bertoti, 1988, "Effect of therapeutic horseback riding on posture in children with cerebral palsy", *Physical Therapy*, vol. 68, no. 10, pp. 1505-1512.
28. Bialik and Givon, 2009, "Cerebral palsy: classification and etiology", *Acta Orthop Traumatol Turc*, vol. 43, no. 2, pp. 77-80.
29. Bohannon and Smith, 1987, "Interrater reliability of a modified ashworth scale of muscle spasticity", *Physical Therapy*, vol. 67, no. 2, pp. 206-207.

30. Bohannon, *et al.*, 1987, "Relationship between static muscle strength deficits and spasticity in stroke patients with hemiparesis", *Physical Therapy*, vol. 67, no. 7, pp. 1068-1071.
31. Bonnechère, *et al.*, 2015, "Balance improvement after physical therapy training using specially developed serious games for cerebral palsy children: preliminary results", *Disability and rehabilitation*, pp. 1-4.
32. Bower, 2009, "Finnie's handling the young child with cerebral palsy at home", *Butterworth heinemann elsevier*, 4th edn, United Kingdom.
33. Boyd, Morris and Graham, 2001, "Management of upper limb dysfunction in children with cerebral palsy: a systematic review", *European Journal of Neurology*, vol. 8, no. s5, pp. 150-166.
34. Boyraz, *et al.*, 2015, "Clonus: definition, mechanism, treatment", *Med Glas (Zenica)*, vol. 12, no. 1, pp. 19-26.
35. Brashear, 2010, "Spasticity", *Demos Medical Publishing*, New York.
36. Breakwell, Smith and Wright, 2012, "Research methods in psychology*", Los Angeles, Calif; London: SAGE, Los Angeles, Calif*, 4th ed. / edited by Glynis M. Breakwell, Jonathan A. Smith and Daniel B. Wright; London.
37. Burtner, Qualls and Woollacott, 1998, "Muscle activation characteristics of stance balance control in children with spastic cerebral palsy", *Gait & posture*, vol. 8, no. 3, pp. 163-174.
38. Burtner, *et al.*, 2014, "Motor learning in children with hemiplegic cerebral palsy: feedback effects on skill acquisition", *Developmental Medicine & Child Neurology*, vol. 56, no. 3, pp. 259-266.
39. Callahan, 2017, "Center of Pressure Excursion During a Single Leg Standing Test in Ambulatory Children with Cerebral Palsy".
40. Camargos, *et al.*, 2012, "Relação entre independência funcional e qualidade de vida na paralisia cerebral", *Fisioter Mov*, vol. 25, no. 1, pp. 83-92.
41. Campbell, 2007, "Chi-squared and Fisher–Irwin tests of two-by-two tables with small sample recommendations", *Statistics in medicine*, vol. 26, no. 19, pp. 3661-3675.
42. Can Child, "Gross Motor Function Measure (GMFM)", *Homepage of CanChild*, [Online]. Available: https://canchild.ca/en/resources/44-gross-motor-function-measure-gmfm [16th of March 2017].
43. University of Cambridge, *"Medical Library"* [Online]. Available: https://library.medschl.cam.ac.uk/research-support/databases [5th of April 2020].
44. Casady and Nichols-Larsen, 2004, "The effect of hippotherapy on ten children with cerebral palsy", *Pediatric physical therapy: the official publication of the Section on Pediatrics of the American Physical Therapy Association*, vol. 16, no. 3, pp. 165-172.
45. Chapman, D, 2009. "Avanced Search Features of Pubmed". *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, vol. 8, no. 1, pp 58-59.
46. CerebralPalsy.org, 2015, "Definition of cerebral palsy", *Homepage of My child (TM)*, [Online]. Available: http://cerebralpalsy.org/about-cerebral-palsy/definition/ [26th of November 2016].
47. Cerquozzi, *et al.*, "An Exploratory Survey of Occupational Therapists' Role in Hippotherapy",

48. Chagas, *et al.*, 2008, "Classificação da função motora e do desempenho funcional de crianças com paralisia cerebral", *Revista brasileira de fisioterapia*, vol. 12, no. 5.
49. Champagne, Corriveau and Dugas, 2016, "Effect of hippotherapy on motor proficiency and function in children with cerebral palsy who walk", *Physical & Occupational Therapy in Pediatrics*, pp. 1-13.
50. Chang, *et al.,* 2017, "Gross motor function change after multilevel soft tissue release in children with cerebral palsy", *Biomedical journal*, vol. 40, no. 3, pp. 163-168.
51. Chang, Chen and Huang, 2011, "A Kinect-based system for physical rehabilitation: A pilot study for young adults with motor disabilities", *Research in developmental disabilities*, vol. 32, no. 6, pp. 2566-2570.
52. Charalambous, 2014, "Interrater reliability of a modified Ashworth scale of muscle spasticity" in *Classic Papers in Orthopaedics* Springer, pp. 415-417.
53. Chen, *et al.*, 2013a, "Validity, responsiveness, minimal detectable change, and minimal clinically important change of Pediatric Balance Scale in children with cerebral palsy", *Research in developmental disabilities,* vol. 34, no. 3, pp. 916-922.
54. Chen, *et al.*, 2013b, "Determinants of quality of life in children with cerebral palsy: A comprehensive biopsychosocial approach", *Research in developmental disabilities,* vol. 35, no. 2, pp. 520-528.
55. Christofoletti, Hygashi and Godoy, 2007, "Paralisia cerebral: uma análise do comprometimento motor sobre a qualidade de vida", *Fisioter Mov,* vol. 20, no. 1, pp. 37-44.
56. Clarke and Eiser, 2004, "The measurement of health-related quality of life (QOL) in paediatric clinical trials: a systematic review", *Health and quality of life outcomes,* vol. 2, no. 1, pp. 66.
57. Clayton and Hobbs, 2017, "The role of biomechanical analysis of horse and rider in equitation science", *Applied Animal Behaviour Science.*
58. Clayton, *et al.*, 2011, "Center-of-Pressure Movements During Equine-Assisted Activities", *American Journal of Occupational Therapy,* vol. 65, no. 2, pp. 211-216.
59. Clayton, 2004, "The dynamic horse: a biomechanical guide to equine movement and performance", *Sport Horse Publications*, Mason, MI.
60. Collingridge, and Gantt, 2008, "The quality of qualitative research", *American Journal of Medical Quality,* vol. 23, no. 5, pp. 389-395.
61. CPTRH 2017, "About CPTRH", *Homepage of CSP,* [Online]. Available: http://cptrh.csp.org.uk/about-cptrh [30th of June 2017].
62. Curtis, *et al.*, 2015, "The central role of trunk control in the gross motor function of children with cerebral palsy: a retrospective cross-sectional study", *Developmental Medicine & Child Neurology,* vol. 57, no. 4, pp. 351-357.
63. Damiano, *et al.*, 2006, "Comparing functional profiles of children with hemiplegic and diplegic cerebral palsy in GMFCS Levels I and II: are separate classifications needed?", *Developmental medicine and child neurology,* vol. 48, no. 10, pp. 797-803.
64. Davis, *et al.*, 2009, "A randomized controlled trial of the impact of therapeutic horse riding on the quality of life, health, and function of children with cerebral

palsy", *Developmental Medicine & Child Neurology,* vol. 51, no. 2, pp. 111-119.
65. de Cocq, Van Weeren and Back, 2006, "Saddle pressure measuring: validity, reliability and power to discriminate between different saddle-fits", *The Veterinary Journal,* vol. 172, no. 2, pp. 265-273.
66. de Cocq, *et al.,* 2009, "Usability of normal force distribution measurements to evaluate asymmetrical loading of the back of the horse and different rider positions on a standing horse", *The Veterinary Journal,* vol. 181, no. 3, pp. 266-273.
67. de Mello, 2016, "Cirurgias e intervenções físicas no tratamento da espasticidade na paralisia cerebral", *Acta Fisiátrica,* vol. 17, no. 2, pp. 84-91.
68. Debuse, 2005, *An exploration of German and British physiotherapists' views on the effects of hippotherapy and their measurement*. PhD Thesis presented to the University of Edinburgh, UK.
69. Debuse, Gibb and Chandler, 2009, "Effects of hippotherapy on people with cerebral palsy from the users' perspective: a qualitative study", *Physiotherapy Theory & Practice,* vol. 25, no. 3, pp. 174-192 19p.
70. del Rosario-Montejo, *et al.,* 2015, "Efectividad de la terapia ecuestre en niños con retraso psicomotor", *Neurología,* vol. 30, no. 7, pp. 425-432.
71. Demura, *et al.,* 2008, "Age-stage differences in body sway during a static upright posture based on sway factors and relative accumulation of power frequency", *Perceptual and motor skills,* vol. 107, no. 1, pp. 89-98.
72. Deutz, *et al.,* 2018, "Impact of Hippotherapy on Gross Motor Function and Quality of Life in Children with Bilateral Cerebral Palsy: A Randomized Open-Label Crossover Study", *Neuropediatrics.*
73. Diaz, 2014, "Adjustable saddle and adjusting assembly".
74. Diniz, Medeiros and Squinca, 2007, "Reflexões sobre a versão em Português da Classificação Internacional de Funcionalidade, Incapacidade e Saúde Comments on the Portuguese translation of the International Classification of Functioning", *Cad.Saúde Pública,* vol. 23, no. 10, pp. 2507-2510.
75. Diwan, *et al.,* 2017, "Correlation between motor impairment and participation in children with cerebral palsy", *International Journal of Contemporary Pediatrics,* vol. 1, no. 2, pp. 79-83.
76. Donker, *et al.,* 2008, "Children with cerebral palsy exhibit greater and more regular postural sway than typically developing children", *Experimental brain research,* vol. 184, no. 3, pp. 363-370.
77. Duarte and Freitas, 2010, "Revision of posturography based on force plate for balance evaluation", *Brazilian Journal of physical therapy,* vol. 14, no. 3, pp. 183-192.
78. Dwivedi, Mallawaarachchi and Alvarado, 2017. "Analysis of small sample size studies using nonparametric bootstrap test with pooled resampling method". *Statistics in Medicine,* vol 36. P2187-2205.
79. Dyson, Carson and Fisher, 2015, "Saddle fitting, recognizing an ill-fitting saddle and the consequences of an ill-fitting saddle to horse and rider", *Equine Veterinary Education,* vol. 27, no. 10, pp. 533-543.
80. EBSCO: CINAHL research database, [Online]. Available: https://www.ebscohost.com/nursing/products/cinahl-databases/cinahl-complete [05th of April 2020].

81. EFDS, *"*Disability: Facts and Statistics", *Homepage of English Federation of Disability Sport*, [Online]. Available: http://www.efds.co.uk/resources/facts_and_statistics [2nd of March 2017].
82. Egan and Zierath, 2013, "Exercise metabolism and the molecular regulation of skeletal muscle adaptation", *Cell metabolism*, vol. 17, no. 2, pp. 162-184.
83. El-hakiem and Agha, 2017, "Effect of treadmill training with partial body weight support on spine geometry and gross motor function in children with diplegic cerebral palsy", *International Journal of Therapies and Rehabilitation Research*, vol. 6, no. 1, pp. 46-52.
84. Eliasson, 2008, "Improving Hand Function in Children with Cerebral Palsy Theory, Evidence and Intervention", *Mac Keith Press*, London.
85. El-Meniawy and Thabet, 2012, "Modulation of back geometry in children with spastic diplegic cerebral palsy via hippotherapy training", *Egyptian Journal of Medical Human Genetics*, vol. 13, no. 1, pp. 63-71.
86. Enoka, 2008, "Neuromechanics of human movement, 4th ed", *Scitech Book News*, vol. 32, no. 3.
87. Farquhar, 1995, "Definitions of quality of life: a taxonomy", *Journal of advanced nursing*, vol. 22, no. 3, pp. 502-508.
88. Field, 2009, "Discovering statistics using SPSS", *SAGE*, 3rd ed., London.
89. Fink, 2003, "How to Manage, Analyze and Interpret Survey Data", *SAGE Publications, Inc.*, 2nd ed.
90. Fízková, *et al.*, 2013, "The effect of hippotherapy on gait in patients with spastic cerebral palsy", *Acta Gymnica*, vol. 43, no. 4, pp. 17-23.
91. Fleck, 1992, "Hippotherapy: Mechanics of human walking and horseback riding", *University of Delaware*.
92. Flett, 2003, "Rehabilitation of spasticity and related problems in childhood cerebral palsy", *Journal of paediatrics and child health*, vol. 39, no. 1, pp. 6-14.
93. Franjoine, Gunther and Taylor, 2003, "Pediatric balance scale: a modified version of the berg balance scale for the school-age child with mild to moderate motor impairment", *Pediatric physical therapy : the official publication of the Section on Pediatrics of the American Physical Therapy Association*, vol. 15, no. 2, pp. 114-128.
94. Frank, McCloskey and Dole, 2011, "Effect of hippotherapy on perceived self-competence and participation in a child with cerebral palsy", *Pediatric physical therapy: the official publication of the Section on Pediatrics of the American Physical Therapy Association*, vol. 23, no. 3, pp. 301-308.
95. Frevel and Maurer, 2014, "Internet-based home training is capable to improve balance in multiple sclerosis: a comparative trial with hippotherapy", *European journal of physical and rehabilitation medicine*.
96. Fruehwirth, *et al.*, 2004, "Evaluation of pressure distribution under an English saddle at walk, trot and canter", *Equine veterinary journal*, vol. 36, no. 8, pp. 754-757.
97. Garner and Rigby, 2014, "Human pelvis motions when walking and when riding a therapeutic horse", *Human movement science*, vol. 39, pp. 121-137.
98. Glinianaia, *et al.*, 2017, "Predicting the prevalence of cerebral palsy by severity level in children aged 3 to 15 years across England and Wales by 2020", *Developmental Medicine & Child Neurology*.

99. Goldie, Bach and Evans, 1989, "Force platform measures for evaluating postural control: reliability and validity", *Archives of Physical Medicine and Rehabilitation*, vol. 70, no. 7, pp. 510-517.
100. Gorter, *et al.*, 2004, "Limb distribution, motor impairment, and functional classification of cerebral palsy", *Developmental medicine and child neurology*, vol. 46, no. 7, pp. 461-467.
101. GOV-UK 2014, 16 January-last update, "Disabilities facts and figures: official statistics", Available: https://www.gov.uk/government/publications/disability-facts-and-figures/disability-facts-and-figures [3rd of February 2017].
102. Gregório and Krueger, 2013, "Influência da equoterapia no controle cervical e de tronco em uma criança com paralisia cerebral", *Revista UniAndrade*, vol. 14, no. 1, pp. 65-75.
103. Greve and Dyson, 2013, "The horse–saddle–rider interaction", *The veterinary journal*, vol. 195, no. 3, pp. 275-281.
104. Gribble and Hertel, 2004, "Effect of lower-extremity muscle fatigue on postural control", *Archives of Physical Medicine and Rehabilitation*, vol. 85, no. 4, pp. 589-592.
105. Gürkan, *et al.*, 2016, "Effects of long-term training program on static and dynamic balance in young subjects", *Clinical & Investigative Medicine*, vol. 39, no. 6, pp. 31-33.
106. Haehl, Giuliani and Lewis, 1999, "Influence of Hippotherapy on the Kinematics and Functional Performance of Two Children with Cerebral Palsy.", *Pediatric physical therapy*, vol. 11, no. 2, pp. 89-101.
107. Hall, 2011, "Guyton and Hall textbook of medical physiology", *Saunders/Elsevier*, 12th ed., Philadelphia, PA.
108. Hamill, Washington and White, 2007, "The effect of hippotherapy on postural control in sitting for children with cerebral palsy", *Physical & Occupational Therapy in Pediatrics*, vol. 27, no. 4, pp. 23-42.
109. Hamill, 2015, "Biomechanical basis of human movement", *Lippincott Williams & Wilkins*, Fourth ed., Philadelphia, PA.
110. Hammer, *et al.*, 2005, "Evaluation of therapeutic riding (Sweden)/hippotherapy (United States). A single-subject experimental design study replicated in eleven patients with multiple sclerosis", *Physiotherapy theory and practice*, vol. 21, no. 1, pp. 51-77.
111. Hankins and Speer, 2003, "Defining the pathogenesis and pathophysiology of neonatal encephalopathy and cerebral palsy", *Obstetrics & Gynecology*, vol. 102, no. 3, pp. 628-636.
112. Harris, 1993, "Horse gaits, balance and movement", *Howell Book House*, Hoboken, N.J.
113. Hartz and Benson, 2000. "A comparison of observational studies and randomized, controlled trials". *N Engl J Med.* Jun 22;342(25):1878-86. doi: 10.1056/NEJM200006223422506.
114. Hawkins, 2014, "Biomeasurement: a student´s guide to biostatistics", *Oxford University Press*, Third ed, New York.
115. Hawley, *et al.*, 2014, "Integrative biology of exercise", *Cell*, vol. 159, no. 4, pp. 738-749.

116. Heinonen, *et al.*, 2014, "Organ-specific physiological responses to acute physical exercise and long-term training in humans", *Physiology (Bethesda, Md.)*, vol. 29, no. 6, pp. 421-436.
117. Herdman and Clendaniel, 2014, “Vestibular rehabilitation”, *FA Davis*, 4th edn.
118. Herrero, *et al.*, 2012a, "Therapeutic effects of hippotherapy in cerebral palsy: a systematic review", *Fisioterapia*, vol. 34, no. 5, pp. 225-234 10p.
119. Herrero, *et al.*, 2012b, "Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial", *Clinical rehabilitation*, vol. 26, no. 12, pp. 1105-1113.
120. Herrero, *et al.*, 2010, "Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial", *BMC musculoskeletal disorders*, vol. 11, no. 1, pp. 71.
121. Hicks, *et al.*, 2008, "Crouched postures reduce the capacity of muscles to extend the hip and knee during the single-limb stance phase of gait", *Journal of Biomechanics*, vol. 41, no. 5, pp. 960-967.
122. Himmelmann, *et al.*, 2006, "Gross and fine motor function and accompanying impairments in cerebral palsy", *Developmental medicine and child neurology*, vol. 48, no. 6, pp. 417-423.
123. Himpens, *et al.*, 2008, "Prevalence, type, distribution, and severity of cerebral palsy in relation to gestational age: a meta-analytic review", *Developmental Medicine & Child Neurology*, vol. 50, no. 5, pp. 334-340.
124. Hochmuller, *et al.*, 2007, "Efeitos Agudos da Equoterapia Sobre a Espasticidade e Controle de Tronco na Diplegia Espástica", *Brazilian Journal of Physical Therapy*, vol. 11, no. Suppl., pp. 398-398.
125. Holt, Fonseca and LaFiandra, 2000, "The dynamics of gait in children with spastic hemiplegic cerebral palsy: theoretical and clinical implications", *Human Movement Science*, vol. 19, no. 3, pp. 375-405.
126. Holt, Obusek and Fonseca, 1996, "Constraints on disordered locomotion a dynamical systems perspective on spastic cerebral palsy", *Human Movement Science*, vol. 15, no. 2, pp. 177-202.
127. Horak, 1997, "Clinical assessment of balance disorders", *Gait & posture*, vol. 6, no. 1, pp. 76-84.
128. Horak, 2006, "Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls?", *Age and Ageing*, vol. 35, no. suppl_2, pp. ii7-ii11.
129. Howard, *et al.*, 2005, "Cerebral palsy in Victoria: motor types, topography and gross motor function", *Journal of paediatrics and child health*, vol. 41, no. 9-10, pp. 479-483.
130. Hsieh, *et al.*, 2016, "Effects of hippotherapy on body functions, activities and participation in children with cerebral palsy based on ICF-CY assessments", *Disability and rehabilitation*, pp. 1-11.
131. Hyun, *et al.*, 2012, "The Effects of Hippotherapy on the Motor Function of Children with Spastic Bilateral Cerebral Palsy", *Journal of Physical Therapy Science*, vol. 24, no. 12, pp. 1277-1280.

132. Ingebrigtsen, 2015, “Effects of gross motor functioning and transition phase on health-related quality of life in Norwegian adolescents with cerebral palsy”, *NTNU*.
133. Ivanhoe and Reistetter, 2004, "Spasticity: the misunderstood part of the upper motor neuron syndrome", *American journal of physical medicine & rehabilitation,* vol. 83, no. 10, pp. S3-S9.
134. Janura, *et al.,* 2009, "An assessment of the pressure distribution exerted by a rider on the back of a horse during hippotherapy", *Human movement science*, vol. 28, no. 3, pp. 387-393.
135. Janura, *et al.,* 2012, "The variability of a horse’s movement at walk in hippotherapy", *Kinesiology,* vol. 44, no. 2, pp. 148-154.
136. John Concato, 2000. “Randomized, Controlled Trials, Observational Studies, And The Hierarchy of Research Designs”. *N Engl J Med*. Jun 22; 342(25): 1887–1892. doi: 10.1056/NEJM200006223422507;
137. Johnson and Barnes, 2008, “Upper motor neuron syndrome and spasticity: clinical management and neurophysiology*”, Cambridge University Press.* 2nd edition, Cambridge, UK.
138. Jones, *et al.,* 2007, "Cerebral palsy: introduction and diagnosis (part I)", *Journal of Pediatric Health Care,* vol. 21, no. 3, pp. 146-152.
139. Kakebeeke, Lechner and Knapp, 2005, "The effect of passive cycling movements on spasticity after spinal cord injury: preliminary results", *Spinal Cord*, vol. 43, no. 8, pp. 483-488.
140. Kang, Jung and Yu, 2012, "Effects of Hippotherapy on the Sitting Balance of Children with Cerebral Palsy: a Randomized Control Trial", *Journal of Physical Therapy Science,* vol. 24, no. 9, pp. 833-836.
141. Karlsson and Frykberg, 2000, "Correlations between force plate measures for assessment of balance", *Clinical Biomechanics,* vol. 15, no. 5, pp. 365-369.
142. Karlsson, *et al.,* 2000, "Amplitude and frequency analysis of force plate data in sitting children with and without MMC", *Clinical Biomechanics,* vol. 15, no. 7, pp. 541-545.
143. Kazdin, 2008, "Evidence-based treatment and practice: new opportunities to bridge clinical research and practice, enhance the knowledge base, and improve patient care.", *American psychologist,* vol. 63, no. 3, pp. 146.
144. Kernozek and Lewin, 1998, "Seat interface pressures of individuals with paraplegia: influence of dynamic wheelchair locomotion compared with static seated measurements", *Archives of Physical Medicine and Rehabilitation,* vol. 79, no. 3, pp. 313-316.
145. Kerr Graham and Selber, 2003, "Musculoskeletal aspects of cerebral palsy", *The Journal of bone and joint surgery. British volume,* vol. 85, no. 2, pp. 157-166.
146. Kirshblum, 1999, "Treatment alternatives for spinal cord injury related spasticity", *The journal of spinal cord medicine,* vol. 22, no. 3, pp. 199-217.
147. Kistler Group, 2015, “Kistler MARS Measurement, Analysis and Reporting Software”, *Homepage of Kistler,* [Online]. Available: https://www.kistler.com/?type=669&fid=60647&model=document&callee=frontend [4th of April 2017].

148. Koca and Ataseven, 2016, "What is hippotherapy? The indications and effectiveness of hippotherapy", *Northern clinics of Istanbul,* vol. 2, no. 3, pp. 247-252.
149. Krigger, 2006, "Cerebral palsy: an overview.", *American Family Physician,* vol. 73, no. 1.
150. Kuczyński and Słonka, 1999, "Influence of artificial saddle riding on postural stability in children with cerebral palsy", *Gait & posture,* vol. 10, no. 2, pp. 154-160.
151. Kurz, *et al.,* 2014, "Neurophysiological abnormalities in the sensorimotor cortices during the motor planning and movement execution stages of children with cerebral palsy", *Developmental Medicine & Child Neurology,* vol. 56, no. 11, pp. 1072-1077.
152. Kwon, *et al.,* 2011, "Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy", *Archives of Physical Medicine and Rehabilitation,* vol. 92, no. 5, pp. 774-779.
153. Kwon, *et al.,* 2015, "Effect of Hippotherapy on Gross Motor Function in Children with Cerebral Palsy: A Randomized Controlled Trial", *The Journal of Alternative and Complementary Medicine,* vol. 21, no. 1, pp. 15-21.
154. Lafond, Duarte and Prince, 2004, "Comparison of three methods to estimate the center of mass during balance assessment", *Journal of Biomechanics,* vol. 37, no. 9, pp. 1421-1426.
155. Lagarde, *et al.,* 2005, "Coordination dynamics of the horse-rider system", *Journal of motor behavior,* vol. 37, no. 6, pp. 418-424.
156. Lance, 1980, "Symposium synopsis", *Spasticity: disordered motor control,* pp. 485-500.
157. Law *et al.,* 1998, "critical review form - quantitative studies; and guidelines for critical review form - Quantitative studies (McMaster University)".
158. Lechner, *et al.,* 2003, "The short-term effect of hippotherapy on spasticity in patients with spinal cord injury", *Spinal cord,* vol. 41, no. 9, pp. 502-505.
159. Lechner, *et al.,* 2007, "The effect of hippotherapy on spasticity and on mental well-being of persons with spinal cord injury", *Archives of Physical Medicine and Rehabilitation,* vol. 88, no. 10, pp. 1241-1248.
160. Lederman, 2009, "The myth of core stability", *Journal of Bodywork and Movement Therapies,* vol. 14, no. 1, pp. 84-98.
161. Lee, Kim and Na, 2014, "The Effects of Hippotherapy and a Horse Riding Simulator on the Balance of Children with Cerebral Palsy", *Journal of physical therapy science,* vol. 26, no. 3, pp. 423.
162. Lee, Kim and Yong, 2014, "Effects of Hippotherapy on Recovery of Gait and Balance Ability in Patients with Stroke", *Journal of physical therapy science,* vol. 26, no. 2, pp. 309.
163. Lemay, *et al.,* 2014, "Postural and dynamic balance while walking in adults with incomplete spinal cord injury", *Journal of electromyography and kinesiology,* vol. 24, no. 5, pp. 739-746.
164. Li, *et al.,* 2015, "A motor cortex circuit for motor planning and movement", *Nature,* vol. 519, no. 7541, pp. 51-56.
165. Lin, *et al.,* 2015, "Evaluating functional outcomes of botulinum toxin type an injection combined with occupational therapy in the upper limbs of

children with cerebral palsy: a 9-month follow-Up from the perspectives of both child and caregiver", *PloS one,* vol. 10, no. 11, pp. e0142769.

166. Lindroth, Sullivan and Silkwood-Sherer, 2015, "Does hippotherapy effect use of sensory information for balance in people with multiple sclerosis?", *Physiotherapy theory and practice,* vol. 31, no. 8, pp. 575-581.

167. Liporoni and Oliveira, 2010, "Equoterapia como tratamento alternativo para pacientes com seqüelas neurológicas", *Investigacao,* vol. 5, no. 1-6.

168. Long, 2013, "Hippotherapy as a Tool for Improving Motor Skills, Postural Stability, and Self Confidence in Cerebral Palsy and Multiple Sclerosis", *Sound Neuroscience: An Undergraduate Neuroscience Journal,* vol. 1, no. 2, pp. 3.

169. Lucena-Antón, Rosety-Rodríguez and Moral-Munoz, 2018, "Effects of a hippotherapy intervention on muscle spasticity in children with cerebral palsy: A randomized controlled trial", *Complementary therapies in clinical practice,* vol. 31, pp. 188-192.

170. Machin, 2007, "Medical statistics: a textbook for the health sciences", *Wiley,* 4th ed., Chichester.

171. MacKinnon, *et al.,* 1995, "A study of therapeutic effects of horseback riding for children with cerebral palsy", *Physical & Occupational Therapy in Pediatrics,* vol. 15, no. 1, pp. 17-34.

172. Mackow, *et al.,* 2014, "Influence of neurophysiological hippotherapy on the transference of the centre of gravity among children with cerebral palsy", *Ortopedia, traumatologia, rehabilitacja,* vol. 16, no. 6, pp. 581-593.

173. MacPhail, *et al.,* 1998, "Trunk postural reactions in children with and without cerebral palsy during therapeutic horseback riding", *Pediatric physical therapy,* vol. 10, no. 4, pp. 143-147.

174. Mäenpää, *et al.,* 2017, "Multiprofessional evaluation in clinical practice: establishing a core set of outcome measures for children with cerebral palsy", *Developmental Medicine & Child Neurology,* vol. 59, no. 3, pp. 322-328.

175. Maher, *et al.,* 2008, "Self-reported quality of life in adolescents with cerebral palsy", *Physical & Occupational Therapy in Pediatrics,* vol. 28, no. 1, pp. 41-57.

176. Maher, Toohey and Ferguson, 2016, "Physical activity predicts quality of life and happiness in children and adolescents with cerebral palsy", *Disability and rehabilitation,* vol. 38, no. 9, pp. 865-869.

177. Manikowska, *et al.,* 2013, "The effect of a hippotherapy session on spatiotemporal parameters of gait in children with cerebral palsy - pilot study", *Ortopedia, traumatologia, rehabilitacja,* vol. 15, no. 3, pp. 253-257.

178. Marin-Padilla, 1970, "Prenatal and early postnatal ontogenesis of the human motor cortex: a Golgi study. I. The sequential development of the cortical layers", *Brain research,* vol. 23, no. 2, pp. 167-183.

179. Marois, *et al.,* 2016, "Gross Motor Function Measure Evolution Ratio: Use as a control for natural progression in cerebral palsy", *Archives of Physical Medicine and Rehabilitation,* vol. 97, no. 5, pp. 807-814. e2.

180. Marret, Vanhulle and Laquerriere, 2013, "Pathophysiology of cerebral palsy", *Handbook of clinical neurology,* vol. 111, pp. 169-176.

181. Martins, 2016, "The Role of Spasticity in Functional Neurorehabilitation-Part I: The Pathophysiology of Spasticity, the

Relationship with the Neuroplasticity, Spinal Shock and Clinical Signs", *Archives of Medicine*.
182. Massetti, *et al.*, 2014, "Motor learning through virtual reality in cerebral palsy–a literature review", *MedicalExpress*, vol. 1, no. 6, pp. 302-306.
183. Massion, 1992, "Movement, posture and equilibrium: interaction and coordination", *Progress in neurobiology*, vol. 38, no. 1, pp. 35-56.
184. Matusiak-Wieczorek, Malachowska-Sobieska and Synder, 2016, "Influence of Hippotherapy on Body Balance in the Sitting Position Among Children with Cerebral Palsy", *Ortopedia, traumatologia, rehabilitacja*, vol. 18, no. 2, pp. 165-175.
185. Mayer, Esquenazi and Childers, 1997, "Common patterns of clinical motor dysfunction", *Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine*, vol. 20, no. S6, pp. 21-35.
186. McGee and Reese, 2009, "Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy", *Pediatric physical therapy : the official publication of the Section on Pediatrics of the American Physical Therapy Association*, vol. 21, no. 2, pp. 212-218.
187. McGibbon, *et al.*, 1998, "Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: A pilot study", *Developmental Medicine & Child Neurology*, vol. 40, no. 11, pp. 754-762.
188. McGibbon, *et al.*, 2009, "Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy", *Archives of Physical Medicine and Rehabilitation*, vol. 90, no. 6, pp. 966-974.
189. MedCalc, nd., “Free statistical calculators: Comparison of proportions calculator”, *Homepage of MEDCALC® easy-to-use statistical software*, [Online].
Available: https://www.medcalc.org/calc/comparison_of_proportions.php [26 th of June 2017].
190. Mendoza, Gómez-Conesa and Montesinos, 2015, "Association between gross motor function and postural control in sitting in children with Cerebral Palsy: a correlational study in Spain", *BMC pediatrics*, vol. 15, no. 1, pp. 124.
191. Mikołajczyk, Ligęza and Jankowicz-Szymańska, 2017, "The effect of hippotherapy on postural balance", *European Journal of Clinical and Experimental Medicine*, no. 1.
192. Miller and Johnston, 2005, "Should the Babinski sign be part of the routine neurologic examination?", *Neurology*, vol. 65, no. 8, pp. 1165-1168.
193. Moher, *et al.*, 2009, "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement", *PLoS med*, vol. 6, no. 7, pp. e1000097.
194. Moraes, *et al.*, 2016, "The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy", *Journal of Physical Therapy Science*, vol. 28, no. 8, pp. 2220-2226.
195. Moraes, *et al.*, 2015, "Equoterapia no controle postural e equilíbrio em indivíduos com paralisia cerebral: revisão sistemática", *Revista Neurociencias*, vol. 4, no. 23, pp. 546.

196. Moreau, *et al.*, 2016, "Research Report Effectiveness of Rehabilitation Interventions to Improve Gait Speed in Children with Cerebral Palsy: Systematic Review and Meta-analysis".
197. Morgan, *et al.*, 2016, "Effectiveness of motor interventions in infants with cerebral palsy: a systematic review", *Developmental Medicine & Child Neurology*, vol. 58, no. 9, pp. 900-909.
198. Morgan, 2012, "Combination removable traction control saddle cover, accessory traction control & saddle fitting shim system for mountable sports riding equipment*", Google Patents.*
199. Mutlu, *et al.*, 2018, "Agreement between parents and clinicians on the communication function levels and relationship of classification systems of children with cerebral palsy", *Disability and health journal*, vol. 11, no. 2, pp. 281-286.
200. Mutoh, *et al.*, 2018, "Impact of serial gait analyses on long-term outcome of hippotherapy in children and adolescents with cerebral palsy", *Complementary Therapies in Clinical Practice*, vol. 30, pp. 19-23.
201. Mutoh, *et al.*, 2016, "Application of a tri-axial accelerometry-based portable motion recorder for the quantitative assessment of hippotherapy in children and adolescents with cerebral palsy", *Journal of physical therapy science*, vol. 28, no. 10, pp. 2970-2974.
202. Nahm, *et al.*, 2018, "Management of hypertonia in cerebral palsy", *Current opinion in pediatrics*, vol. 30, no. 1, pp. 57-64.
203. National Institute for Health and Care Excellence, 2012, "Spasticity in under 19s: management. Clinical guideline", *National Institute for Health and Care Excellence*, England, United Kingdom.
204. Natus, nd., "How to Control Balance*", Homepage of Natus: balance and mobility*, [Online]. Available: http://balanceandmobility.com/for-patients/how-to-control-your-balance/ [30th of March 2017].
205. Nevison and Timmis, 2013, "The effect of physiotherapy intervention to the pelvic region of experienced riders on seated postural stability and the symmetry of pressure distribution to the saddle: A preliminary study", *Journal of Veterinary Behavior: Clinical Applications and Research*, .
206. Newell, 1991, "Motor skill acquisition", *Annual Review of Psychology*, vol. 42, no. 1, pp. 213-237.
207. NICE, 2017a, "Cerebral Palsy in children and young people", *National Institute for Health and Care Excellence*, England, United Kingdom.
208. NICE 2017b, "Cerebral palsy in under 25s: assessment and management", *National Institute for Health and Care Excellence*, England, United Kingdom, pp. 1-47.
209. NICE 2017c, "Physical therapy for children and young people with spasticity", *National Institute for Health and Care Excellence*, England, United Kingdom.
210. NICE 2012d, "Spasticity in under 19s: management", *National Institute for Health and Care Excellence*, England, United Kingdom, pp. 1-42.
211. Nicholls, 2012, "From neuron to brain*", Sinauer Associates*, 5th ed. Sunderland, Mass.
212. Nonnekes, *et al.*, 2017, "Pathophysiology, diagnostic work-up and management of balance impairments and falls in patients with hereditary

spastic paraplegia", *Journal of Rehabilitation Medicine,* vol. 49, no. 5, pp. 369-377.
213. Novak, *et al.,* 2013, "A systematic review of interventions for children with cerebral palsy: state of the evidence", *Developmental Medicine & Child Neurology,* vol. 55, no. 10, pp. 885-910.
214. Odeen, 1981, "Reduction of muscular hypertonus by long-term muscle stretch", *Scandinavian journal of rehabilitation medicine,* vol. 13, no. 2-3, pp. 93-99.
215. Office for Disability Issues, 2014, "Disability facts and figures", Goverment UK, United Kingdom.
216. Oliveira, Golina and Cunha, 2010, "Aplicabilidade do Sistema de Classificação da Função Motora Grossa (GMFCS) na paralisia cerebral–revisão da literatura", *Arq Bras Cienc Saúde.[Internet],* vol. 35, no. 3.
217. Oliveira, *et al.,* 2015, "O Efeito da Equoterapia no Tratamento da Paralisia Cerebral: Revisão de Literatura".
218. Oskoui, *et al.,* 2013, "An update on the prevalence of cerebral palsy: a systematic review and meta-analysis", *Developmental Medicine & Child Neurology,* vol. 55, no. 6, pp. 509-519.
219. Oxford Dictionary, 2015, "Definition", *Homepage of oxforddictionaries.com,* [Online]. Available: http://www.oxforddictionaries.com/definition/english/saddle [26th of November, 2015].
220. Pakula, Braun and Yeargin-Allsopp, 2009, "Cerebral palsy: classification and epidemiology", *Physical Medicine and Rehabilitation Clinics of North America,* vol. 20, no. 3, pp. 425-452.
221. Palisano, *et al.,* 2000, "Validation of a model of gross motor function for children with cerebral palsy", *Physical Therapy,* vol. 80, no. 10, pp. 974.
222. Palisano, *et al.,* 2007, "GMFCS-E&R", *CanChild Centre for Childhood Disability Research, McMaster University*.
223. Palisano, *et al.,* 1997, "Development and reliability of a system to classify gross motor function in children with cerebral palsy", *Developmental Medicine & Child Neurology,* vol. 39, no. 4, pp. 214-223.
224. Palmieri, *et al.,* 2002, "Center-of-pressure parameters used in the assessment of postural control", *Journal of Sport Rehabilitation,* vol. 11, no. 1, pp. 51-66.
225. Pandyan, *et al.,* 2005, "Spasticity: clinical perceptions, neurological realities and meaningful measurement", *Disability and rehabilitation,* vol. 27, no. 1-2, pp. 2-6.
226. Pandyan, *et al.,* 1999, "A review of the properties and limitations of the Ashworth and modified Ashworth Scales as measures of spasticity", *Clinical rehabilitation,* vol. 13, no. 5, pp. 373-383.
227. Park, *et al.,* 2014, "Effects of Hippotherapy on Gross Motor Function and Functional Performance of Children with Cerebral Palsy", *Yonsei medical journal,* vol. 55, no. 6, pp. 1736-1742.
228. Park and Kim, 2013, "Structural equation modeling of motor impairment, gross motor function, and the functional outcome in children with cerebral palsy", *Research in developmental disabilities,* vol. 34, no. 5, pp. 1731-1739.

229. Paulson and Vargus-Adams, 2017, "Overview of Four Functional Classification Systems Commonly Used in Cerebral Palsy", *Children*, vol. 4, no. 4, pp. 30.
230. Pavão, *et al.*, 2014, "Functional balance and gross motor function in children with cerebral palsy", *Research in developmental disabilities*, vol. 35, no. 10, pp. 2278-2283.
231. Pavão, *et al.*, 2013, "Assessment of postural control in children with cerebral palsy: a review", *Research in developmental disabilities*, vol. 34, no. 5, pp. 1367-1375.
232. PeDRO: database. [Online] Available: https://www.pedro.org.au/; [05th of April 2020].
233. Pereira, Teixeira and Santos, 2012, "Qualidade de vida: abordagens, conceitos e avaliação", *Revista brasileira de educação física e esporte*, vol. 26, no. 2, pp. 241-250.
234. Pfeifer, *et al.*, 2009, "Classification of cerebral palsy: association between gender, age, motor type, topography and Gross Motor Function", *Arquivos de Neuro-Psiquiatria*, vol. 67, no. 4, pp. 1057-1061.
235. pliance®-s *, nd.,* "Saddle", *Homepage of Novel.de,* [Online]. Available: http://www.novel.de/novelcontent/pliance/saddle [31st of March 2017].
236. Pollock, *et al.*, 2000, "What is balance?", *Clinical rehabilitation*, vol. 14, no. 4, pp. 402-406.
237. Power, *et al.*, 2018, "Health-related quality of life of children and adolescents with cerebral palsy in low-and middle-income countries: a systematic review", *Developmental Medicine & Child Neurology*, vol. 60, no. 5, pp. 469-479.
238. Prado, *et al.*, 2013, "Função motora e qualidade de vida de indivíduos com paralisia cerebral", *ABCS Health Sciences*, vol. 38, no. 2.
239. Prieto, *et al.*, 2018, "A equoterapia na reabilitação de indivíduos com paralisia cerebral: uma revisão sistemática de ensaios clínicos/The hippotherapy in the rehabilitation of individuals with cerebral palsy: a systematic review of clinical trials", *Cadernos Brasileiros de Terapia Ocupacional*, vol. 26, no. 1.
240. Queiroz, 2016, "Associação entre comprometimento motor, mobilidade e qualidade de vida em crianças com paralisia cerebral espástica, nível I, II e III do Gross Motor Function Classification System", .
241. Rebelatto, *et al.*, 2008, "Equilíbrio estático e dinâmico em indivíduos senescentes e o índice de massa corporal", *Fisioter Mov*, vol. 21, no. 3, pp. 69-75.
242. Ribeiro, 2006, "A repercussão da equoterapia na qualidade de vida da pessoa portadora de lesão medular traumática", *Monografia (Mestrado em Psicologia), Universidade Católica Dom Bosco, Campo Grande, .*
243. Rigby, Garner and Skurla, 2009, "Comparing the Pelvis Kinematics of Able-bodied Children During Normal Gait and when Riding a Therapeutic Horse*", Baylor University.*
244. Rimmer, 2006, "Use of the ICF in identifying factors that impact participation in physical activity/rehabilitation among people with disabilities", *Disability and rehabilitation*, vol. 28, no. 17, pp. 1087-1095.

245. Robertson, *et al.*, 2014, “Research methods in biomechanics*”, Whittlesey*, Second edition, Champaign, IL: Human Kinetics.
246. Rosan, Braccialli and Araujo, 2016, "Contribuição da Equoterapia para a Participação e Qualidade de Vida do Praticante com Paralisia Cerebral em Diferentes Contextos", *Revista Diálogos e Perspectivas em Educação Especial*, vol. 3, no. 01.
247. Rose, *et al.*, 2002, "Postural balance in children with cerebral palsy", *Developmental Medicine & Child Neurology,* vol. 44, no. 01, pp. 58-63.
248. Rosenbaum, *et al.*, 2007, "A report: the definition and classification of cerebral palsy April 2006", *Dev Med Child Neurol Suppl,* vol. 109, no. suppl 109, pp. 8-14.
249. Rosenbaum, *et al.*, 2008, "Development of the gross motor function classification system for cerebral palsy", *Developmental Medicine & Child Neurology,* vol. 50, no. 4, pp. 249-253.
250. Russell, *et al.*, 2000, "Improved scaling of the gross motor function measure for children with cerebral palsy: evidence of reliability and validity", *Physical Therapy,* vol. 80, no. 9, pp. 873-885.
251. Russell, *et al.*, 1989, "The gross motor function measure: a means to evaluate the effects of physical therapy", *Developmental Medicine & Child Neurology,* vol. 31, no. 3, pp. 341-352.
252. Saether, *et al.*, 2013, "Clinical tools to assess balance in children and adults with cerebral palsy: a systematic review", *Developmental Medicine & Child Neurology,* vol. 55, no. 11, pp. 988-999.
253. Sakzewski, Gordon and Eliasson, 2014, "The state of the evidence for intensive upper limb therapy approaches for children with unilateral cerebral palsy", *Journal of child neurology,* vol. 29, no. 8, pp. 1077-1090.
254. Sankar and Mundkur, 2005, "Cerebral palsy-definition, classification, etiology and early diagnosis", *The Indian Journal of Pediatrics,* vol. 72, no. 10, pp. 865-868.
255. Santos, Dantas and Oliveira, 2004, "Desenvolvimento motor de crianças, de idosos e de pessoas com transtornos da coordenação", *Rev Paul Educ Fís,* vol. 18, no. 1, pp. 33-44.
256. Scott, 2005, “Special needs, special horses: A guide to the benefits of therapeutic riding*”, University of North Texas Press*.
257. Schusdziarra, Schusdziarra and Abelshauser 2004, *“*Anatomy of dressage*”, Half Halt Press, Inc.,* 1st edn, United States.
258. Seidl and Zannon, 2004, "Quality of life and health: conceptual and methodological issues", *Cadernos de saude publica,* vol. 20, no. 2, pp. 580-588.
259. Shaw, Connelly and Zecevic, 2010, "Pragmatism in practice: Mixed methods research for physiotherapy", *Physiotherapy theory and practice,* vol. 26, no. 8, pp. 510-518.
260. Shumway-Cook, *et al.*, 2003, "Effect of balance training on recovery of stability in children with cerebral palsy", *Developmental medicine and child neurology,* vol. 45, no. 9, pp. 591-602.
261. Shumway-Cook, Brauer and Woollacott, 2000, "Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test", *Physical Therapy,* vol. 80, no. 9, pp. 896-903.

262. Shumway-Cook and Horak, 1986, "Assessing the influence of sensory interaction of balance. Suggestion from the field", *Physical Therapy*, vol. 66, no. 10, pp. 1548-1550.
263. Shurtleff and Engsberg, 2010, "Changes in Dynamic Trunk and Head Stability and Function after hippotherapy in children with cerebral palsy : a pilot study", *Physical and Ocupational Therapy in Pediatrics,* vol. 30, no. 2, pp. 150.
264. Shurtleff, Standeven and Engsberg, 2009, "Changes in dynamic trunk/head stability and functional reach after hippotherapy", *Archives of Physical Medicine and Rehabilitation,* vol. 90, no. 7, pp. 1185-1195.
265. Shurtleff and Engsberg, 2012, "Long-term effects of hippotherapy on one child with cerebral palsy: a research case study", *British Journal of Occupational Therapy,* vol. 75, no. 8, pp. 359-366.
266. Siegel S. "Nomparametric Statistics for the Behavioral Sciences". McGraw-Hill Book company, INC. New York, 1956.
267. Silkwood-Sherer and Warmbier, 2007, "Effects of hippotherapy on postural stability, in persons with multiple sclerosis: a pilot study", *Journal of neurologic physical therapy: JNPT,* vol. 31, no. 2, pp. 77-84.
268. Silkwood-Sherer, *et al.*, 2012, "Hippotherapy--an intervention to habilitate balance deficits in children with movement disorders: a clinical trial", *Physical Therapy,* vol. 92, no. 5, pp. 707-717.
269. Sincero, 2012, 2-last update, "Constructing Survey Questions*",* *Homepage of Eplorable.com,* [Online]. Available: https://explorable.com/constructing-survey-questions [26th of November, 2015].
270. Siqueira, *et al.,* 2007, "Efeitos da Equoterapia como Tratamento Coadjuvante da Espasticidade", *Brazilian Journal of Physical Therapy,* vol. 11, no. Suppl., pp. 414-414.
271. Steenbergen, *et al.*, 2013, "Impaired motor planning and motor imagery in children with unilateral spastic cerebral palsy: challenges for the future of pediatric rehabilitation", *Developmental Medicine & Child Neurology,* vol. 55, no. s4, pp. 43-46.
272. Silva, Nadal and Infantosi, 2012. "Investigating the center of pressure velocity Romberg´s quotient for assessing the visual role on the body sway.", *Revista Brasileira de Engenharia Biomédica,* vol 28, no. 4.
273. Ruben Geert Van den Berg. "SPSS-tutorial: nonparametric tests." *SPSS tutorials.* [online]. Available at: https://www.spss-tutorials.com/spss-friedman-test-simple-example/ ; [28th of December 2020).
274. Sterba, 2007, "Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy?", *Developmental medicine & child neurology,* vol. 49, no. 1, pp. 68-73.
275. Sterba, *et al.,* 2002, "Horseback riding in children with cerebral palsy: effect on gross motor function", *Developmental Medicine & Child Neurology,* vol. 44, no. 5, pp. 301-308.
276. Stergiou, A., Tzoufi, M., Ntzani, E., Varvarousis, D., Beris, A. & Ploumis, A. 2017, "Therapeutic Effects of Horseback Riding Interventions: A Systematic Review and Meta-analysis", *American journal of physical medicine & rehabilitation.*

277. Stevenson and Playford, 2016, "Neurological rehabilitation and the management of spasticity", *Medicine*, vol. 44, no. 9, pp. 530-536.
278. Stifani, 2014, "Motor neurons and the generation of spinal motor neuron diversity", *Frontiers in cellular neuroscience,* vol. 8, pp. 293.
279. Sun, *et al.*, 2017, "Effect of Autologous Cord Blood Infusion on Motor Function and Brain Connectivity in Young Children with Cerebral Palsy: A Randomized, Placebo-Controlled Trial", *Stem cells translational medicine,* vol. 6, no. 12, pp. 2071-2078.
280. Tan, *et al.*, 2014, "Long-term trajectories of health-related quality of life in individuals with cerebral palsy: a multicenter longitudinal study", *Archives of Physical Medicine and Rehabilitation,* vol. 95, no. 11, pp. 2029-2039.
281. Taub, Uswatte and Elbert, 2002, "New treatments in neurorehabiliation founded on basic research", *Nature Reviews Neuroscience,* vol. 3, no. 3, pp. 228-236.
282. Teixeira, 2013, "Equilíbrio e controle postural", *Brazilian Journal of Biomechanics= Revista Brasileira de Biomecânica,* vol. 11, no. 20, pp. 30-40.
283. Terada, *et al.*, 2004, "Electromyographic analysis of the rider's muscles at trot", *Equine and Comparative Exercise Physiology,* vol. 1, no. 03, pp. 193-198.
284. The Association of Chartered Physiotherapists in Therapeutic Riding (ACPTR), nd., “The Association of Chartered Physiotherapists in Therapeutic Riding (ACPTR)”, *Homepage of ACPTR,* [Online]. Available: http://acptr.csp.org.uk/about-us [30th of July 2017].
285. Thompson, Ketcham and Hall, 2014, "Hippotherapy in children with developmental delays: Physical function and psychological benefits", *Advances in Physical Education,* vol. 4, no. 02, pp. 60.
286. Timmis, 2010, *Visuomotor control of step descent: the importance of visual information from the lower visual field in regulating landing control*, PhD edn, University of Bradford, Bradford, UK.
287. Toovey, *et al.*, 2017, "Task-specific gross motor skills training for ambulant school-aged children with cerebral palsy: a systematic review", *BMJ paediatrics open,* vol. 1, no. 1, pp. e000078-2017-000078. eCollection 2017.
288. Trompetto, *et al.*, 2014, "Pathophysiology of spasticity: implications for neurorehabilitation", *BioMed research international,* vol. 2014, pp. 354906.
289. Tseng, Chen and Tam, 2013, "Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy", *Disability and rehabilitation,* vol. 35, no. 2, pp. 89-99.
290. van den Noort, *et al.*, 2017, "European consensus on the concepts and measurement of the pathophysiological neuromuscular responses to passive muscle stretch", *European Journal of Neurology*.
291. Varni, 2017, “The PedsQL - measurement model for the pediatric quality of life inventory”, *Homepage of PedsMetrics,* [Online]. Available: http://www.pedsql.org/about_pedsql.html [28th of March 2018].
292. Varni, *et al.*, 2006, "The PedsQL in pediatric cerebral palsy: reliability, validity, and sensitivity of the Generic Core Scales and Cerebral Palsy

Module", *Developmental medicine and child neurology,* vol. 48, no. 6, pp. 442-449.
293. Varni, *et al.,* 2005, "Health-related quality of life of children and adolescents with cerebral palsy: hearing the voices of the children", *Developmental medicine and child neurology,* vol. 47, no. 9, pp. 592-597.
294. Varni, Seid and Kurtin, 2001, "PedsQL™ 4.0: Reliability and validity of the Pediatric Quality of Life Inventory™ Version 4.0 Generic Core Scales in healthy and patient populations", *Medical care,* vol. 39, no. 8, pp. 800-812.
295. Varni, Seid and Rode, 1999, "The PedsQL™: measurement model for the pediatric quality of life inventory", *Medical care,* vol. 37, no. 2, pp. 126-139.
296. Verbecque, da Costa and Hallemans, 2015, "Psychometric properties of functional balance tests in children: a literature review", *Developmental Medicine & Child Neurology,* vol. 57, no. 6, pp. 521-529.
297. Verbecque, Vereeck and Hallemans, A. 2016, "Postural sway in children: A literature review", *Gait & posture,* vol. 49, pp. 402-410.
298. Vos, *et al.,* 2016, "Longitudinal association between gross motor capacity and neuromusculoskeletal function in children and youth with cerebral palsy", *Archives of Physical Medicine and Rehabilitation,* vol. 97, no. 8, pp. 1329-1337.
299. Whalen and Case-Smith, 2012, "Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review", *Physical & Occupational Therapy in Pediatrics,* vol. 32, no. 3, pp. 229-242.
300. Whoqol Group, 1995, "The World Health Organization quality of life assessment (WHOQOL): position paper from the World Health Organization", *Social science & medicine,* vol. 41, no. 10, pp. 1403-1409.
301. Winter, 2009, "Biomechanics and motor control of human movement", *Hoboken, Wiley,* N.J.
302. Wood and Rosenbaum, 2000, "The gross motor function classification system for cerebral palsy: a study of reliability and stability over time", *Developmental medicine and child neurology,* vol. 42, no. 5, pp. 292-296.
303. Woollacott, *et al.,* 2005, "Effect of balance training on muscle activity used in recovery of stability in children with cerebral palsy: a pilot study", *Developmental medicine and child neurology,* vol. 47, no. 7, pp. 455-461.
304. Woollacott and Shumway-Cook, 2005, "Postural dysfunction during standing and walking in children with cerebral palsy: what are the underlying problems and what new therapies might improve balance?", *Neural plasticity,* vol. 12, no. 2-3, pp. 211-9; discussion 263-72.
305. WHO Group, 1998, "The World Health Organization quality of life assessment (WHOQOL): development and general psychometric properties", *Social science & medicine,* vol. 46, no. 12, pp. 1569-1585.
306. World Health Organization, 2011, "World report on disability", *WHO,* accessed at: www.who.int [15th of July 2018].

307. World Health Organization, 2007, “International Classification of Functioning, Disability, and Health: Children & Youth Version: ICF-CY”. *World Health Organization.*
308. Yam and Leung, 2006, "Interrater reliability of Modified Ashworth Scale and Modified Tardieu Scale in children with spastic cerebral palsy", *Journal of child neurology*, vol. 21, no. 12, pp. 1031-1035.
309. Zadnikar and Kastrin, 2011, "Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis", *Developmental medicine & child neurology,* vol. 53, no. 8, pp. 684-691.
310. Zarrinkalam, *et al.*, 2010, "CP or not CP? A review of diagnoses in a cerebral palsy register", *Pediatric neurology*, vol. 42, no. 3, pp. 177-180.
311. Zolnerkevic, 2015, “A arte de parar em pé”, *Pesquisa Fapesp,* 228th edn, Sao Paulo, Brazil.

Appendix

Appendix 1 – Prisma Check-list

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	N/A
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1-3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/A
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	6-8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-9

Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5-9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	7-8
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	N/A
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	N/A

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	10-11
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	12; 12- 26
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	N/A
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	12-26
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A

Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	27-34
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	34-35
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	35
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	35

Appendix 2: Critical Review Form - Quantitative Studies (Law, et al., 1998)

REFERENCE: EXEMPLE OF 1 PAPER ANALYSED

Champagne, Corriveau and Dugas, (2016).

STUDY PURPOSE: Was the purpose stated clearly? **Yes** ____No	Outline the purpose of the study (i.e., study objective or aim):
	" To evaluate the effect of HPOT on physical capacities of children with cerebral palsy"
LITERATURE: Was relevant background literature reviewed? **Yes** ____ No	Describe the justification of the need for this study (3-4 key points)
	⇒ "The effect of HPOT on the fine motor function has not been determined." ⇒ "well-described protocol are needed in order to determine whether outcomes for children with CP differ based on how HPOT is provided." ⇒ "Overall, evidence concerning HPOT and body function is still inconclusive."
DESIGN: ____randomized ____cohort (population -based) **before and after** ____ case-control ____cross-sectional (1+ group at 1 point in time) ____single case design ____case study	Describe the study design:
	Quasi-experimental design with pre-post tests.
	Can the author answer the study question with the study design?
	Yes
	Were the design and/or method used introducing biases. If so describe:
	Yes. There was a convenient sample and had different diagnosis of cerebral palsy.
SAMPLE SIZE: N = 13 Was sample size justified? _**Yes** ____No ____N/A Was Power Discussed? ____Yes ____No **N/A**	Sample Description (e.g., age, gender, diagnosis, other characteristics)
	Children (4-16 years old) with diagnosis of diplegia or spastic hemiplegia, with GMFCS level I and II.
	How was sample identified? Was it a representative sample?
	Convenient sample from rehabilitation centres of Quebec. No.
	If there were more than one group, was there similarity and differences between the groups? Describe:

	N/A
	Was informed consent and assent obtained?
	Yes

OUTCOMES:

Specify the frequency of outcome measurement (i.e., pre, post, follow-up):
Pre, post (after 10 weeks) and follow-up (after 10 weeks of the end of the program).

Outcome areas (e.g., self care, productivity)	List measures used (e.g., Sensory Profile, VMI)	Reliable and Valid?
⇒ Motor development ⇒ Motor function ⇒	⇒ BOT2-SF ⇒ GMFM-88	⇒ Yes and Yes ⇒ Yes and Yes

INTERVENTION: Intervention was described in detail? **Yes** ___No ___Not addressed Contamination was avoided? Yes ___No **Not addressed**	Provide a short description of the intervention including type of intervention, who delivered it, how often and in what setting. - 30 minutes of HPOT session, once a week, for 10 weeks. - 30 minutes of horse preparation, mounting and dismounting and feeding. - Eight different positions were used when the children were riding: forward sitting, backward sitting, side sitting, prone over barrel (lying down on the stomach), prone on forearms, quadruped facing backward, kneeling facing forward, standing in the stirrups. The horse was moving in multidirectional reaching, catching and throwing.

RESULTS:
Results were reported in terms of statistical significance?
Yes
___No
___NA
___Not addressed

What were the results?

Outcomes	Results	Statistical Significance
⇒ Dimensions D and E of GMFM ⇒ 3 items of BOT2-SF (fine motor precision, balance and strength)	⇒ Improved after treatment and follow-up when both compared to baseline ⇒ Improved between baseline and after treatment	⇒ P<0.005 ⇒ P<0.05

Was the analysis, that is the type of statistically tests used, appropriate for the type of outcome	Explain: The have used nonparametric tests given the data was not always normally distributed.

measures and the methodology? **Yes** ____No ____Not addressed	If not statistically significant (i.e., $p < 0.05$ or 0.01), was study big enough to show an important difference if it should occur (power and sample size)?
	N/A
Clinical importance was reported? **Yes** ____No ____Not addressed	What is the clinical importance of the results (that is even if the results were statistically significant were the differences large enough to be clinically meaningful?
	Results supporting that HPOT improves gross motor function and that it can impact fine gross motor function in children with CP.
Drop-outs were reported? **Yes** ____No	If yes, why did they drop out? How were drop-out participants included in the statistical analysis?
	2 drop outs, excluded after the baseline evaluation. They were not included on the statistical analysis
CONCLUSIONS AND CLINICAL IMPLECATIONS: The conclusions made by the authors were appropriate given study methods and results. _**Yes** ____No	What did the author concluded?
	"Hippotherapy provided by a trained therapist who applies an intense and graded session for 10 weeks can improve body functions and performance of gross and fine motor activities in children with cerebral palsy".
	What were the main limitations of the study as stated by the author(s) and from your point of view?
	- Small number of participants - Participants being their own control (repeated measure design) - Assessors not blind
	What are the implications of these results for your practice?
	The implications of this study for my practice are: - The confirmation of the effectiveness of GMFM-88 to evaluate gross motor function improvements after HPOT. - The fact HPOT has been shown to improve gross and fine motor function indicate a recommendation for the use of this technique.

Appendix 3: List of Papers – Literature Review.

List: Flavia Regina Bueno – March., 2017.

1. HPOT AND Cerebral Palsy (PubMed – 23 included to analysis)

1	Influence of Hippotherapy on Body Balance in the Sitting Position Among Children with Cerebral Palsy. Matusiak-Wieczorek E, Małachowska-Sobieska M, Synder M. Ortop Traumatol Rehabil. 2016 Mar 23;18(2):165-175. doi: 10.5604/15093492.1205024.
2	Changes in Cardiorespiratory Responses and Kinematics with Hippotherapy in Youth with and Without Cerebral Palsy. Rigby BR, Gloeckner AR, Sessums S, Lanning BA, Grandjean PW. Res Q Exerc Sport. 2017 Jan 11:1-10. doi: 10.1080/02701367.2016.1266458.
3	Application of a tri-axial accelerometry-based portable motion recorder for the quantitative assessment of hippotherapy in children and adolescents with cerebral palsy. Mutoh T, Mutoh T, Takada M, Doumura M, Ihara M, Taki Y, Tsubone H, Ihara M. J Phys Ther Sci. 2016 Oct;28(10):2970-2974.
4	Experience of using hippotherapy in complex effects on muscle spirals in children with spastic forms of cerebral palsy. Strashko EY, Kapustianska AA, Bobyreva LE. Wiad Lek. 2016;69(3 pt 2):527-529. Missing paper
5	The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy. Moraes AG, Copetti F, Angelo VR, Chiavoloni LL, David AC. J Phys Ther Sci. 2016 Aug;28(8):2220-6. doi: 10.1589/jpts.28.2220.
6	Different horse's paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study. Antunes FN, Pinho AS, Kleiner AF, Salazar AP, Eltz GD, de Oliveira Junior AA, Cechetti F, Galli M, Pagnussat AS. Res Dev Disabil. 2016 Dec; 59:65-72. doi: 10.1016/j.ridd.2016.07.015.
7	Effects of hippotherapy on body functions, activities and participation in children with cerebral palsy based on ICF-CY assessments. Hsieh YL, Yang CC, Sun SH, Chan SY, Wang TH, Luo HJ. Disabil Rehabil. 2016 Jul 20:1-11.
8	Effect of Hippotherapy on Motor Proficiency and Function in Children with Cerebral Palsy Who Walk.

	Champagne D, Corriveau H, Dugas C. Phys Occup Ther Pediatr. 2017 Feb;37(1):51-63. doi: 10.3109/01942638.2015.1129386.
9	Influence of neurophysiological hippotherapy on the transference of the centre of gravity among children with cerebral palsy. Maćków A, Małachowska-Sobieska M, Demczuk-Włodarczyk E, Sidorowska M, Szklarska A, Lipowicz A. Ortop Traumatol Rehabil. 2014 Nov-Dec;16(6):581-93. doi: 10.5604/15093492.1135048.
10	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon JY, Chang HJ, Yi SH, Lee JY, Shin HY, Kim YH. J Altern Complement Med. 2015 Jan;21(1):15-21. doi: 10.1089/acm.2014.0021.
11	Effects of hippotherapy on gross motor function and functional performance of children with cerebral palsy. Park ES, Rha DW, Shin JS, Kim S, Jung S. Yonsei Med J. 2014 Nov;55(6):1736-42. doi: 10.3349/ymj.2014.55.6.1736. missing paper
12	The effects of hippotherapy and a horse riding simulator on the balance of children with cerebral palsy. Lee CW, Kim SG, Na SS. J Phys Ther Sci. 2014 Mar;26(3):423-5. doi: 10.1589/jpts.26.423.
13	The effect of a hippotherapy session on spatiotemporal parameters of gait in children with cerebral palsy - pilot study. Manikowska F, Jóźwiak M, Idzior M, Chen PJ, Tarnowski D. Ortop Traumatol Rehabil. 2013 Jun 28;15(3):253-7. doi: 10.5604/15093492.1058420.
14	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial. Herrero P, Gómez-Trullén EM, Asensio A, García E, Casas R, Monserrat E, Pandyan A. Clin Rehabil. 2012 Dec;26(12):1105-13. doi: 10.1177/0269215512444633.
15	Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. Kwon JY, Chang HJ, Lee JY, Ha Y, Lee PK, Kim YH. Arch Phys Med Rehabil. 2011 May;92(5):774-9. doi: 10.1016/j.apmr.2010.11.031.
16	Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial. Herrero P, Asensio A, García E, Marco A, Oliván B, Ibarz A, Gómez-Trullén EM, Casas R.

	BMC Musculoskelet Disord. 2010 Apr 16;11:71. doi: 10.1186/1471-2474-11-71.
17	Changes in trunk and head stability in children with cerebral palsy after hippotherapy: a pilot study. Shurtleff TL, Engsberg JR. Phys Occup Ther Pediatr. 2010 May;30(2):150-63. doi: 10.3109/01942630903517223.
18	Changes in dynamic trunk/head stability and functional reach after hippotherapy. Shurtleff TL, Standeven JW, Engsberg JR. Arch Phys Med Rehabil. 2009 Jul;90(7):1185-95. doi: 10.1016/j.apmr.2009.01.026.
19	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D. Arch Phys Med Rehabil. 2009 Jun;90(6):966-74. doi: 10.1016/j.apmr.2009.01.011.
20	Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy. McGee MC, Reese NB. Pediatr Phys Ther. 2009 Summer;21(2):212-8. doi: 10.1097/PEP.0b013e3181a39532.
21	The effect of hippotherapy on ten children with cerebral palsy. Casady RL, Nichols-Larsen DS. Pediatr Phys Ther. 2004 Fall;16(3):165-72.
22	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). Benda W, McGibbon NH, Grant KL. J Altern Complement Med. 2003 Dec;9(6):817-25.
23	The effect of hippotherapy on postural control in sitting for children with cerebral palsy. Hamill D, Washington KA, White OR. Phys Occup Ther Pediatr. 2007;27(4):23-42.
24	Effect of hippotherapy on perceived self-competence and participation in a child with cerebral palsy. Frank A, McCloskey S, Dole RL. Pediatr Phys Ther. 2011 Fall;23(3):301-8. doi: 10.1097/PEP.0b013e318227caac.

2. HPOT and Cerebral Palsy (pubmed—38 excluded)

	Article reference	**Reasons for exclusion**
Hippotherapy AND cerebral palsy (Pubmed n = 39)		
1	What is hippotherapy? The indications and effectiveness of hippotherapy.	Descriptive paper.

2	Effects of Hippotherapy on Psychosocial Aspects in Children With Cerebral Palsy and Their Caregivers: A Pilot Study. Jang CH, Joo MC, Noh SE, Lee SY, Lee DB, Lee SH, Kim HK, Park HI. Ann Rehabil Med. 2016 Apr;40(2):230-6. doi: 10.5535/arm.2016.40.2.230.	Non physical outcomes
3	Intervention for an Adolescent With Cerebral Palsy During Period of Accelerated Growth. Reubens R, Silkwood-Sherer DJ. Pediatr Phys Ther. 2016 Spring;28(1):117-25. doi: 10.1097/PEP.0000000000000223.	Non physical outcomes
4	Hippotherapy in adult patients with chronic brain disorders: a pilot study. Sunwoo H, Chang WH, Kwon JY, Kim TW, Lee JY, Kim YH. Ann Rehabil Med. 2012 Dec;36(6):756-61. doi: 10.5535/arm.2012.36.6.756.	Health condition
5	Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: a pilot study. McGibbon NH, Andrade CK, Widener G, Cintas HL. Dev Med Child Neurol. 1998 Nov;40(11):754-62.	Intervention
6	Therapist-Designed Adaptive Riding in Children With Cerebral Palsy: Results of a Feasibility Study. Angsupaisal M, Visser B, Alkema A, Meinsma-van der Tuin M, Maathuis CG, Reinders-Messelink H, Hadders-Algra M. Phys Ther. 2015 Aug;95(8):1151-62. doi: 10.2522/ptj.20140146.	Intervention
7	The effect of therapeutic horseback riding on balance in community-dwelling older adults: a pilot study. Homnick TD, Henning KM, Swain CV, Homnick DN. J Appl Gerontol. 2015 Feb;34(1):118-26. doi: 10.1177/0733464812467398.	Intervention
8	Effectiveness of equine therapy in children with psychomotor impairment. Del Rosario-Montejo O, Molina-Rueda F, Muñoz-Lasa S, Alguacil-Diego IM. Neurologia. 2015 Sep;30(7):425-32. doi: 10.1016/j.nrl.2013.12.023.	Intervention
9	Therapeutic effects of a horse riding simulator in children with cerebral palsy. Silva e Borges MB, Werneck MJ, da Silva Mde L, Gandolfi L, Pratesi R. Arq Neuropsiquiatr. 2011 Oct;69(5):799-804.	Intervention

11	The Efficacy of Equine-Assisted Activities and Therapies on Improving Physical Function. Rigby BR, Grandjean PW. J Altern Complement Med. 2016 Jan;22(1):9-24. doi: 10.1089/acm.2015.0171. Review.	Literature review.
12	Exercise interventions improve postural control in children with cerebral palsy: a systematic review. Dewar R, Love S, Johnston LM. Dev Med Child Neurol. 2015 Jun;57(6):504-20. doi: 10.1111/dmcn.12660. Review.	Literature review.
13	Commentary on "Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study". Bjornson K, Coyner P. Pediatr Phys Ther. 2012 Fall;24(3):258. doi: 10.1097/PEP.0b013e31825cc9ee. No abstract available.	Commentary.
14	Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study. Bongers BC, Takken T. Pediatr Phys Ther. 2012 Fall;24(3):252-7. doi: 10.1097/PEP.0b013e31825c1a7d.	Therapeutic horseback riding + not appropriate outcome measures + unsure about the health condition.
15	Evidence to practice commentary: the evidence alert traffic light grading system. Novak I. Phys Occup Ther Pediatr. 2012 Aug;32(3):256-9. doi: 10.3109/01942638.2012.698148. No abstract available.	Commentary.
16	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. Tseng SH, Chen HC, Tam KW. Disabil Rehabil. 2013 Jan;35(2):89-99. doi: 10.3109/09638288.2012.687033. Review.	Literature review.
17	Effect of therapeutic riding on functional scoliosis as observed by roentgenography. Ihara M, Ihara M, Doumura M. Pediatr Int. 2012 Feb;54(1):160-2. doi: 10.1111/j.1442-200X.2011.03456.x. No abstract available.	Therapeutic riding.
18	Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review. Whalen CN, Case-Smith J. Phys Occup Ther Pediatr. 2012 Aug;32(3):229-42. doi: 10.3109/01942638.2011.619251. Review.	Literature review.

19	The effect of robo-horseback riding therapy on spinal alignment and associated muscle size in MRI for a child with neuromuscular scoliosis: an experimenter-blind study. Lee DR, Lee NG, Cha HJ, Yun Sung O, You SJ, Oh JH, Bang HS. NeuroRehabilitation. 2011;29(1):23-7. doi: 10.3233/NRE-2011-0673.	Health condition = neuromuscular scoliosis
20	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis. Zadnikar M, Kastrin A. Dev Med Child Neurol. 2011 Aug;53(8):684-91. doi: 10.1111/j.1469-8749.2011.03951.x. Review.	Literature review.
21	Center-of-pressure movements during equine-assisted activities. Clayton HM, Kaiser LJ, de Pue B, Kaiser L. Am J Occup Ther. 2011 Mar-Apr;65(2):211-6.	Intervention = horse riding
22	Incidence and risk factors of hip joint pain in children with severe cerebral palsy. Jóźwiak M, Harasymczuk P, Koch A, Kotwicki T. Disabil Rehabil. 2011;33(15-16):1367-72. doi: 10.3109/09638288.2010.532281.	No HPOT intervention
23	The effects of a 5-week therapeutic horseback riding program on gross motor function in a child with cerebral palsy: a case study. Drnach M, O'Brien PA, Kreger A. J Altern Complement Med. 2010 Sep;16(9):1003-6. doi: 10.1089/acm.2010.0043.	Intervention = therapeutic horseback riding
24	Complementary and alternative methods in cerebral palsy. Oppenheim WL. Dev Med Child Neurol. 2009 Oct;51 Suppl 4:122-9. doi: 10.1111/j.1469-8749.2009.03424.x. Review.	Literature review.
25	Effects of hippotherapy on people with cerebral palsy from the users' perspective: a qualitative study. Debuse D, Gibb C, Chandler C. Physiother Theory Pract. 2009 Apr;25(3):174-92. doi: 10.1080/09593980902776662.	Qualitative study.
26	Influence of mechanical hippotherapy on skin temperature responses in lower limbs in children with cerebral palsy. Zurek G, Dudek K, Pirogowicz I, Dziuba A, Pokorski M. J Physiol Pharmacol. 2008 Dec;59 Suppl 6:819-24.	Outcomes = skin temperature responses in lower limbs
27	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review. Anttila H, Suoranta J, Malmivaara A, Mäkelä M, Autti-Rämö I.	Literature review.

	Am J Phys Med Rehabil. 2008 Jun;87(6):478-501. doi: 10.1097/PHM.0b013e318174ebed. Review.	
28	The utilization of hippotherapy as auxiliary treatment in the rehabilitation of children with cerebral palsy. Lisiński P, Stryła W. Ortop Traumatol Rehabil. 2001;3(4):538-40.	Descriptive paper.
29	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness? Snider L, Korner-Bitensky N, Kammann C, Warner S, Saleh M. Phys Occup Ther Pediatr. 2007;27(2):5-23	Literature review
30	Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? Sterba JA. Dev Med Child Neurol. 2007 Jan;49(1):68-73.	Literature review
31	An exploration of German and British physiotherapists' views on the effects of hippotherapy and their measurement. Debuse D, Chandler C, Gibb C. Physiother Theory Pract. 2005 Oct-Dec;21(4):219-42.	Qualitative
32	Complementary and alternative therapies for cerebral palsy. Liptak GS. Ment Retard Dev Disabil Res Rev. 2005;11(2):156-63.	Literature review.
33	Hippotherapy. Meregillano G. Phys Med Rehabil Clin N Am. 2004 Nov;15(4):843-54, vii.	Literature review.
34	[Hippotherapy as a method for complex rehabilitation of patients with late residual stage of infantile cerebral palsy]. Sokolov PL, Dremova GV, Samsonova SV. Zh Nevrol Psikhiatr Im S S Korsakova. 2002;102(10):42-5.	Article in Russian.
35	[Etiologies of cerebral palsy and classical treatment possibilities]. Maurer U. Wien Med Wochenschr. 2002;152(1-2):14-8.	Article in German.
36	[Hippotherapy--a supplementary treatment for motion disturbance caused by cerebral palsy (author's transl)]. Tauffkirchen E. Padiatr Padol. 1978;13(4):405-11.	Article in German.
37	[Hippotherapy and therapeutic horseback riding in the treatment of children and adolescents with cerebral pareses and dysmelias]. Horster R, Lippold-von Hörde H, Rieger C. ZFA (Stuttgart). 1976 Jan 10;52(1):15-21.	Article in German.
38	Hippotherapy--an intervention to habilitate balance deficits in children with movement disorders: a clinical trial. Silkwood-Sherer DJ, Killian CB, Long TM, Martin KS. Phys Ther. 2012 May;92(5):707-17. doi: 10.2522/ptj.20110081.	Health condition = movement disorders

39	[Therapy with the help of a horse - attempt at a situational analysis (author's transl)]. Riesser H. Rehabilitation (Stuttg). 1975 Aug;14(3):145-9	Article in German.

3. HPOT And CP (Pedro – 2 included)

Hippotherapy AND cerebral palsy (PEDro n = 13)	
1	Effects of hippotherapy on the sitting balance of children with cerebral palsy: a randomized control trial. Kang H, Jung J, Yu J Journal of Physical Therapy Science 2012 Oct;24(9):833-836
2	Modulation of back geometry in children with spastic diplegic cerebral palsy via hippotherapy training el-Meniawy GH, Thabet NS. Egyptian Journal of Medical Human Genetics 2012 Feb;13(1):63-71

4. HPOT and CP (pedro – 11 excluded)

Hippotherapy AND cerebral palsy (PEDro n = 13)		
1	Exercise interventions improve postural control in children with cerebral palsy: a systematic review [with consumer summary]	Literature review
2	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy [with consumer summary]	Literature review
3	Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review	Literature review
4	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis	Literature review
5	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review	Literature review
6	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness?	Literature review
7	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial [with consumer summary]	Duplicate

	Herrero P, Gomez-Trullen EM, Asensio A, Garcia E, Casas R, Monserrat E, Pandyan A Clinical Rehabilitation 2012 Dec;26(12):1105-1113	
8	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon J-Y, Chang HJ, Yi S-H, Lee JY, Shin H-Y, Kim Y-H Journal of Alternative & Complementary Medicine 2015 Jan;21(1):15-21	Duplicate
9	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D Archives of Physical Medicine and Rehabilitation 2009 Jun;90(6):966-974	Duplicate
10	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). Benda W, McGibbon NH, Grant KL Journal of Alternative & Complementary Medicine 2003 Dec;9(6):817-825	Duplicate
11	The effects of hippotherapy and a horse riding simulator on the balance of children with cerebral palsy. Lee C-W, Kim SG, Na SS. Journal of Physical Therapy Science 2014 Mar;26(3):423-425	Duplicate

5. HPOT and CP (Scopus – 5 included)

Hippotherapy AND cerebral palsy (Scopus n = 109)	
1	The effect of hippotherapy on gait in patients with spastic cerebral palsy. Fízková, V., Krejčí, E., Svoboda, Z. , Elfmark, M., Janura, M. Acta Universitatis Palackianae Olomucensis, Gymnica Volume 43, Issue 4, 2013, Pages 17-23
2	The effects of hippotherapy on the motor function of children with spastic bilateral cerebral palsy . Chang, H.J., Kwon, J.-Y., Lee, J.-Y., Kim, Y.-H. Journal of Physical Therapy Science Volume 24, Issue 12, 2 December 2012, Pages 1277-1280. DOI: 10.1589/jpts.24.1277
3	Long-term effects of hippotherapy on one child with cerebral palsy: A research case study (Article) Shurtleff, T. , Engsberg, J. British Journal of Occupational Therapy. Volume 75, Issue 8, August 2012, Pages 359-366
4	Influence of artificial saddle riding on postural stability in children with cerebral palsy (Article)

	Kuczyński, M., Slonka, K.
5	Influence of hippotherapy on the kinematics and functional performance two children with cerebral palsy (Article) Haehl, V., Giuliani, C., Lewis, C. Pediatric Physical Therapy. Volume 11, Issue 2, 1999, Pages 89-101

6. HPOT and CP (Scopus – 104 excluded)

Hippotherapy AND cerebral palsy (Scopus n = 109)		
1	Changes in Cardiorespiratory Responses and Kinematics With Hippotherapy in Youth With and Without Cerebral Palsy. Rigby BR, Gloeckner AR, Sessums S, Lanning BA, Grandjean PW. Res Q Exerc Sport. 2017 Jan 11:1-10. doi: 10.1080/02701367.2016.1266458.	**Duplicate**
2	Different horse's paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study. Antunes FN, Pinho AS, Kleiner AF, Salazar AP, Eltz GD, de Oliveira Junior AA, Cechetti F, Galli M, Pagnussat AS. Res Dev Disabil. 2016 Dec;59:65-72. doi: 10.1016/j.ridd.2016.07.015.	**Duplicate**
3	Application of a tri-axial accelerometry-based portable motion recorder for the quantitative assessment of hippotherapy in children and adolescents with cerebral palsy. Mutoh T, Mutoh T, Takada M, Doumura M, Ihara M, Taki Y, Tsubone H, Ihara M. J Phys Ther Sci. 2016 Oct;28(10):2970-2974.	**Duplicate**
4	The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy. Moraes AG, Copetti F, Angelo VR, Chiavoloni LL, David AC. J Phys Ther Sci. 2016 Aug;28(8):2220-6. doi: 10.1589/jpts.28.2220.	**Duplicate**
5	Effects of hippotherapy on body functions, activities and participation in children with cerebral palsy based on ICF-CY assessments. Hsieh YL, Yang CC, Sun SH, Chan SY, Wang TH, Luo HJ. Disabil Rehabil. 2016 Jul 20:1-11.	**Duplicate**
6	Improved postural control and balance in cerebral palsy: A systematic review | [Mejora del control postural y equilibrio en la parálisis cerebral infantil: Revisión sistemática]	**Article in Spanish**
7	Hippotherapy acute impact on heart rate variability non-linear dynamics in neurological disorders	**Health condition**

	Cabiddu, R. , Borghi-Silva, A., Trimer, R., Trimer, V., Ricci, P.A., Italiano Monteiro, C., Camargo Magalhães Maniglia, M., Silva Pereira, A.M., Rodrigues das Chagas, G., Carvalho, E.M.	
8	Possibilities of hippotherapy for child patients with cerebral palsy (Article) [Možnosti hipoterapie u dětských pacientůs dětskou mozkovou obrnou] Čapková, K.a, Pavlů, D.	**Article in Czech m**
9	Influence of Hippotherapy on Body Balance in the Sitting Position Among Children with Cerebral Palsy. Matusiak-Wieczorek E, Małachowska-Sobieska M, Synder M. Ortop Traumatol Rehabil. 2016 Mar 23;18(2):165-175. doi: 10.5604/15093492.1205024.	**Duplicate**
10	Effects of Hippotherapy on Psychosocial Aspects in Children With Cerebral Palsy and Their Caregivers: A Pilot Study. Jang CH, Joo MC, Noh SE, Lee SY, Lee DB, Lee SH, Kim HK, Park HI. Ann Rehabil Med. 2016 Apr;40(2):230-6. doi: 10.5535/arm.2016.40.2.230.	**Non physical outcomes**
11	Using accelerometers to assess the effects of hippotherapy on movement execution in children with spastic cerebral palsy - A pilot study. Bednarikova, H. , Janura, M., Bizovská, L.	**Article in Czech**
12	Intervention for an Adolescent With Cerebral Palsy During Period of Accelerated Growth. Reubens R, Silkwood-Sherer DJ. Pediatr Phys Ther. 2016 Spring;28(1):117-25. doi: 10.1097/PEP.0000000000000223.	**Non physical outcomes**
13	The effects of hippotherapy on attention and memory skills of children with CP, from a long-term perspective. Krejčí, E.	**Article in Slovak**
14	The Efficacy of Equine-Assisted Activities and Therapies on Improving Physical Function. Rigby BR, Grandjean PW. J Altern Complement Med. 2016 Jan;22(1):9-24. doi: 10.1089/acm.2015.0171. Review.	**Literature review.**
15	Effectiveness of equine therapy in children with psychomotor impairment. Del Rosario-Montejo O, Molina-Rueda F, Muñoz-Lasa S, Alguacil-Diego IM. Neurologia. 2015 Sep;30(7):425-32. doi: 10.1016/j.nrl.2013.12.023.	**Intervention**
16	The impact of hippotherapy on the quality of trunk stabilisation, evaluated by EMG biofeedback, in children with infantile cerebral palsy. Lakomy-Gawryszewska, A.A. , Józefowicz, K., Raniszewska, A., Langer, D., Hansdorfer-Korzon, R., Bieszczad, D., Górska, K., Cichoń-Kotek, M., Pilarska, E.	**Not yet published.**

17	The influence of hippotherapy on functional state of neuromuscular system in children with cerebral palsy in the form of double spastic hemiplegia. Volokitin, A.S., Bruykov, A.A., Apokin, V.V., Gulin, A.V.	**Article in Russian**
18	Development of joint mobility in children with spastic cerebral palsy under the influence of hippotherapy . Volokitin, A.S., Bruykov, A.A., Gulin, A.V., Apokin, V.V.	**Article in Russian**
19	Effects of hippotherapy on postural stability in cerebral palsy: Report of a case (Letter) [Efectos de la hipoterapia en la estabilidad postural en parálisis cerebral infantil: A propósito de un caso clínico] Fernández-Gutiérrez, C., Apolo-Arenas, M.D. , Martínez-García, Y., Caña-Pino, A.	**Article in Spanish**
20	Hippotherapy in the postural control and balance in individuals with cerebral palsy: Systematic review [Equoterapia no controle postural e equilíbrio em indivíduos com paralisia cerebral: Revisão sistemática] Moraes, A.G.a , Silva, M.a, Copetti, F.b, Abreu, A.C.a, de David, A.C.a	**Article in Portuguese**
21	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon JY, Chang HJ, Yi SH, Lee JY, Shin HY, Kim YH. J Altern Complement Med. 2015 Jan;21(1):15-21. doi: 10.1089/acm.2014.0021.	**Duplicate**
22	Exercise interventions improve postural control in children with cerebral palsy: a systematic review. Dewar R, Love S, Johnston LM. Dev Med Child Neurol. 2015 Jun;57(6):504-20. doi: 10.1111/dmcn.12660. Review.	**Literature review.**
23	Therapist-Designed Adaptive Riding in Children With Cerebral Palsy: Results of a Feasibility Study. Angsupaisal M, Visser B, Alkema A, Meinsma-van der Tuin M, Maathuis CG, Reinders-Messelink H, Hadders-Algra M. Phys Ther. 2015 Aug;95(8):1151-62. doi: 10.2522/ptj.20140146.	**Intervention**
24	The benefit of hippotherapy for improvement of attention and memory in children with cerebral palsy: A pilot study. Krejčí, E.ab , Janura, M.a, Svoboda, Z.a	**Non physical outcomes**
25	Effects of equine therapy in gross motor function of patients with chronic non-progressive encephalopathy (Article)	**Article in Portuguese**

	[Efeitos da Equoterapia na função motora grossa de pacientes com encefalopatia crônica não progressiva] Da Silva, L.M.a , De Sousa Monteiro, E.a, De Paiva, S.S.C.a, Torres, M.V.b, De Carvalho, M.E.I.M.c	
26	The effect of therapeutic horseback riding on balance in community-dwelling older adults: a pilot study. Homnick TD, Henning KM, Swain CV, Homnick DN. J Appl Gerontol. 2015 Feb;34(1):118-26. doi: 10.1177/0733464812467398.	**Intervention**
27	Influence of neurophysiological hippotherapy on the transference of the centre of gravity among children with cerebral palsy Maćkó, A.ac , Małachowska-Sobieska, M.ac, Demczuk-Włodarczyk, E.a, Sidorowska, M.a, Szklarska, A.b, Lipowicz, A.b	**Article in Polish**
28	Effects of hippotherapy on gross motor function and functional performance of children with cerebral palsy. Park ES, Rha DW, Shin JS, Kim S, Jung S. Yonsei Med J. 2014 Nov;55(6):1736-42. doi: 10.3349/ymj.2014.55.6.1736.	**Duplicate**
29	The effects of hippotherapy and a horse riding simulator on the balance of children with cerebral palsy. Lee CW, Kim SG, Na SS. J Phys Ther Sci. 2014 Mar;26(3):423-5. doi: 10.1589/jpts.26.423.	**Duplicate**
30	The effects of hippotherapy on motor and psychic functions of CP affected children and young persons. Krejčí, E.ab , Janura, M.a, Svoboda, Z.a	**Article in Czech**
31	Continuous vs. blocks of physiotherapy for motor development in children with cerebral palsy and similar syndromes: A prospective randomized study . Brunner, A.-L.a, Rutz, E.b, Juenemann, S.c, Brunner, R.b	**Intervention**
32	The effects of the therapeutic riding on children with cerebral palsy Laiou, A.a , Christakou, A.b, Poluzos, N.c, Nikolaou, I.c	**Article in Greek**
33	A systematic review of interventions for children with cerebral palsy: State of the evidence. novak, I.ab, Mcintyre, S.ab, Morgan, C.ab, Campbell, L.b, Dark, L.a, Morton, N.a, Stumbles, E.a, Wilson, S..-A.a, Goldsmith, S.ab	**Literature review**
34	Promoting function and participation to improve living a life with cerebral palsy (Article) Msall, M.E.	**Intervention**

35	The effect of a hippotherapy session on spatiotemporal parameters of gait in children with cerebral palsy - pilot study. Manikowska F, Jóźwiak M, Idzior M, Chen PJ, Tarnowski D. Ortop Traumatol Rehabil. 2013 Jun 28;15(3):253-7. doi: 10.5604/15093492.1058420.	**Duplicate**
36	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. Tseng SH, Chen HC, Tam KW. Disabil Rehabil. 2013 Jan;35(2):89-99. doi: 10.3109/09638288.2012.687033. Review.	**Literature review.**
37	The therapeutic interventions in cerebral palsy . Feferman, H., Harro, J., Patel, D.R. , Merrick, J.	**Book Chapter**
38	Effects of hippotherapy on the sitting balance of children with cerebral palsy: a randomized control trial. Kang H, Jung J, Yu J. Journal of Physical Therapy Science 2012 Oct;24(9):833-836	**Duplicate**
39	Hippotherapy in adult patients with chronic brain disorders: a pilot study. Sunwoo H, Chang WH, Kwon JY, Kim TW, Lee JY, Kim YH. Ann Rehabil Med. 2012 Dec;36(6):756-61. doi: 10.5535/arm.2012.36.6.756.	**Health condition**
40	Historical overview of the rationale for the pharmacological use of prolonged-release fampridine in multiple sclerosis. Fernandez, O.a , Berger, T.b, Hartung, H.-P.c, Putzki, N.d	**health condition.**
41	Assessment of the impact of hippotherapy on the level of satisfaction with life and acceptance of illness among parents of children with cerebral palsy. Białoszewski, D., Lewandowska, M., Korabiewska, I., Rongies, W., Woińska, M., Gotlib, J.	**Non physical outcomes**
42	Therapeutic effects of hippotherapy in cerebral palsy: A systematic review (Short Survey) [Efectos terapéuticos de la hipoterapia en la parálisis cerebral: una revisión sistemática] Herrero Gallego, P., García Antón, E. , Monserrat Cantera, M.E., Oliván Blázquez, B., Gómez Trullén, E.M., Trenado Molina, J.	**Article in Spanish.** Literature review
43	The medical management of cerebral palsy. Smith, M.a, Kurian, M.A.b	**Literature review**
44	Commentary on "Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study". Bjornson, K., Coyner, P.	**Commentary**
45	Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review. Whalen CN, Case-Smith J. Phys Occup Ther Pediatr. 2012 Aug;32(3):229-42. doi: 10.3109/01942638.2011.619251. Review.	**Literature review.**

46	Cerebral palsy: The whys and hows. Fairhurst, C.	**Literature review.**
47	Evidence to practice commentary: The evidence alert traffic light grading system Novak, I.	**Commentary**
48	Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study. Bongers BC, Takken T. Pediatr Phys Ther. 2012 Fall;24(3):252-7. doi: 10.1097/PEP.0b013e31825c1a7d.	**Therapeutic horseback riding + not appropriate outcome measures + unsure about the health condition.**
49	Hippotherapy--an intervention to habilitate balance deficits in children with movement disorders: a clinical trial. Silkwood-Sherer DJ, Killian CB, Long TM, Martin KS. Phys Ther. 2012 May;92(5):707-17. doi: 10.2522/ptj.20110081.	**Health condition** = movement disorders
50	Modulation of back geometry in children with spastic diplegic cerebral palsy via hippotherapy training. el-Meniawy GH, Thabet NS. Egyptian Journal of Medical Human Genetics 2012 Feb;13(1):63-71	**Duplicate**
51	Effect of therapeutic riding on functional scoliosis as observed by roentgenography. Ihara M, Ihara M, Doumura M. Pediatr Int. 2012 Feb;54(1):160-2. doi: 10.1111/j.1442-200X.2011.03456.x. No abstract available.	**Therapeutic riding.**
52	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial. Herrero P, Gómez-Trullén EM, Asensio A, García E, Casas R, Monserrat E, Pandyan A. Clin Rehabil. 2012 Dec;26(12):1105-13. doi: 10.1177/0269215512444633.	**Duplicate**
53	Possibilities of hippotherapy use in clinical practice 1. Svoboda, Z.ac , Janura, M.a, Dvořáková, T.a, Živný, B.b	**Article in Slovak**
54	Possibilities of hippotherapy use in clinical practice 2 (Article) [Možnosti využití hipoterapie v klinické praxi 2] Svoboda, Z.ac , Janura, M.a, Dvořáková, T.a, Živný, B.b	**Article in Slovak**
55	Therapeutic effects of a horse riding simulator in children with cerebral palsy. Silva e Borges MB, Werneck MJ, da Silva Mde L, Gandolfi L, Pratesi R.	**Intervention**

	Arq Neuropsiquiatr. 2011 Oct;69(5):799-804.	
56	Effect of hippotherapy on perceived self-competence and participation in a child with cerebral palsy. Frank A, McCloskey S, Dole RL. Pediatr Phys Ther. 2011 Fall;23(3):301-8. doi: 10.1097/PEP.0b013e318227caac.	**Duplicate**
57	WBSN for the assessment of the hippotherapy: A case study Nerino, R.a , Bergero, D.b , Bertolo, F.c , Guiot, C.c , Contin, L.d , Garbin, P.d	**Conference Paper**
58	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis. Zadnikar M, Kastrin A. Dev Med Child Neurol. 2011 Aug;53(8):684-91. doi: 10.1111/j.1469-8749.2011.03951.x. Review.	**Literature review.**
59	Incidence and risk factors of hip joint pain in children with severe cerebral palsy. Jóźwiak M, Harasymczuk P, Koch A, Kotwicki T. Disabil Rehabil. 2011;33(15-16):1367-72. doi: 10.3109/09638288.2010.532281.	**No HPOT intervention**
60	Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. Kwon JY, Chang HJ, Lee JY, Ha Y, Lee PK, Kim YH. Arch Phys Med Rehabil. 2011 May;92(5):774-9. doi: 10.1016/j.apmr.2010.11.031.	**Duplicate**
61	Center-of-pressure movements during equine-assisted activities. Clayton HM, Kaiser LJ, de Pue B, Kaiser L. Am J Occup Ther. 2011 Mar-Apr;65(2):211-6.	**Intervention = horse riding**
62	Influence of hippotherapy on the different postural-locomotion functions of patients with spastic quadruparetic form of cerebral palsy (Article) [Pôsodenie hipoterapie na rôzne posturálne lokomočné funkcie pri spastigkej kvauruparetickej forme detskej mozgovej obrny] Hornáček, K.a , Kafková, A.b, Páleníková, A.a	**Article in Slovak**
63	Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial. Herrero P, Asensio A, García E, Marco A, Oliván B, Ibarz A, Gómez-Trullén EM, Casas R. BMC Musculoskelet Disord. 2010 Apr 16;11:71. doi: 10.1186/1471-2474-11-71.	**Duplicate**

64	Changes in trunk and head stability in children with cerebral palsy after hippotherapy: a pilot study. Shurtleff TL, Engsberg JR. Phys Occup Ther Pediatr. 2010 May;30(2):150-63. doi: 10.3109/01942630903517223.	**Duplicate**
65	Complementary and alternative methods in cerebral palsy. Oppenheim WL. Dev Med Child Neurol. 2009 Oct;51 Suppl 4:122-9. doi: 10.1111/j.1469-8749.2009.03424.x. Review.	**Literature review. Descriptive paper.**
66	Management of motor problems in cerebral palsy: A critical update for the clinician Papavasiliou, A.S.	**Literature review**
67	Changes in dynamic trunk/head stability and functional reach after hippotherapy. Shurtleff TL, Standeven JW, Engsberg JR. Arch Phys Med Rehabil. 2009 Jul;90(7):1185-95. doi: 10.1016/j.apmr.2009.01.026.	**Duplicate**
68	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D. Arch Phys Med Rehabil. 2009 Jun;90(6):966-74. doi: 10.1016/j.apmr.2009.01.011.	**Duplicate**
69	Effects of hippotherapy on people with cerebral palsy from the users' perspective: a qualitative study. Debuse D, Gibb C, Chandler C. Physiother Theory Pract. 2009 Apr;25(3):174-92. doi: 10.1080/09593980902776662.	**Qualitative study.**
70	A randomized controlled trial of the impact of therapeutic horse riding on the quality of life, health, and function of children with cerebral palsy (Note) Rosenbaum, P.	**Intervention. Outcomes.**
71	Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy. McGee MC, Reese NB. Pediatr Phys Ther. 2009 Summer;21(2):212-8. doi: 10.1097/PEP.0b013e3181a39532.	**Duplicate**
72	Influence of mechanical hippotherapy on skin temperature responses in lower limbs in children with cerebral palsy. Zurek G, Dudek K, Pirogowicz I, Dziuba A, Pokorski M. J Physiol Pharmacol. 2008 Dec;59 Suppl 6:819-24.	**Outcomes = skin temperature responses in lower limbs**

73	The clinical picture of a child with spastic diplegia on a horse, depending on the position of the hippotherapeutic team. Małachowska-Sobieska, M., Demczuk-Włodarczyk, E., Wronecki, K., Skolimowski, T., Szpyt, K., Wojna, D., Zawadzka, D.	**polish**
74	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review. Anttila H, Suoranta J, Malmivaara A, Mäkelä M, Autti-Rämö I. Am J Phys Med Rehabil. 2008 Jun;87(6):478-501. doi: 10.1097/PHM.0b013e318174ebed. Review.	**Literature review.**
75	Thermovision assessment of the simulate hippotherapy effectiveness for children with diversiform of the cerebral palsy. Zurek, G.a, Dudek, K.b, Dziuba, A.c	**Outcomes**
76	Physical therapy of cerebral palsy Miller, F., Bolton, M., Capone, K., Damiano, D., Hanlon, J., Hines, M., Hoopes, D., Jeanson, E., King, M.M., Kiser, D., Koczur, L., McManus, M., Mullan, B., Peischl, D., Rolph, B., Rush, A.J., Strine, C., Travis, S.	**Book**
77	The hippotherapy and its import in therapy of infantile paralysis (the Casuistik) (Article) [Hippoterapia a jej význam v liečbe detskej mozgovej obrny (Kazuistika)] Dziaková, M.ab, Moudrá, A.a, Repiská, A.a, Šimšík, D.a, Majerník, J.a, Dolná, Z.a	**Article in Slovak**
78	Hippotherapy and the significance of complementary and alternative medicine: A Q&A with William Benda, M.D., FACEP, FAAEM . Lane, K.W.	**Note**
79	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness? Snider L, Korner-Bitensky N, Kammann C, Warner S, Saleh M. Phys Occup Ther Pediatr. 2007;27(2):5-23	**Literature review**
80	The effect of hippotherapy on postural control in sitting for children with cerebral palsy. Hamill D, Washington KA, White OR. Phys Occup Ther Pediatr. 2007;27(4):23-42.	**Duplicate**
81	Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? Sterba JA. Dev Med Child Neurol. 2007 Jan;49(1):68-73.	**Literature review**
82	Rett syndrome. A review with emphasis on clinical characteristics and intervention. Lotan, M. , Ben-Zeev, B.	**Literature review**

83	An exploration of German and British physiotherapists' views on the effects of hippotherapy and their measurement. Debuse D, Chandler C, Gibb C. Physiother Theory Pract. 2005 Oct-Dec;21(4):219-42.	**Qualitative**
84	Special needs, special horses: A guide to the benefits of therapeutic riding	**Book**
85	Therapeutic interventions in cerebral palsy .Patel, D.R.ab	**Conference Paper**
86	Complementary and alternative therapies for cerebral palsy. Liptak GS. Ment Retard Dev Disabil Res Rev. 2005;11(2):156-63.	**Literature review.**
87	Hippotherapy. Meregillano G. Phys Med Rehabil Clin N Am. 2004 Nov;15(4):843-54, vii.	**Literature review.**
88	Hippotherapy contribution in the management of disability (Article) [Apports de l'hippothérapie dans la prise en charge du handicap] Proust, P., Cottalorda, J. , Alamartine, E., Gautheron, V.	**Article in French**
89	The effect of hippotherapy on ten children with cerebral palsy. Casady RL, Nichols-Larsen DS. Pediatr Phys Ther. 2004 Fall;16(3):165-72.	**Duplicate**
90	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). Benda W, McGibbon NH, Grant KL. J Altern Complement Med. 2003 Dec;9(6):817-25.	**Duplicate**
91	Cerebral palsy - Etiology and therapy (Article) [Ursachen der zerebralparese und klassische behandlungsmöglichkeiten] Maurer, U.ab	**Article in German**
92	Hippotherapy as a method for complex rehabilitation of patients with late residual stage of infantile cerebral palsy (Article) [Ippoterapiia kak metod kompleksnoi reabilitatsii bol'nykh v pozdnei rezidual'noi stadii detskogo tserebral'nogo paralicha.] Sokolov, P.L., Dremova, G.V., Samsonova, S.V.	**Article in Russian**
93	Multiple simultaneous approach in lower extremity spasticity surgery (Article) Sayli, U.ab, Avci, S.b	**Health condition**
94	Hippotherapy as a part of cerebral palsy and other movement disorders treatment (Article)	**Article in Slovak**

	[Hipoterapia ako sucast liecby DMO a inych pohybovych poruch] Wagnerova, D.	
95	Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: a pilot study. McGibbon NH, Andrade CK, Widener G, Cintas HL. Dev Med Child Neurol. 1998 Nov;40(11):754-62.	**Intervention**
96	Therapeutic horse-riding (hippotherapy): Recreation or treatment? [EQUITAZIONE TERAPEUTICA (IPPOTERAPIA): SVAGO O TERAPIA?] Bassan, L., Alfieri, V.	**Article in Italian**
97	Hippotherapy in multiple sclerosis patients and children with cerebral mobility disturbances [HIPPOTHERAPIE BEI MULTIPLE-SKLEROSE-KRANKEN UND KINDERN MIT ZEREBRALEN BEWEGUNGSSTORUNGEN] Riesser, H.	**Article in German**
98	Therapeutic horseback riding: Situation in Austria [STAND DER HIPPOTHERAPIE IN Osterreich] Kyrle, P., Schwarzenberg, T., Tauffkirchen, E.	**Article in German**
99	Hippotherapy. A supplementary treatment for motion disturbance caused by cerebral palsy (Article) [REITTHERAPIE - EINE ERWEITERTE BEHANDLUNG BEI ZEREBRALEN BEWEGUNGSSTORUNGEN] Tauffkirchen, E.	**Article in German**
100	Hippotherapy as treatment of preschool children with cerebral palsy [HIPPOTHERAPIE ALS BEHANDLUNG ZEREBRALPARETISCHER KINDER IM VORSCHULALTER] Waller, E., Wolf, H.	**Article in German**
101	Horseback riding therapy for children with movement malfunction considering especially cerebral palsy patients [REITEN ALS THERAPIE BEI BEWEGUNGSGESTORTEN KINDERN MIT BESONDERER BERUCKSICHTIGUNG DER ZEREBRALPARESE]	**Article in German**

	Satter, L.	
102	Therapy with the help of a horse: attempt at a situational analysis (Article) [THERAPIE MIT UND AUF DEM PFERD: VERSUCH EINER BESTANDSAUFNAHME] Riesser, H.	**Article in German**
103	Is hyppotherapy beneficial for rehabilitation of children with cerebral palsy? Yildirim Şik, B., Çekmece, C., Dursun, N. , Dursun, E., Balikçi, E., Altunkanat, Z., Gülcü, M.A. Turkiye Klinikleri Journal of Medical Sciences. Volume 32, Issue 3, 2012, Pages 601-608 deleted-polish	**Article in polish**
104	The usefulness of hippotherapy in the rehabilitation of cerebrally palsied children. Pilot study. Białoszewski, D. , Korabiewska, I., Lewandowska, M., Wasiak, K. Fizjoterapia Polska. Volume 11, Issue 2, 2011, Pages 175-181 deleted-polish	**Article in polish**

7. HPOT and CP (cinahl = 1)

Hippotherapy AND cerebral palsy (cinahl=49)	
1	The Effects of Hippotherapy on the Motor Function of Children with Spastic Bilateral Cerebral Palsy. Hyun Jung Chang; Kwon, Jeong-Yi; Lee, Ji-Young; Kim, Yun-Hee Journal of Physical Therapy Science (J PHYS THER SCI), Dec2012; 24(12): 1277-1280. (4

8. HPOT and CP (cinahl = 48)

	Article reference	**Reasons for exclusion**
Hippotherapy AND cerebral palsy (cinahl = 49)		
1	Effect of Hippotherapy on Motor Proficiency and Function in Children with Cerebral Palsy Who Walk. Champagne D, Corriveau H, Dugas C. Phys Occup Ther Pediatr. 2017 Feb;37(1):51-63. doi: 10.3109/01942638.2015.1129386.	**duplicate**
2	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon JY, Chang HJ, Yi SH, Lee JY, Shin HY, Kim YH. J Altern Complement Med. 2015 Jan;21(1):15-21. doi: 10.1089/acm.2014.0021	**duplicate**
3	Changes in Cardiorespiratory Responses and Kinematics With Hippotherapy in Youth With and Without Cerebral Palsy.	**duplicate**

	Rigby BR, Gloeckner AR, Sessums S, Lanning BA, Grandjean PW. Res Q Exerc Sport. 2017 Jan 11:1-10. doi: 10.1080/02701367.2016.1266458.	
4	Different horse's paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study. Antunes FN, Pinho AS, Kleiner AF, Salazar AP, Eltz GD, de Oliveira Junior AA, Cechetti F, Galli M, Pagnussat AS. Res Dev Disabil. 2016 Dec;59:65-72. doi: 10.1016/j.ridd.2016.07.015.	**duplicate**
5	Effects of hippotherapy on people with cerebral palsy from the users' perspective: a qualitative study. Debuse D, Gibb C, Chandler C. Physiother Theory Pract. 2009 Apr;25(3):174-92. doi: 10.1080/09593980902776662.	**Qualitative study.**
6	Effects of hippotherapy on postural stability in cerebral palsy: report of a case.. Fernández-Gutiérrez, C.; Apolo-Arenas, M. D.; Martínez-García, Y.; Caña-Pino, A	**spanish**
7	Effect of hippotherapy on perceived self-competence and participation in a child with cerebral palsy. Frank A, McCloskey S, Dole RL. Pediatr Phys Ther. 2011 Fall;23(3):301-8. doi: 10.1097/PEP.0b013e318227caac.	**Duplicate**
8	Long-term effects of hippotherapy on one child with cerebral palsy: A research case study (Article) Shurtleff, T. , Engsberg, J. British Journal of Occupational Therapy. Volume 75, Issue 8, August 2012, Pages 359-366	**duplicate**
9	Effects of hippotherapy on the sitting balance of children with cerebral palsy: a randomized control trial. Kang H, Jung J, Yu J Journal of Physical Therapy Science 2012 Oct;24(9):833-836	**duplicate**
10	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis. Zadnikar M, Kastrin A. Dev Med Child Neurol. 2011 Aug;53(8):684-91. doi: 10.1111/j.1469-8749.2011.03951.x. Review.	**Literature review.**
11	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). Benda W, McGibbon NH, Grant KL. J Altern Complement Med. 2003 Dec;9(6):817-25.	**duplicate**
12	Therapeutic effects of hippotherapy in cerebral palsy: A systematic review (Short Survey) [Efectos terapéuticos de la hipoterapia en la parálisis cerebral: una revisión sistemática] Herrero Gallego, P., García Antón, E. , Monserrat Cantera, M.E., Oliván Blázquez, B., Gómez Trullén, E.M., Trenado Molina, J.	**Article in Spanish.**
13	Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. Kwon JY, Chang HJ, Lee JY, Ha Y, Lee PK, Kim YH. Arch Phys Med Rehabil. 2011 May;92(5):774-9. doi: 10.1016/j.apmr.2010.11.031.	**duplicate**
14	Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial. Herrero P, Asensio A, García E, Marco A, Oliván B, Ibarz A, Gómez-Trullén EM, Casas R. BMC Musculoskelet Disord. 2010 Apr 16;11:71. doi: 10.1186/1471-2474-11-71.	**duplicate**
15	Electromyographic analysis during **hippotherapy** sessions in practitioners with**cerebral palsy**. 2012	**portuguese**
16	Changes in trunk and head stability in children with cerebral palsy after hippotherapy: a pilot study. Shurtleff TL, Engsberg JR. Phys Occup Ther Pediatr. 2010 May;30(2):150-63. doi: 10.3109/01942630903517223	**duplicate**
17	heart rate variability in hippotherapy riders with cerebral palsy. *Detail Only Available* Academic Journal (includes abstract) Negri AP; Cunha AB; Zamunér AR; Garbellini D; Moreno MA; Haddad CM; Revista Terapia Manual, 2010	**Other physical outcomes**
18	Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy. McGee MC, Reese NB. Pediatr Phys Ther. 2009 Summer;21(2):212-8. doi: 10.1097/PEP.0b013e3181a39532.	**duplicate**
19	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D. Arch Phys Med Rehabil. 2009 Jun;90(6):966-74. doi: 10.1016/j.apmr.2009.01.011.	**duplicate**

20	'The influence of the hippotherapy on the autonomic control of heart rate in children with cerebral palsy'. *Detail Only Available* Academic Journal (includes abstract) Negri AP; Cunha AB; Garbellini DG; Moreno MA; Revista Terapia Manual, 2009 Sep-Oct; 7(33): 376-381.6p. (Journal Article - research, tables/charts) ISSN: 1677-5937	**Other outcomes**
21	The effect of hippotherapy on postural control in sitting for children with cerebral palsy. Hamill D, Washington KA, White OR. Phys Occup Ther Pediatr. 2007;27(4):23-42.	**duplicate**
22	Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? Sterba JA. Dev Med Child Neurol. 2007 Jan;49(1):68-73.	**Literature review**
23	Examining the effectiveness of hippotherapy in children with cerebral palsy(part 2) *Detail Only Available* Academic Journal (includes abstract) Gehrts K; Zeitschrift fur Physiotherapeuten, 2006 Sep; 58(9): 952-962. 11p. (Journal Article - tables/charts) ISSN: 1614-0397	**german**
24	Examining its effectiveness of hippotherapy in children with cerebral palsy(part 1) *Detail Only Available* Academic Journal (includes abstract) Gehrts K; Zeitschrift fur Physiotherapeuten, 2006 Aug; 58(8): 822-833. 12p. (Journal Article - pictorial, tables/charts) ISSN: 1614-0397	**german**
25	Influence of recreational and sports activities in the conduct of hippotherapy in neurological patients -- randomized controlled trial. *Detail Only Available* Academic Journal Henrique de Sousa, Fernando; Tavella Navega, Marcelo; ConScientiae Saude, 2012; 11(4): 587-597. 11p. (Journal Article - research, tables/charts, randomized controlled trial) ISSN: 1677-1028	**portuguese**
26	The effect of hippotherapy on ten children with cerebral palsy. Casady RL, Nichols-Larsen DS. Pediatr Phys Ther. 2004 Fall;16(3):165-72.	**Duplicate**
27	Effectiveness of robot-assisted gait training in children with cerebral palsy: a bicenter, pragmatic, randomized, cross-over trial (PeLoGAIT). *Detail Only Available* Academic Journal (includes abstract) Ammann-Reiffer, C.; Bastiaenen, C. H. G.; Meyer-Heim, A. D.; van Hedel, H. J. A.; BMC Pediatrics,3/2/2017; 17 1-9. 9p. (journal article) ISSN: 1471-2431 PMID: 28253887	**Other therapies**
28	An exploration of German and British physiotherapists' views on the effects of hippotherapy and their measurement. Debuse D, Chandler C, Gibb C. Physiother Theory Pract. 2005 Oct-Dec;21(4):219-42.	**Qualitative**
29	Influence of hippotherapy on the kinematics and functional performance two children with cerebral palsy (Article) Haehl, V., Giuliani, C., Lewis, C. Pediatric Physical Therapy. Volume 11, Issue 2, 1999, Pages 89-101	**duplicate**
30	Changes in dynamic trunk/head stability and functional reach after hippotherapy. Shurtleff TL, Standeven JW, Engsberg JR. Arch Phys Med Rehabil. 2009 Jul;90(7):1185-95. doi: 10.1016/j.apmr.2009.01.026.	**duplicate**

31	An Olympic legacy for occupational therapists?...Shurtleff T, Engsberg J (2012) Long-term effects of hippotherapy on one child with cerebral palsy: a research case study. British Journal of Occupational Therapy, 75(8), 359-66. *Detail Only Available* Academic Journal Martin, Marion; British Journal of Occupational Therapy, 10/15/2012; 75(10): 481-481. 1p. (Journal Article - commentary, letter) ISSN: 0308-0226	**comment**
32	Exercise interventions improve postural control in children with cerebral palsy: a systematic review. *Detail Only Available* Academic Journal (includes abstract) Dewar, Rosalee; Love, Sarah; Johnston, Leanne Marie; Developmental Medicine & Child Neurology,Jun2015; 57(6): 504-520. 17p. (Journal Article - research, systematic review) ISSN: 0012-1622 PMID: 25523410	**review**
33	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial. Herrero P, Gómez-Trullén EM, Asensio A, García E, Casas R, Monserrat E, Pandyan A. Clin Rehabil. 2012 Dec;26(12):1105-13. doi: 10.1177/0269215512444633.	**duplicate**
34	Hippotherapy: an effective approach to occupational therapy intervention. *Detail Only Available* Periodical (includes abstract) Latella D; Langford S; OT Practice, 2008 Feb 4; 13(2): 16-20. 5p. (Journal Article - case study, pictorial, tables/charts) ISSN: 1084-4902	**Not the condition**
35	Therapeutic Effects of Horseback Riding Therapy on Gross Motor Function in Children with Cerebral Palsy: A Systematic Review. *Detail Only Available* Academic Journal (includes abstract) Whalen, Cara N.; Case-Smith, Jane; Physical & Occupational Therapy in Pediatrics, Aug2012; 32(3):229-242. 14p. (Journal Article - research, systematic review, tables/charts) ISSN: 0194-2638 PMID: 22122355	**review**
36	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. *Detail Only Available* Academic Journal (includes abstract) Tseng, Sung-Hui; Chen, Hung-Chou; Tam, Ka-Wai; Disability & Rehabilitation, Jan2013; 35(2): 89-99.11p. (Journal Article - meta analysis, research, systematic review, tables/charts) ISSN: 0963-8288 PMID: 22630812	**review**
37	Incidence and risk factors of hip joint pain in children with severe cerebral palsy. *Detail Only Available* Academic Journal (includes abstract) Jóóźźwiak, Marek; Harasymczuk, Piotr; Koch, Aleksander; Kotwicki, Tomasz; Disability & Rehabilitation,Aug2011; 33(15/16): 1367-1372. 6p. (Journal Article - diagnostic images, pictorial, research, tables/charts) ISSN: 0963-8288PMID: 21091045	**Not hpot**

38	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness? *Detail Only Available* Academic Journal (includes abstract) Snider L; Korner-Bitensky N; Kammann C; Warner S; Saleh M; Physical & Occupational Therapy in Pediatrics, 2007; 27(2): 5-23. 19p. (Journal Article - research, systematic review, tables/charts) ISSN: 0194-2638 PMID: 17442652	**Not hpot**
39	Complementary and alternative methods in cerebral palsy. *Detail Only Available* Academic Journal (includes abstract) Oppenheim WL; Developmental Medicine & Child Neurology, Oct2009 Supplement 4; 51 122-129. 8p.(Journal Article) ISSN: 0012-1622 PMID: 19740219	**Not hpot**
	Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: a pilot study. McGibbon NH, Andrade CK, Widener G, Cintas HL. Dev Med Child Neurol. 1998 Nov;40(11):754-62.	**Intervention**
	Accelerometer position vs. VO2000: a measure of energy expenditure duringhippotherapy therapeutic exercise. *Detail Only Available* Academic Journal Millard, TL; Hayes, DM; Fitzgerald, K; Perry, M; Thomas, C; Vinson, B; Pediatric Physical Therapy, 2012 Winter; 24(4): 379-379. 1p. (Journal Article - abstract, research) ISSN: 0898-5669	**Not physical outcome**
	nterview with a practitioner. Hippotherapy: Cathy Delinger, P.T. and Terri Cummins, Horse Expert. *Detail Only Available* Academic Journal Alternative Health Practitioner, 1997 Fall-Winter; 3(3): 161-165. 5p. (Journal Article - interview) ISSN: 1076-1675 **Subjects:** Pet Therapy; Horses; Pediatric Physical Therapy; Child: 6-12 years	**interview**
	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review. *Detail Only Available* Academic Journal (includes abstract) Anttila H; Suoranta J; Malmivaara A; Mäkelä M; Autti-Rämö I; American Journal of Physical Medicine & Rehabilitation, Jun2008; 87(6): 478-501. 24p. (Journal Article - research, systematic review, tables/charts) ISSN: 0894-9115PMID: 18496250	**review**
	WHAT FACTORS INFLUENCE THE CHOICE OF COMPLEMENTARY AND ALTERNATIVE THERAPY AMONG CEREBRAL PALSY ADULTS. *Detail Only Available* Academic Journal (includes abstract) Berbrayer, David; American Journal of Physical Medicine & Rehabilitation, Mar2014 Supplement; a78-a78. 1p. (Journal Article - research) ISSN: 0894-9115	**Not hpot**
	Hippotherapy. Meregillano G. Phys Med Rehabil Clin N Am. 2004 Nov;15(4):843-54, vii.	**Literature review.**
	Therapeutic interventions in cerebral palsy. *Detail Only Available*	**review**

	Academic Journal (includes abstract) Feferman, Helayne; Harro, Janell; Patel, Dilip R.; Merrick, Joav; International Journal of Child & Adolescent Health, 2011; 4(4): 333-339. 7p. (Journal Article - review) ISSN: 1939-5930	
	Hippotherapy practice in sensory integration therapy...XIIth Development of Physiotherapy Symposium, Eskisehir Osmangazi Universitesi Kongre Merkezi Eskisehir, November 2008 *Detail Only Available* Academic Journal Gezgin C; Kayihan H; Turkish Journal of Physiotherapy Rehabilitation, 2008 Dec; 19(3): 154-154. 1p. (Journal Article - abstract, research) ISSN: 1300-8757	**Conference abstract**
	Hippotherapy. *Detail Only Available* Periodical Andersen HE; Journal of Cognitive Rehabilitation, 2010 Spring; 28(1): 2p-2p. 1p. (Journal Article) ISSN: 1062-2969 **Subjects:** Horseback Riding; Pet Therapy	**book**

List: Second Examiner – April, 2017.

Included

Hippotherapy AND cerebral palsy (Pubmed n = 62)	
1	Influence of Hippotherapy on Body Balance in the Sitting Position Among Children with Cerebral Palsy. Matusiak-Wieczorek E, Małachowska-Sobieska M, Synder M. Ortop Traumatol Rehabil. 2016 Mar 23;18(2):165-175. doi: 10.5604/15093492.1205024.
2	Changes in Cardiorespiratory Responses and Kinematics With Hippotherapy in Youth With and Without Cerebral Palsy. Rigby BR, Gloeckner AR, Sessums S, Lanning BA, Grandjean PW. Res Q Exerc Sport. 2017 Jan 11:1-10. doi: 10.1080/02701367.2016.1266458.
3	Application of a tri-axial accelerometry-based portable motion recorder for the quantitative assessment of hippotherapy in children and adolescents with cerebral palsy. Mutoh T, Mutoh T, Takada M, Doumura M, Ihara M, Taki Y, Tsubone H, Ihara M. J Phys Ther Sci. 2016 Oct;28(10):2970-2974.
4	Experience of using hippotherapy in complex effects on muscle spirals in children with spastic forms of cerebral palsy. Strashko EY, Kapustianska AA, Bobyreva LE. Wiad Lek. 2016;69(3 pt 2):527-529. Missing paper

5	The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy. Moraes AG, Copetti F, Angelo VR, Chiavoloni LL, David AC. J Phys Ther Sci. 2016 Aug;28(8):2220-6. doi: 10.1589/jpts.28.2220.
6	Different horse's paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study. Antunes FN, Pinho AS, Kleiner AF, Salazar AP, Eltz GD, de Oliveira Junior AA, Cechetti F, Galli M, Pagnussat AS. Res Dev Disabil. 2016 Dec;59:65-72. doi: 10.1016/j.ridd.2016.07.015.
7	Effects of hippotherapy on body functions, activities and participation in children with cerebral palsy based on ICF-CY assessments. Hsieh YL, Yang CC, Sun SH, Chan SY, Wang TH, Luo HJ. Disabil Rehabil. 2016 Jul 20:1-11.
8	Effect of Hippotherapy on Motor Proficiency and Function in Children with Cerebral Palsy Who Walk. Champagne D, Corriveau H, Dugas C. Phys Occup Ther Pediatr. 2017 Feb;37(1):51-63. doi: 10.3109/01942638.2015.1129386.
9	Influence of neurophysiological hippotherapy on the transference of the centre of gravity among children with cerebral palsy. Maćków A, Małachowska-Sobieska M, Demczuk-Włodarczyk E, Sidorowska M, Szklarska A, Lipowicz A. Ortop Traumatol Rehabil. 2014 Nov-Dec;16(6):581-93. doi: 10.5604/15093492.1135048.
10	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon JY, Chang HJ, Yi SH, Lee JY, Shin HY, Kim YH. J Altern Complement Med. 2015 Jan;21(1):15-21. doi: 10.1089/acm.2014.0021.
11	Effects of hippotherapy on gross motor function and functional performance of children with cerebral palsy. Park ES, Rha DW, Shin JS, Kim S, Jung S. Yonsei Med J. 2014 Nov;55(6):1736-42. doi: 10.3349/ymj.2014.55.6.1736. missing paper
12	The effects of hippotherapy and a horse riding simulator on the balance of children with cerebral palsy. Lee CW, Kim SG, Na SS. J Phys Ther Sci. 2014 Mar;26(3):423-5. doi: 10.1589/jpts.26.423.

13	The effect of a hippotherapy session on spatiotemporal parameters of gait in children with cerebral palsy - pilot study. Manikowska F, Jóźwiak M, Idzior M, Chen PJ, Tarnowski D. Ortop Traumatol Rehabil. 2013 Jun 28;15(3):253-7. doi: 10.5604/15093492.1058420.
14	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial. Herrero P, Gómez-Trullén EM, Asensio A, García E, Casas R, Monserrat E, Pandyan A. Clin Rehabil. 2012 Dec;26(12):1105-13. doi: 10.1177/0269215512444633.
15	Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. Kwon JY, Chang HJ, Lee JY, Ha Y, Lee PK, Kim YH. Arch Phys Med Rehabil. 2011 May;92(5):774-9. doi: 10.1016/j.apmr.2010.11.031.
16	Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial. Herrero P, Asensio A, García E, Marco A, Oliván B, Ibarz A, Gómez-Trullén EM, Casas R. BMC Musculoskelet Disord. 2010 Apr 16;11:71. doi: 10.1186/1471-2474-11-71.
17	Changes in trunk and head stability in children with cerebral palsy after hippotherapy: a pilot study. Shurtleff TL, Engsberg JR. Phys Occup Ther Pediatr. 2010 May;30(2):150-63. doi: 10.3109/01942630903517223.
18	Changes in dynamic trunk/head stability and functional reach after hippotherapy. Shurtleff TL, Standeven JW, Engsberg JR. Arch Phys Med Rehabil. 2009 Jul;90(7):1185-95. doi: 10.1016/j.apmr.2009.01.026.
19	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D. Arch Phys Med Rehabil. 2009 Jun;90(6):966-74. doi: 10.1016/j.apmr.2009.01.011.
20	Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy. McGee MC, Reese NB. Pediatr Phys Ther. 2009 Summer;21(2):212-8. doi: 10.1097/PEP.0b013e3181a39532.
21	The effect of hippotherapy on ten children with cerebral palsy. Casady RL, Nichols-Larsen DS. Pediatr Phys Ther. 2004 Fall;16(3):165-72.
22	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy).

	Benda W, McGibbon NH, Grant KL. J Altern Complement Med. 2003 Dec;9(6):817-25.
23	The effect of hippotherapy on postural control in sitting for children with cerebral palsy. Hamill D, Washington KA, White OR. Phys Occup Ther Pediatr. 2007;27(4):23-42.
Hippotherapy AND multiple sclerosis (PubMed n = 11)	
1	Does hippotherapy effect use of sensory information for balance in people with multiple sclerosis? Lindroth JL, Sullivan JL, Silkwood-Sherer D. Physiother Theory Pract. 2015;31(8):575-81. doi: 10.3109/09593985.2015.1067266.
2	Internet-based home training is capable to improve balance in multiple sclerosis: a randomized controlled trial. Frevel D, Mäurer M. Eur J Phys Rehabil Med. 2015 Feb;51(1):23-30.missing paper
3	Effects of hippotherapy on postural stability, in persons with multiple sclerosis: a pilot study. Silkwood-Sherer D, Warmbier H. J Neurol Phys Ther. 2007 Jun;31(2):77-84.
4	Evaluation of therapeutic riding (Sweden)/hippotherapy (United States). A single-subject experimental design study replicated in eleven patients with multiple sclerosis. Hammer A, Nilsagård Y, Forsberg A, Pepa H, Skargren E, Oberg B. Physiother Theory Pract. 2005 Jan-Mar;21(1):51-77.
Hippotherapy AND stroke (PubMed n = 11)	
1	Effects of hippotherapy on recovery of gait and balance ability in patients with stroke. Lee CW, Kim SG, Yong MS. J Phys Ther Sci. 2014 Feb;26(2):309-11. doi: 10.1589/jpts.26.309.
2	A hippotherapy simulator is effective to shift weight bearing toward the affected side during gait in patients with stroke. Sung YH, Kim CJ, Yu BK, Kim KM. NeuroRehabilitation. 2013;33(3):407-12. doi: 10.3233/NRE-130971.
3	Use of hippotherapy in gait training for hemiparetic post-stroke. Beinotti F, Correia N, Christofoletti G, Borges G. Arq Neuropsiquiatr. 2010 Dec;68(6):908-13.
Hippotherapy AND spinal cord injury (PubMed n = 5)	
1	The effect of hippotherapy on spasticity and on mental well-being of persons with spinal cord injury. Lechner HE, Kakebeeke TH, Hegemann D, Baumberger M. Arch Phys Med Rehabil. 2007 Oct;88(10):1241-8.
2	The short-term effect of hippotherapy on spasticity in patients with spinal cord injury.

	Lechner HE, Feldhaus S, Gudmundsen L, Hegemann D, Michel D, Zäch GA, Knecht H. Spinal Cord. 2003 Sep;41(9):502-5.
Hippotherapy AND cerebral palsy (PEDro n = 13)	
1	Effects of hippotherapy on the sitting balance of children with cerebral palsy: a randomized control trial. Kang H, Jung J, Yu J Journal of Physical Therapy Science 2012 Oct;24(9):833-836
2	Modulation of back geometry in children with spastic diplegic cerebral palsy via hippotherapy training el-Meniawy GH, Thabet NS. Egyptian Journal of Medical Human Genetics 2012 Feb;13(1):63-71
Hippotherapy AND cerebral palsy (Scopus n = 109)	
1	The effect of hippotherapy on gait in patients with spastic cerebral palsy. Fízková, V., Krejčí, E., Svoboda, Z. , Elfmark, M., Janura, M. Acta Universitatis Palackianae Olomucensis, Gymnica Volume 43, Issue 4, 2013, Pages 17-23
2	The effects of hippotherapy on the motor function of children with spastic bilateral cerebral palsy . Chang, H.J., Kwon, J.-Y., Lee, J.-Y., Kim, Y.-H. Journal of Physical Therapy Science Volume 24, Issue 12, 2 December 2012, Pages 1277-1280. DOI: 10.1589/jpts.24.1277
3	Long-term effects of hippotherapy on one child with cerebral palsy: A research case study (Article) Shurtleff, T. , Engsberg, J. British Journal of Occupational Therapy. Volume 75, Issue 8, August 2012, Pages 359-366
4	Influence of artificial saddle riding on postural stability in children with cerebral palsy (Article) Kuczyński, M., Slonka, K.
5	Influence of hippotherapy on the kinematics and functional performance two children with cerebral palsy (Article) Haehl, V., Giuliani, C., Lewis, C. Pediatric Physical Therapy. Volume 11, Issue 2, 1999, Pages 89-101

Excluded

	Article reference	Reasons for exclusion

Hippotherapy AND cerebral palsy (Pubmed n = 62)		
1	What is hippotherapy? The indications and effectiveness of hippotherapy.	Not an intervention. Descriptive paper.
2	Effects of Hippotherapy on Psychosocial Aspects in Children With Cerebral Palsy and Their Caregivers: A Pilot Study. Jang CH, Joo MC, Noh SE, Lee SY, Lee DB, Lee SH, Kim HK, Park HI. Ann Rehabil Med. 2016 Apr;40(2):230-6. doi: 10.5535/arm.2016.40.2.230.	Non physical outcomes
3	Intervention for an Adolescent With Cerebral Palsy During Period of Accelerated Growth. Reubens R, Silkwood-Sherer DJ. Pediatr Phys Ther. 2016 Spring;28(1):117-25. doi: 10.1097/PEP.0000000000000223.	Non physical outcomes
4	Hippotherapy in adult patients with chronic brain disorders: a pilot study. Sunwoo H, Chang WH, Kwon JY, Kim TW, Lee JY, Kim YH. Ann Rehabil Med. 2012 Dec;36(6):756-61. doi: 10.5535/arm.2012.36.6.756.	Health condition
5	Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: a pilot study. McGibbon NH, Andrade CK, Widener G, Cintas HL. Dev Med Child Neurol. 1998 Nov;40(11):754-62.	Intervention
6	Therapist-Designed Adaptive Riding in Children With Cerebral Palsy: Results of a Feasibility Study. Angsupaisal M, Visser B, Alkema A, Meinsma-van der Tuin M, Maathuis CG, Reinders-Messelink H, Hadders-Algra M. Phys Ther. 2015 Aug;95(8):1151-62. doi: 10.2522/ptj.20140146.	Intervention
7	The effect of therapeutic horseback riding on balance in community-dwelling older adults: a pilot study. Homnick TD, Henning KM, Swain CV, Homnick DN. J Appl Gerontol. 2015 Feb;34(1):118-26. doi: 10.1177/0733464812467398.	Intervention
8	Effectiveness of equine therapy in children with psychomotor impairment. Del Rosario-Montejo O, Molina-Rueda F, Muñoz-Lasa S, Alguacil-Diego IM. Neurologia. 2015 Sep;30(7):425-32. doi: 10.1016/j.nrl.2013.12.023.	Intervention
9	Therapeutic effects of a horse riding simulator in children with cerebral palsy.	Intervention

	Silva e Borges MB, Werneck MJ, da Silva Mde L, Gandolfi L, Pratesi R. Arq Neuropsiquiatr. 2011 Oct;69(5):799-804.	
10	Effect of hippotherapy on perceived self-competence and participation in a child with cerebral palsy. Frank A, McCloskey S, Dole RL. Pediatr Phys Ther. 2011 Fall;23(3):301-8. doi: 10.1097/PEP.0b013e318227caac.	Outcomes
11	The Efficacy of Equine-Assisted Activities and Therapies on Improving Physical Function. Rigby BR, Grandjean PW. J Altern Complement Med. 2016 Jan;22(1):9-24. doi: 10.1089/acm.2015.0171. Review.	Literature review.
12	Exercise interventions improve postural control in children with cerebral palsy: a systematic review. Dewar R, Love S, Johnston LM. Dev Med Child Neurol. 2015 Jun;57(6):504-20. doi: 10.1111/dmcn.12660. Review.	Literature review.
13	Commentary on "Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study". Bjornson K, Coyner P. Pediatr Phys Ther. 2012 Fall;24(3):258. doi: 10.1097/PEP.0b013e31825cc9ee. No abstract available.	Commentary.
14	Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study. Bongers BC, Takken T. Pediatr Phys Ther. 2012 Fall;24(3):252-7. doi: 10.1097/PEP.0b013e31825c1a7d.	Therapeutic horseback riding + not appropriate outcome measures + unsure about the health condition.
15	Evidence to practice commentary: the evidence alert traffic light grading system. Novak I. Phys Occup Ther Pediatr. 2012 Aug;32(3):256-9. doi: 10.3109/01942638.2012.698148. No abstract available.	Commentary.
16	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. Tseng SH, Chen HC, Tam KW. Disabil Rehabil. 2013 Jan;35(2):89-99. doi: 10.3109/09638288.2012.687033. Review.	Literature review.

17	Effect of therapeutic riding on functional scoliosis as observed by roentgenography. Ihara M, Ihara M, Doumura M. Pediatr Int. 2012 Feb;54(1):160-2. doi: 10.1111/j.1442-200X.2011.03456.x. No abstract available.	Therapeutic riding.
18	Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review. Whalen CN, Case-Smith J. Phys Occup Ther Pediatr. 2012 Aug;32(3):229-42. doi: 10.3109/01942638.2011.619251. Review.	Literature review.
19	The effect of robo-horseback riding therapy on spinal alignment and associated muscle size in MRI for a child with neuromuscular scoliosis: an experimenter-blind study. Lee DR, Lee NG, Cha HJ, Yun Sung O, You SJ, Oh JH, Bang HS. NeuroRehabilitation. 2011;29(1):23-7. doi: 10.3233/NRE-2011-0673.	Intervention = horseback riding Health condition = neuromuscular scoliosis
20	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis. Zadnikar M, Kastrin A. Dev Med Child Neurol. 2011 Aug;53(8):684-91. doi: 10.1111/j.1469-8749.2011.03951.x. Review.	Literature review.
21	Center-of-pressure movements during equine-assisted activities. Clayton HM, Kaiser LJ, de Pue B, Kaiser L. Am J Occup Ther. 2011 Mar-Apr;65(2):211-6.	Intervention = horse riding
22	Incidence and risk factors of hip joint pain in children with severe cerebral palsy. Jóźwiak M, Harasymczuk P, Koch A, Kotwicki T. Disabil Rehabil. 2011;33(15-16):1367-72. doi: 10.3109/09638288.2010.532281.	No HPOT intervention
23	The effects of a 5-week therapeutic horseback riding program on gross motor function in a child with cerebral palsy: a case study. Drnach M, O'Brien PA, Kreger A. J Altern Complement Med. 2010 Sep;16(9):1003-6. doi: 10.1089/acm.2010.0043.	Intervention = therapeutic horseback riding
24	Complementary and alternative methods in cerebral palsy. Oppenheim WL. Dev Med Child Neurol. 2009 Oct;51 Suppl 4:122-9. doi: 10.1111/j.1469-8749.2009.03424.x. Review.	Literature review. Descriptive paper.
25	Effects of hippotherapy on people with cerebral palsy from the users' perspective: a qualitative study. Debuse D, Gibb C, Chandler C.	Qualitative study.

	Physiother Theory Pract. 2009 Apr;25(3):174-92. doi: 10.1080/09593980902776662.	
26	Influence of mechanical hippotherapy on skin temperature responses in lower limbs in children with cerebral palsy. Zurek G, Dudek K, Pirogowicz I, Dziuba A, Pokorski M. J Physiol Pharmacol. 2008 Dec;59 Suppl 6:819-24.	Intervention = therapeutic horse riding Outcomes = skin temperature responses in lower limbs
27	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review. Anttila H, Suoranta J, Malmivaara A, Mäkelä M, Autti-Rämö I. Am J Phys Med Rehabil. 2008 Jun;87(6):478-501. doi: 10.1097/PHM.0b013e318174ebed. Review.	Literature review.
28	The utilization of hippotherapy as auxiliary treatment in the rehabilitation of children with cerebral palsy. Lisiński P, Stryła W. Ortop Traumatol Rehabil. 2001;3(4):538-40.	Descriptive paper.
29	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness? Snider L, Korner-Bitensky N, Kammann C, Warner S, Saleh M. Phys Occup Ther Pediatr. 2007;27(2):5-23	Literature review
30	Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? Sterba JA. Dev Med Child Neurol. 2007 Jan;49(1):68-73.	Literature review
31	An exploration of German and British physiotherapists' views on the effects of hippotherapy and their measurement. Debuse D, Chandler C, Gibb C. Physiother Theory Pract. 2005 Oct-Dec;21(4):219-42.	Qualitative
32	Complementary and alternative therapies for cerebral palsy. Liptak GS. Ment Retard Dev Disabil Res Rev. 2005;11(2):156-63.	Literature review.
33	Hippotherapy. Meregillano G. Phys Med Rehabil Clin N Am. 2004 Nov;15(4):843-54, vii.	Literature review.
34	[Hippotherapy as a method for complex rehabilitation of patients with late residual stage of infantile cerebral palsy]. Sokolov PL, Dremova GV, Samsonova SV. Zh Nevrol Psikhiatr Im S S Korsakova. 2002;102(10):42-5.	Article in Russian.
35	[Etiologies of cerebral palsy and classical treatment possibilities].	Article in German.

	Maurer U. Wien Med Wochenschr. 2002;152(1-2):14-8.	
36	[Hippotherapy--a supplementary treatment for motion disturbance caused by cerebral palsy (author's transl)]. Tauffkirchen E. Padiatr Padol. 1978;13(4):405-11.	Article in German.
37	[Hippotherapy and therapeutic horseback riding in the treatment of children and adolescents with cerebral pareses and dysmelias]. Horster R, Lippold-von Hörde H, Rieger C. ZFA (Stuttgart). 1976 Jan 10;52(1):15-21.	Article in German.
38	Hippotherapy--an intervention to habilitate balance deficits in children with movement disorders: a clinical trial. Silkwood-Sherer DJ, Killian CB, Long TM, Martin KS. Phys Ther. 2012 May;92(5):707-17. doi: 10.2522/ptj.20110081.	Health condition = movement disorders
39	[Therapy with the help of a horse - attempt at a situational analysis (author's transl)]. Riesser H. Rehabilitation (Stuttg). 1975 Aug;14(3):145-9	Article in German.
	Hippotherapy AND multiple sclerosis (PubMed n = 11)	
1	What is hippotherapy? The indications and effectiveness of hippotherapy. Koca TT, Ataseven H. North Clin Istanb. 2016 Jan 15;2(3):247-252. doi: 10.14744/nci.2016.71601. Review.	Literature review
2	Effect of therapeutic horseback riding on balance and gait of people with multiple sclerosis. Muñoz-Lasa S, Ferriero G, Valero R, Gomez-Muñiz F, Rabini A, Varela E. G Ital Med Lav Ergon. 2011 Oct-Dec;33(4):462-7.	Intervention = therapeutic horseback riding
3	Autoimmune diseases and rehabilitation. Flachenecker P. Autoimmun Rev. 2012 Jan;11(3):219-25. doi: 10.1016/j.autrev.2011.05.016.	Literature review.
4	Does hippotherapy improve balance in persons with multiple sclerosis: a systematic review. Bronson C, Brewerton K, Ong J, Palanca C, Sullivan SJ. Eur J Phys Rehabil Med. 2010 Sep;46(3):347-53.	Literature review.
5	[The horse as an aid in therapy]. Barolin GS, Samborski R. Wien Med Wochenschr. 1991;141(20):476-81	Article in German
6	[Hippotherapy]. Huber EG. Fortschr Med. 1979 Aug 2;97(29):1253-5.	Article in German

7	[Hippotherapy in multiple sclerosis (author's transl)]. Wuethrich R, Kuenzle U. J Belge Med Phys Rehabil. 1978;1(3):265-8	Article in French
	Hippotherapy AND stroke (PubMed n = 11)	
1	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon JY, Chang HJ, Yi SH, Lee JY, Shin HY, Kim YH. J Altern Complement Med. 2015 Jan;21(1):15-21. doi: 10.1089/acm.2014.0021.	Health condition
2	Hippotherapy in adult patients with chronic brain disorders: a pilot study. Sunwoo H, Chang WH, Kwon JY, Kim TW, Lee JY, Kim YH. Ann Rehabil Med. 2012 Dec;36(6):756-61. doi: 10.5535/arm.2012.36.6.756.	Health condition
3	What is hippotherapy? The indications and effectiveness of hippotherapy. Koca TT, Ataseven H. North Clin Istanb. 2016 Jan 15;2(3):247-252. doi: 10.14744/nci.2016.71601.	Literature review
4	Cardio-metabolic responses during horse riding at three different speeds. Sainas G, Melis S, Corona F, Loi A, Ghiani G, Milia R, Tocco F, Marongiu E, Crisafulli A. Eur J Appl Physiol. 2016 Oct;116(10):1985-92. doi: 10.1007/s00421-016-3450-7.	Intervention = horse riding Outcomes = Oxygen uptake (VO2), carbon dioxide production (VCO2), and heart rate (HR)
5	Effects of horseback riding therapy on quality of life in patients post stroke. Beinotti F, Christofoletti G, Correia N, Borges G. Top Stroke Rehabil. 2013 May-Jun;20(3):226-32. doi: 10.1310/tsr2003-226.	Intervention = horseback riding
6	Therapeutic effects of mechanical horseback riding on gait and balance ability in stroke patients. Han JY, Kim JM, Kim SK, Chung JS, Lee HC, Lim JK, Lee J, Park KY. Ann Rehabil Med. 2012 Dec;36(6):762-9. doi: 10.5535/arm.2012.36.6.762.	Intervention = horseback riding

7	The effects of a rhythm and music-based therapy program and therapeutic riding in late recovery phase following stroke: a study protocol for a three-armed randomized controlled trial. Bunketorp Käll L, Lundgren-Nilsson Å, Blomstrand C, Pekna M, Pekny M, Nilsson M. BMC Neurol. 2012 Nov 21;12:141. doi: 10.1186/1471-2377-12-141.	Intervention = rhythm and music-based therapy program or therapeutic riding
8	[The horse as an aid in therapy]. Barolin GS, Samborski R. Wien Med Wochenschr. 1991;141(20):476-81.	Article in German.
Hippotherapy AND spinal cord injury (PubMed n = 5)		
1	What is hippotherapy? The indications and effectiveness of hippotherapy. Koca TT, Ataseven H. North Clin Istanb. 2016 Jan 15;2(3):247-252. doi: 10.14744/nci.2016.71601.	Literature review.
2	Therapeutic horse back riding of a spinal cord injured veteran: a case study. Asselin G, Penning JH, Ramanujam S, Neri R, Ward C. Rehabil Nurs. 2012 Nov-Dec;37(6):270-6. doi: 10.1002/rnj.027.	Intervention = therapeutic horseback riding
3	[Scuba diving -- a therapeutic option for patients with paraplegia]. Haydn T, Brenneis C, Schmutzhard J, Gerstenbrand F, Saltuan L, Schmutzhard E. Neuropsychiatr. 2007;21(3):226-9.	Article in German.
Hippotherapy AND cerebral palsy (PEDro n = 13)		
1	Exercise interventions improve postural control in children with cerebral palsy: a systematic review [with consumer summary]	Literature review
2	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy [with consumer summary]	Literature review
3	Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review	Literature review
4	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis	Literature review
5	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review	Literature review

6	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness?	Literature review
7	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial [with consumer summary] Herrero P, Gomez-Trullen EM, Asensio A, Garcia E, Casas R, Monserrat E, Pandyan A Clinical Rehabilitation 2012 Dec;26(12):1105-1113	Duplicate
8	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon J-Y, Chang HJ, Yi S-H, Lee JY, Shin H-Y, Kim Y-H Journal of Alternative & Complementary Medicine 2015 Jan;21(1):15-21	Duplicate
9	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D Archives of Physical Medicine and Rehabilitation 2009 Jun;90(6):966-974	Duplicate
10	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). Benda W, McGibbon NH, Grant KL Journal of Alternative & Complementary Medicine 2003 Dec;9(6):817-825	Duplicate
11	The effects of hippotherapy and a horse riding simulator on the balance of children with cerebral palsy. Lee C-W, Kim SG, Na SS. Journal of Physical Therapy Science 2014 Mar;26(3):423-425	Duplicate
Hippotherapy AND multiple sclerosis (PEDro n = 2)		
1	Internet-based home training is capable to improve balance in multiple sclerosis: a randomized controlled trial. Frevel D, Maurer M European Journal of Physical and Rehabilitation Medicine 2015 Feb;51(1):23-30	Duplicate
2	Hippotherapie bei multipler sklerose: ergebnisse einer prospektiven, randomisierten, einfach-blinden studie und ubersicht uber die literatur (Hippotherapy in multiple sclerosis -- results of a prospective, controlled, randomised single-blind trial and review of the literature) [German] Schatz L, Boswell S, Eitel A, Gusowski K, Flachenecker P Neurologie und Rehabilitation 2014;20(5):246-252	Article in German.
Hippotherapy AND stroke (PEDro n =1)		

1	Effects of hippotherapy on recovery of gait and balance ability in patients with stroke Lee C-W, Kim SG, Yong MS. Journal of Physical Therapy Science 2014 Feb;26(2):309-311	Duplicate
Hippotherapy AND spinal cord injury (PEDro n = 1)		
1	The effect of hippotherapy on spasticity and on mental well-being of persons with spinal cord injury Lechner HE, Kakebeeke TH, Hegemann D, Baumberger M Archives of Physical Medicine and Rehabilitation 2007 Oct;88(10):1241-1248	Duplicate
Hippotherapy AND cerebral palsy (Scopus n = 109)		
1	Changes in Cardiorespiratory Responses and Kinematics With Hippotherapy in Youth With and Without Cerebral Palsy. Rigby BR, Gloeckner AR, Sessums S, Lanning BA, Grandjean PW. Res Q Exerc Sport. 2017 Jan 11:1-10. doi: 10.1080/02701367.2016.1266458.	Duplicate
2	Different horse's paces during hippotherapy on spatio-temporal parameters of gait in children with bilateral spastic cerebral palsy: A feasibility study. Antunes FN, Pinho AS, Kleiner AF, Salazar AP, Eltz GD, de Oliveira Junior AA, Cechetti F, Galli M, Pagnussat AS. Res Dev Disabil. 2016 Dec;59:65-72. doi: 10.1016/j.ridd.2016.07.015.	Duplicate
3	Application of a tri-axial accelerometry-based portable motion recorder for the quantitative assessment of hippotherapy in children and adolescents with cerebral palsy. Mutoh T, Mutoh T, Takada M, Doumura M, Ihara M, Taki Y, Tsubone H, Ihara M. J Phys Ther Sci. 2016 Oct;28(10):2970-2974.	Duplicate
4	The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy. Moraes AG, Copetti F, Angelo VR, Chiavoloni LL, David AC. J Phys Ther Sci. 2016 Aug;28(8):2220-6. doi: 10.1589/jpts.28.2220.	Duplicate
5	Effects of hippotherapy on body functions, activities and participation in children with cerebral palsy based on ICF-CY assessments. Hsieh YL, Yang CC, Sun SH, Chan SY, Wang TH, Luo HJ. Disabil Rehabil. 2016 Jul 20:1-11.	Duplicate
6	Improved postural control and balance in cerebral palsy: A systematic review | [Mejora del control postural y equilibrio en la parálisis cerebral infantil: Revisión sistemática]	Article in Spanish

7	Hippotherapy acute impact on heart rate variability non-linear dynamics in neurological disorders Cabiddu, R. , Borghi-Silva, A., Trimer, R., Trimer, V., Ricci, P.A., Italiano Monteiro, C., Camargo Magalhães Maniglia, M., Silva Pereira, A.M., Rodrigues das Chagas, G., Carvalho, E.M.	Outcomes; health condition
8	Possibilities of hippotherapy for child patients with cerebral palsy (Article) [Možnosti hipoterapie u dětských pacientůs dětskou mozkovou obrnou] Čapková, K.a, Pavlů, D.	Article in Czech m
9	Influence of Hippotherapy on Body Balance in the Sitting Position Among Children with Cerebral Palsy. Matusiak-Wieczorek E, Małachowska-Sobieska M, Synder M. Ortop Traumatol Rehabil. 2016 Mar 23;18(2):165-175. doi: 10.5604/15093492.1205024.	Duplicate
10	Effects of Hippotherapy on Psychosocial Aspects in Children With Cerebral Palsy and Their Caregivers: A Pilot Study. Jang CH, Joo MC, Noh SE, Lee SY, Lee DB, Lee SH, Kim HK, Park HI. Ann Rehabil Med. 2016 Apr;40(2):230-6. doi: 10.5535/arm.2016.40.2.230.	Non physical outcomes
11	Using accelerometers to assess the effects of hippotherapy on movement execution in children with spastic cerebral palsy - A pilot study. Bednarikova, H. , Janura, M., Bizovská, L.	Article in Czech
12	Intervention for an Adolescent With Cerebral Palsy During Period of Accelerated Growth. Reubens R, Silkwood-Sherer DJ. Pediatr Phys Ther. 2016 Spring;28(1):117-25. doi: 10.1097/PEP.0000000000000223.	Non physical outcomes
13	The effects of hippotherapy on attention and memory skills of children with CP, from a long-term perspective. Krejčí, E.	Article in Slovak
14	The Efficacy of Equine-Assisted Activities and Therapies on Improving Physical Function. Rigby BR, Grandjean PW. J Altern Complement Med. 2016 Jan;22(1):9-24. doi: 10.1089/acm.2015.0171. Review.	Literature review.
15	Effectiveness of equine therapy in children with psychomotor impairment. Del Rosario-Montejo O, Molina-Rueda F, Muñoz-Lasa S, Alguacil-Diego IM. Neurologia. 2015 Sep;30(7):425-32. doi: 10.1016/j.nrl.2013.12.023.	Intervention

16	The impact of hippotherapy on the quality of trunk stabilisation, evaluated by EMG biofeedback, in children with infantile cerebral palsy. Lakomy-Gawryszewska, A.A. , Józefowicz, K., Raniszewska, A., Langer, D., Hansdorfer-Korzon, R., Bieszczad, D., Górska, K., Cichoń-Kotek, M., Pilarska, E.	Not yet published.
17	The influence of hippotherapy on functional state of neuromuscular system in children with cerebral palsy in the form of double spastic hemiplegia. Volokitin, A.S., Bruykov, A.A., Apokin, V.V., Gulin, A.V.	Article in Russian
18	Development of joint mobility in children with spastic cerebral palsy under the influence of hippotherapy . Volokitin, A.S., Bruykov, A.A., Gulin, A.V., Apokin, V.V.	Article in Russian
19	Effects of hippotherapy on postural stability in cerebral palsy: Report of a case (Letter) [Efectos de la hipoterapia en la estabilidad postural en parálisis cerebral infantil: A propósito de un caso clínico] Fernández-Gutiérrez, C., Apolo-Arenas, M.D. , Martínez-García, Y., Caña-Pino, A.	Article in Spanish
20	Hippotherapy in the postural control and balance in individuals with cerebral palsy: Systematic review [Equoterapia no controle postural e equilíbrio em indivíduos com paralisia cerebral: Revisão sistemática] Moraes, A.G.a , Silva, M.a, Copetti, F.b, Abreu, A.C.a, de David, A.C.a	Article in Portuguese
21	Effect of hippotherapy on gross motor function in children with cerebral palsy: a randomized controlled trial. Kwon JY, Chang HJ, Yi SH, Lee JY, Shin HY, Kim YH. J Altern Complement Med. 2015 Jan;21(1):15-21. doi: 10.1089/acm.2014.0021.	Duplicate
22	Exercise interventions improve postural control in children with cerebral palsy: a systematic review. Dewar R, Love S, Johnston LM. Dev Med Child Neurol. 2015 Jun;57(6):504-20. doi: 10.1111/dmcn.12660. Review.	Literature review.
23	Therapist-Designed Adaptive Riding in Children With Cerebral Palsy: Results of a Feasibility Study. Angsupaisal M, Visser B, Alkema A, Meinsma-van der Tuin M, Maathuis CG, Reinders-Messelink H, Hadders-Algra M. Phys Ther. 2015 Aug;95(8):1151-62. doi: 10.2522/ptj.20140146.	Intervention
24	The benefit of hippotherapy for improvement of attention and memory in children with cerebral palsy: A pilot study. Krejčí, E.ab , Janura, M.a, Svoboda, Z.a	Non physical outcomes

25	Effects of equine therapy in gross motor function of patients with chronic non-progressive encephalopathy (Article) [Efeitos da Equoterapia na função motora grossa de pacientes com encefalopatia crônica não progressiva] Da Silva, L.M.a , De Sousa Monteiro, E.a, De Paiva, S.S.C.a, Torres, M.V.b, De Carvalho, M.E.I.M.c	Article in Portuguese
26	The effect of therapeutic horseback riding on balance in community-dwelling older adults: a pilot study. Homnick TD, Henning KM, Swain CV, Homnick DN. J Appl Gerontol. 2015 Feb;34(1):118-26. doi: 10.1177/0733464812467398.	Intervention
27	Influence of neurophysiological hippotherapy on the transference of the centre of gravity among children with cerebral palsy Maćkó, A.ac , Małachowska-Sobieska, M.ac, Demczuk-Włodarczyk, E.a, Sidorowska, M.a, Szklarska, A.b, Lipowicz, A.b	Article in Polish
28	Effects of hippotherapy on gross motor function and functional performance of children with cerebral palsy. Park ES, Rha DW, Shin JS, Kim S, Jung S. Yonsei Med J. 2014 Nov;55(6):1736-42. doi: 10.3349/ymj.2014.55.6.1736.	Duplicate
29	The effects of hippotherapy and a horse riding simulator on the balance of children with cerebral palsy. Lee CW, Kim SG, Na SS. J Phys Ther Sci. 2014 Mar;26(3):423-5. doi: 10.1589/jpts.26.423.	Duplicate
30	The effects of hippotherapy on motor and psychic functions of CP affected children and young persons. Krejčí, E.ab , Janura, M.a, Svoboda, Z.a	Article in Czech
31	Continuous vs. blocks of physiotherapy for motor development in children with cerebral palsy and similar syndromes: A prospective randomized study . Brunner, A.-L.a, Rutz, E.b, Juenemann, S.c, Brunner, R.b	Intervention
32	The effects of the therapeutic riding on children with cerebral palsy Laiou, A.a , Christakou, A.b, Poluzos, N.c, Nikolaou, I.c	Article in Greek
33	A systematic review of interventions for children with cerebral palsy: State of the evidence. novak, I.ab, Mcintyre, S.ab, Morgan, C.ab, Campbell, L.b, Dark, L.a, Morton, N.a, Stumbles, E.a, Wilson, S..-A.a, Goldsmith, S.ab	Literature review
34	Promoting function and participation to improve living a life with cerebral palsy (Article)	Intervention

	Msall, M.E.	
35	The effect of a hippotherapy session on spatiotemporal parameters of gait in children with cerebral palsy - pilot study. Manikowska F, Jóźwiak M, Idzior M, Chen PJ, Tarnowski D. Ortop Traumatol Rehabil. 2013 Jun 28;15(3):253-7. doi: 10.5604/15093492.1058420.	Duplicate
36	Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. Tseng SH, Chen HC, Tam KW. Disabil Rehabil. 2013 Jan;35(2):89-99. doi: 10.3109/09638288.2012.687033. Review.	Literature review.
37	The therapeutic interventions in cerebral palsy . Feferman, H., Harro, J., Patel, D.R. , Merrick, J.	Book Chapter
38	Effects of hippotherapy on the sitting balance of children with cerebral palsy: a randomized control trial. Kang H, Jung J, Yu J. Journal of Physical Therapy Science 2012 Oct;24(9):833-836	Duplicate
39	Hippotherapy in adult patients with chronic brain disorders: a pilot study. Sunwoo H, Chang WH, Kwon JY, Kim TW, Lee JY, Kim YH. Ann Rehabil Med. 2012 Dec;36(6):756-61. doi: 10.5535/arm.2012.36.6.756.	Health condition
40	Historical overview of the rationale for the pharmacological use of prolonged-release fampridine in multiple sclerosis. Fernandez, O.a , Berger, T.b, Hartung, H.-P.c, Putzki, N.d	Descriptive article. Intervention. health condition.
41	Assessment of the impact of hippotherapy on the level of satisfaction with life and acceptance of illness among parents of children with cerebral palsy. Białoszewski, D., Lewandowska, M., Korabiewska, I., Rongies, W., Woińska, M., Gotlib, J.	Non physical outcomes
42	Therapeutic effects of hippotherapy in cerebral palsy: A systematic review (Short Survey) [Efectos terapéuticos de la hipoterapia en la parálisis cerebral: una revisión sistemática] Herrero Gallego, P., García Antón, E. , Monserrat Cantera, M.E., Oliván Blázquez, B., Gómez Trullén, E.M., Trenado Molina, J.	Article in Spanish. Literature review
43	The medical management of cerebral palsy. Smith, M.a, Kurian, M.A.b	Literature review
44	Commentary on "Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study". Bjornson, K., Coyner, P.	Commentary

45	Therapeutic effects of horseback riding therapy on gross motor function in children with cerebral palsy: a systematic review. Whalen CN, Case-Smith J. Phys Occup Ther Pediatr. 2012 Aug;32(3):229-42. doi: 10.3109/01942638.2011.619251. Review.	Literature review.
46	Cerebral palsy: The whys and hows. Fairhurst, C.	Literature review.
47	Evidence to practice commentary: The evidence alert traffic light grading system Novak, I.	Commentary
48	Physiological demands of therapeutic horseback riding in children with moderate to severe motor impairments: an exploratory study. Bongers BC, Takken T. Pediatr Phys Ther. 2012 Fall;24(3):252-7. doi: 10.1097/PEP.0b013e31825c1a7d.	Therapeutic horseback riding + not appropriate outcome measures + unsure about the health condition.
49	Hippotherapy--an intervention to habilitate balance deficits in children with movement disorders: a clinical trial. Silkwood-Sherer DJ, Killian CB, Long TM, Martin KS. Phys Ther. 2012 May;92(5):707-17. doi: 10.2522/ptj.20110081.	Health condition = movement disorders
50	Modulation of back geometry in children with spastic diplegic cerebral palsy via hippotherapy training. el-Meniawy GH, Thabet NS. Egyptian Journal of Medical Human Genetics 2012 Feb;13(1):63-71	Duplicate
51	Effect of therapeutic riding on functional scoliosis as observed by roentgenography. Ihara M, Ihara M, Doumura M. Pediatr Int. 2012 Feb;54(1):160-2. doi: 10.1111/j.1442-200X.2011.03456.x. No abstract available.	Therapeutic riding.
52	Study of the therapeutic effects of a hippotherapy simulator in children with cerebral palsy: a stratified single-blind randomized controlled trial. Herrero P, Gómez-Trullén EM, Asensio A, García E, Casas R, Monserrat E, Pandyan A. Clin Rehabil. 2012 Dec;26(12):1105-13. doi: 10.1177/0269215512444633.	Duplicate
53	Possibilities of hippotherapy use in clinical practice 1. Svoboda, Z.ac , Janura, M.a, Dvořáková, T.a, Živný, B.b	Article in Slovak
54	Possibilities of hippotherapy use in clinical practice 2 (Article)	Article in Slovak

	[Možnosti využití hipoterapie v klinické praxi 2] Svoboda, Z.ac , Janura, M.a, Dvořáková, T.a, Živný, B.b	
55	Therapeutic effects of a horse riding simulator in children with cerebral palsy. Silva e Borges MB, Werneck MJ, da Silva Mde L, Gandolfi L, Pratesi R. Arq Neuropsiquiatr. 2011 Oct;69(5):799-804.	Intervention
56	Effect of hippotherapy on perceived self-competence and participation in a child with cerebral palsy. Frank A, McCloskey S, Dole RL. Pediatr Phys Ther. 2011 Fall;23(3):301-8. doi: 10.1097/PEP.0b013e318227caac.	Outcomes
57	WBSN for the assessment of the hippotherapy: A case study Nerino, R.a , Bergero, D.b , Bertolo, F.c , Guiot, C.c , Contin, L.d , Garbin, P.d	Conference Paper
58	Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: a meta-analysis. Zadnikar M, Kastrin A. Dev Med Child Neurol. 2011 Aug;53(8):684-91. doi: 10.1111/j.1469-8749.2011.03951.x. Review.	Literature review.
59	Incidence and risk factors of hip joint pain in children with severe cerebral palsy. Jóźwiak M, Harasymczuk P, Koch A, Kotwicki T. Disabil Rehabil. 2011;33(15-16):1367-72. doi: 10.3109/09638288.2010.532281.	No HPOT intervention
60	Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. Kwon JY, Chang HJ, Lee JY, Ha Y, Lee PK, Kim YH. Arch Phys Med Rehabil. 2011 May;92(5):774-9. doi: 10.1016/j.apmr.2010.11.031.	Duplicare
61	Center-of-pressure movements during equine-assisted activities. Clayton HM, Kaiser LJ, de Pue B, Kaiser L. Am J Occup Ther. 2011 Mar-Apr;65(2):211-6.	Intervention = horse riding
62	Influence of hippotherapy on the different postural-locomotion functions of patients with spastic quadruparetic form of cerebral palsy (Article) [Pôsodenie hipoterapie na rôzne posturálne lokomočné funkcie pri spastigkej kvauruparetickej forme detskej mozgovej obrny] Hornáček, K.a , Kafková, A.b, Páleníková, A.a	Article in Slovak

63	Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial. Herrero P, Asensio A, García E, Marco A, Oliván B, Ibarz A, Gómez-Trullén EM, Casas R. BMC Musculoskelet Disord. 2010 Apr 16;11:71. doi: 10.1186/1471-2474-11-71.	Duplicate
64	Changes in trunk and head stability in children with cerebral palsy after hippotherapy: a pilot study. Shurtleff TL, Engsberg JR. Phys Occup Ther Pediatr. 2010 May;30(2):150-63. doi: 10.3109/01942630903517223.	Duplicate
65	Complementary and alternative methods in cerebral palsy. Oppenheim WL. Dev Med Child Neurol. 2009 Oct;51 Suppl 4:122-9. doi: 10.1111/j.1469-8749.2009.03424.x. Review.	Literature review. Descriptive paper.
66	Management of motor problems in cerebral palsy: A critical update for the clinician Papavasiliou, A.S.	Literature review
67	Changes in dynamic trunk/head stability and functional reach after hippotherapy. Shurtleff TL, Standeven JW, Engsberg JR. Arch Phys Med Rehabil. 2009 Jul;90(7):1185-95. doi: 10.1016/j.apmr.2009.01.026.	Duplicate
68	Immediate and long-term effects of hippotherapy on symmetry of adductor muscle activity and functional ability in children with spastic cerebral palsy. McGibbon NH, Benda W, Duncan BR, Silkwood-Sherer D. Arch Phys Med Rehabil. 2009 Jun;90(6):966-74. doi: 10.1016/j.apmr.2009.01.011.	Duplicate
69	Effects of hippotherapy on people with cerebral palsy from the users' perspective: a qualitative study. Debuse D, Gibb C, Chandler C. Physiother Theory Pract. 2009 Apr;25(3):174-92. doi: 10.1080/09593980902776662.	Qualitative study.
70	A randomized controlled trial of the impact of therapeutic horse riding on the quality of life, health, and function of children with cerebral palsy (Note) Rosenbaum, P.	Intervention. Outcomes.

71	Immediate effects of a hippotherapy session on gait parameters in children with spastic cerebral palsy. McGee MC, Reese NB. Pediatr Phys Ther. 2009 Summer;21(2):212-8. doi: 10.1097/PEP.0b013e3181a39532.	Duplicate
72	Influence of mechanical hippotherapy on skin temperature responses in lower limbs in children with cerebral palsy. Zurek G, Dudek K, Pirogowicz I, Dziuba A, Pokorski M. J Physiol Pharmacol. 2008 Dec;59 Suppl 6:819-24.	Intervention = therapeutic horse riding Outcomes = skin temperature responses in lower limbs
73	The clinical picture of a child with spastic diplegia on a horse, depending on the position of the hippotherapeutic team. Małachowska-Sobieska, M., Demczuk-Włodarczyk, E., Wronecki, K., Skolimowski, T., Szpyt, K., Wojna, D., Zawadzka, D.	
74	Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: a focused review. Anttila H, Suoranta J, Malmivaara A, Mäkelä M, Autti-Rämö I. Am J Phys Med Rehabil. 2008 Jun;87(6):478-501. doi: 10.1097/PHM.0b013e318174ebed. Review.	Literature review.
75	Thermovision assessment of the simulate hippotherapy effectiveness for children with diversiform of the cerebral palsy. Zurek, G.a, Dudek, K.b, Dziuba, A.c	Outcomes
76	Physical therapy of cerebral palsy Miller, F., Bolton, M., Capone, K., Damiano, D., Hanlon, J., Hines, M., Hoopes, D., Jeanson, E., King, M.M., Kiser, D., Koczur, L., McManus, M., Mullan, B., Peischl, D., Rolph, B., Rush, A.J., Strine, C., Travis, S.	Book
77	The hippotherapy and its import in therapy of infantile paralysis (the Casuistik) (Article) [Hippoterapia a jej význam v liečbe detskej mozgovej obrny (Kazuistika)] Dziaková, M.ab, Moudrá, A.a, Repiská, A.a, Šimšík, D.a, Majerník, J.a, Dolná, Z.a	Article in Slovak
78	Hippotherapy and the significance of complementary and alternative medicine: A Q&A with William Benda, M.D., FACEP, FAAEM . Lane, K.W.	Note
79	Horseback riding as therapy for children with cerebral palsy: is there evidence of its effectiveness? Snider L, Korner-Bitensky N, Kammann C, Warner S, Saleh M.	Literature review

	Phys Occup Ther Pediatr. 2007;27(2):5-23	
80	The effect of hippotherapy on postural control in sitting for children with cerebral palsy. Hamill D, Washington KA, White OR. Phys Occup Ther Pediatr. 2007;27(4):23-42.	Duplicate
81	Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? Sterba JA. Dev Med Child Neurol. 2007 Jan;49(1):68-73.	Literature review
82	Rett syndrome. A review with emphasis on clinical characteristics and intervention. Lotan, M. , Ben-Zeev, B.	Literature review
83	An exploration of German and British physiotherapists' views on the effects of hippotherapy and their measurement. Debuse D, Chandler C, Gibb C. Physiother Theory Pract. 2005 Oct-Dec;21(4):219-42.	Qualitative
84	Special needs, special horses: A guide to the benefits of therapeutic riding	Book
85	Therapeutic interventions in cerebral palsy .Patel, D.R.ab	Conference Paper
86	Complementary and alternative therapies for cerebral palsy. Liptak GS. Ment Retard Dev Disabil Res Rev. 2005;11(2):156-63.	Literature review.
87	Hippotherapy. Meregillano G. Phys Med Rehabil Clin N Am. 2004 Nov;15(4):843-54, vii.	Literature review.
88	Hippotherapy contribution in the management of disability (Article) [Apports de l'hippothérapie dans la prise en charge du handicap] Proust, P., Cottalorda, J. , Alamartine, E., Gautheron, V.	Article in French
89	The effect of hippotherapy on ten children with cerebral palsy. Casady RL, Nichols-Larsen DS. Pediatr Phys Ther. 2004 Fall;16(3):165-72.	Duplicate
90	Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). Benda W, McGibbon NH, Grant KL. J Altern Complement Med. 2003 Dec;9(6):817-25.	Duplicate
91	Cerebral palsy - Etiology and therapy (Article) [Ursachen der zerebralparese und klassische behandlungsmöglichkeiten] Maurer, U.ab	Article in German

92	Hippotherapy as a method for complex rehabilitation of patients with late residual stage of infantile cerebral palsy (Article) [Ippoterapiia kak metod kompleksnoi reabilitatsii bol'nykh v pozdnei rezidual'noi stadii detskogo tserebral'nogo paralicha.] Sokolov, P.L., Dremova, G.V., Samsonova, S.V.	Article in Russian
93	Multiple simultaneous approach in lower extremity spasticity surgery (Article) Sayli, U.ab, Avci, S.b	Health condition
94	Hippotherapy as a part of cerebral palsy and other movement disorders treatment (Article) [Hipoterapia ako sucast liecby DMO a inych pohybovych poruch] Wagnerova, D.	Article in Slovak
95	Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: a pilot study. McGibbon NH, Andrade CK, Widener G, Cintas HL. Dev Med Child Neurol. 1998 Nov;40(11):754-62.	Intervention
96	Therapeutic horse-riding (hippotherapy): Recreation or treatment? [EQUITAZIONE TERAPEUTICA (IPPOTERAPIA): SVAGO O TERAPIA?] Bassan, L., Alfieri, V.	Article in Italian
97	Hippotherapy in multiple sclerosis patients and children with cerebral mobility disturbances [HIPPOTHERAPIE BEI MULTIPLE-SKLEROSE-KRANKEN UND KINDERN MIT ZEREBRALEN BEWEGUNGSSTORUNGEN] Riesser, H.	Article in German
98	Therapeutic horseback riding: Situation in Austria [STAND DER HIPPOTHERAPIE IN Osterreich] Kyrle, P., Schwarzenberg, T., Tauffkirchen, E.	Article in German
99	Hippotherapy. A supplementary treatment for motion disturbance caused by cerebral palsy (Article) [REITTHERAPIE - EINE ERWEITERTE BEHANDLUNG BEI ZEREBRALEN BEWEGUNGSSTORUNGEN]	Article in German

	Tauffkirchen, E.	
100	Hippotherapy as treatment of preschool children with cerebral palsy [HIPPOTHERAPIE ALS BEHANDLUNG ZEREBRALPARETISCHER KINDER IM VORSCHULALTER] Waller, E., Wolf, H.	Article in German
101	Horseback riding therapy for children with movement malfunction considering especially cerebral palsy patients [REITEN ALS THERAPIE BEI BEWEGUNGSGESTORTEN KINDERN MIT BESONDERER BERUCKSICHTIGUNG DER ZEREBRALPARESE] Satter, L.	Article in German
102	Therapy with the help of a horse: attempt at a situational analysis (Article) [THERAPIE MIT UND AUF DEM PFERD: VERSUCH EINER BESTANDSAUFNAHME] Riesser, H.	Article in German
103	Is hyppotherapy beneficial for rehabilitation of children with cerebral palsy? Yildirim Şik, B., Çekmece, C., Dursun, N. , Dursun, E., Balikçi, E., Altunkanat, Z., Gülcü, M.A. Turkiye Klinikleri Journal of Medical Sciences. Volume 32, Issue 3, 2012, Pages 601-608 deleted-polish	Article in polish
104	The usefulness of hippotherapy in the rehabilitation of cerebrally palsied children. Pilot study. Białoszewski, D. , Korabiewska, I., Lewandowska, M., Wasiak, K. Fizjoterapia Polska. Volume 11, Issue 2, 2011, Pages 175-181 deleted-polish	Article in polish

Appendix 4: Pilot Survey – Form

An exploratory survey on the characteristics of hippotherapy sessions involving individuals with cerebral palsy

Pilot form regard the survey.

You have accepted to participate of this pilot survey regard hippotherapy practice. We kindly ask you to fill up the questions below in order to help us to understand if the survey is ready to be launched for general public and to help us ensure that everything is clear. Many thanks for your participation.

Regard the Session I:

Is there any question do you think is confuse or wrong? If yes, please state which one and why is it confuse.

A.

Regard the Session II.

Is there any question do you think is confuse or wrong? If yes, please state which one and why is it confuse.

A.

Regard the Session III.

Is there any question do you think is confuse or wrong? If yes, please state which one and why is it confuse.

A.

Any other suggestion?

A.

Appendix 5: Survey – English Version

An exploratory survey on the characteristics of hippotherapy sessions involving individuals with cerebral palsy

Choose your language.
- English (1)
- Portuguese (2)

1 Are you a physiotherapist who works with hippotherapy and individuals with cerebral palsy?
- Yes. Please, keep answering the survey. (1)
- No. thank you very much for your participation. (2)

If No. thank you very much for... Is Selected, Then Skip to End of Survey

Consent: PARTICIPANT INFORMATION SHEET
Title of Research Project: An exploratory survey on the characteristics of hippotherapy sessions involving individuals with cerebral palsy
Name of Researcher: Flavia Regina Bueno, MSc Bachelor in Physiotherapy – Federal University of Sao Paulo – Brazil. Master in Health Sciences – University of Cadiz – Spain. PhD Student in Life Science – Anglia Ruskin University, United Kingdom.
Research Collaborators: Dr. Charlotte Nevison, Dr. Steven Abbott and Dr. Genevieve Williams.
Research Group: Sports and Exercise Science Research Group
Section A: The Research Project Information about the study: The aim of this study is to identify the characteristics of typical hippotherapy sessions, and how the outcomes of the sessions are evaluated. This will help inform the design of our future research studies where we plan to objectively access the biomechanical and neuromuscular improvements resulting from hippotherapy using a range of scientific tools in addition to typical clinical evaluation tools. We are looking to recruit qualified physiotherapists that work with hippotherapy and cerebral palsy patients in the UK and Brazil. You have the option to complete the Survey in either Portuguese or English. The survey will investigate what you consider to be key features of a typical hippotherapy session for cerebral palsy patients and how you evaluate physical improvement following hippotherapy. We will not request information about individual patients or ask you to identify yourself or your patients. This is an on-line survey. Please note that because the survey is anonymised from the outset it will not be possible to withdraw any information that you have given once the survey is submitted. Completing the survey will not bring any risk or any direct benefit to you, however, you will be helping to understand how hippotherapy works. The results of this study will be in an anonymised format and may be published in an academic journal, professional publications and are going to be used in Flavia’s PhD thesis. The research is organised by: Flavia Regina Bueno (MSc), PhD student Sports and Exercise Science Research Group – Anglia Ruskin University. Email: frb101@student.anglia.ac.uk
For further queries or complaints regarding this research please contact the lead researcher, MSc Flavia Regina Bueno, at the email or postal address above. Section B: Your participation in the research project you have been invited to take part in the study as described above. We hope you would like to participate in this experiment. You will need 15 to 20 minutes to complete the survey, and we kindly

ask to do so until the end, once you have started. This research has been risk assessed and has received ethical approval from the Sports and Exercise Sciences Department Research Ethical Panel at Anglia Ruskin University. This research has been funding by CAPES, Science without Borders and Anglia Ruskin University.

2 I have read, understood, and printed a copy of, the above consent form and desire of my own free will to participate in this study.

- ❍ Yes (1)
- ❍ No (2)

If No Is Selected, Then Skip to End of Survey

Please before you start the survey contemplate the following definitions of Hippotherapy and Cerebral Palsy: “Hippotherapy refers to the incorporation of equine movement by physical therapy professionals. These professionals use the equine movement within their evidence-based practice and clinical reasoning to engage the sensorimotor and neuromotor systems of their patients to create functional change. Used with other neuromotor and sensorimotor techniques, hippotherapy is part of a patient’s integrated plan of care.” (Modified definition based on the American Hippotherapy Association, 2015a). In this survey we will be asking questions about the practice of hippotherapy to improve physical outcomes in the patient with cerebral palsy. Note: "Cerebral palsy is considered a neurological disorder caused by a non-progressive brain injury or malformation that occurs while the child’s brain is under development. Cerebral palsy primarily affects body movement and muscle coordination." (http://cerebralpalsy.org; accessed 16/11/2015).

Section I Section I - This section contains questions exploring the range of equipment used in your hippotherapy sessions. Please note: For the purpose of this survey, a ‘saddle’ is defined as "a seat fastened on the back of a horse or other animal for riding, typically made of leather and raised at the front and rear". A ‘bareback pad’ is defined as a soft pad which conforms to the back of the horse and does not influence the position of the rider. Also consider the follow definitions: Side-walker: "An individual who has received specific training to assist a therapist during treatment sessions. Their responsibilities include patient safety on and off the horse and assistance during therapy or therapeutic interventions. "Horse handler: "Indicates the individual preparing and handling the horse prior to and during a treatment session. They respond to directions by the therapist to alter the movement of the horse to cause an adaptive response in the client during hippotherapy." (Oxford dictionary, 2015; American Hippotherapy Association, 2015a).

3 Do you use a Hippotherapy Pad?

- ❍ Yes (9)
- ❍ No (10)

If No Is Selected, Then Skip to Do you use saddles?

Answer If Do you use Hippotherapy Pad? Yes, Is Selected
4 Why would you use a hippotherapy pad?
❑ Safety (1)
❑ To focus on balance and proprioception (2)
❑ For my patients' comfort (3)
❑ other reason: (4) ____________________

5 Do you use saddles?
❍ Yes (9)
❍ No (10)

6 Why would you use a saddle?
❑ Safety (1)
❑ Stabilization of my patients' lower torso (2)
❑ To stretch the adductors (3)
❑ Other reason: (4) ____________________

7 Have the saddles used in your hippotherapy sessions been fitted to the horse by a qualified saddler?
❍ Yes (1)
❍ No (2)

8 Do you ensure the saddle fits in the horse prior to each session?
❍ Yes (1)
❍ No (2)

9 Do you have a side walker?
❍ Yes (9)
❍ No (10)

10 Do you have a horse handler?
❍ Yes (9)
❍ No (10)

Section II Section II - This section asks questions relating to the format of a typical hippotherapy session for patients with Cerebral Palsy For the purpose of this survey, please consider: "The intent of the warm-up is to literally increase the temperature of the muscles, thus preparing the body for the demands of the endurance conditioning phase, or main focus, of the workout. A warm-up prepares your heart, lungs, and muscles for the endurance conditioning phase of your aerobic training session" (ACSM, 2011).

11 How long (in minutes) would a typical hippotherapy session last for a patient with cerebral palsy?
- ❍ less than 30 minutes. How long? (1) ____________________
- ❍ 30 minutes (2)
- ❍ 45 minutes (3)
- ❍ 60 minutes (4)

12 Do you include a 'warm up' routine for the patient at the start of each session?
- ❍ Yes, How many minutes would typically last? (1) ____________________
- ❍ No (2)

If No Is Selected, Then Skip to How many sessions of HPOT do you typically do

13 How do you do you facilitate the warm up for your patients? (tick all that apply)
- ❑ The patient sits passively on the horse while it walks. (1)
- ❑ Passive stretching when patient is off the horse (2)
- ❑ The patient is encouraged to stretch whilst on the horse (3)
- ❑ The patient is encouraged to stretching off the horse. (4)
- ❑ Other, please state: (5) ____________________

14 How many sessions of HPOT do you typically recommend?
- ❍ Less than 1 per week (e.g. twice a month) (1)
- ❍ 1 per week (2)
- ❍ 2 per week (3)
- ❍ 3 per week (4)
- ❍ Other. Please state (5) ____________________

15 Typically, how frequently do your patients attend hippotherapy sessions?
- ❍ Less than 1 per week (e.g. twice a month) (1)
- ❍ 1 per week (2)
- ❍ 2 per week (3)
- ❍ 3 per week (4)
- ❍ Other. Please state (5) ____________________

16 Which of the following categories of exercises you normally use on your hippotherapy sessions? (tick all that apply)
- ❑ Exercises focusing on enhancing muscle strength (1)
- ❑ Exercises focusing on enhancing muscle flexibility (2)
- ❑ Exercises focusing on diminish muscle spasticity (3)
- ❑ Exercises focusing on enhancing balance (4)
- ❑ Exercises focusing on enhancing postural control (5)

Section III - This section will be focusing on the physical outcomes you may expect after your hippotherapy treatment and how do you evaluate them, if you do.

17 Do you undertake a standardised, recorded physical assessment as part of your first session with the patient?
- ❍ Yes (1)
- ❍ No (2)

18 Which of the following methods do you MOST employ to evaluate the progress of your patient after one typical session?
- ❍ Observation (1)
- ❍ Clinical tests (2)
- ❍ Self-developed measures outcomes (3)
- ❍ Standardize/ published outcomes (4)

19 Which of the following methods do you consider the MOST adequate to evaluate a clinical improvement after hippotherapy treatment
- ❍ Observation (1)
- ❍ Clinical tests (2)
- ❍ Self-developed measures outcomes (3)
- ❍ Standardize/ published outcomes (4)

20 How often do you generally re-assess your patients' outcomes?
- ❍ every week (1)
- ❍ every two weeks (2)
- ❍ every four weeks (3)
- ❍ Other. Please state in weeks): (4) ____________________

21 Please answer according to the question

	Balance (1)	Posture (2)	gross motor function (3)	spasticity (4)	muscle strength (5)	functional capacity (6)	joint angles mobility (7)	gait (8)	proprioception (9)	motor control (10)
Which of those do you evaluate? (you may choose more than one) (1)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑
Which of these aspects of the patients' functional ability do you see the most IMMEDIATE improvement in following each session? (2)	❑	❑	❑	❑	❑	❑	❑	❑	❑	❑

22 What aspects of patients' functional ability do you regard as most improved as result of hippotherapy? Please rank, considering 10 - most improved).
______ balance (1)
______ posture (2)
______ gross motor function (3)
______ spasticity (4)
______ muscle strength (5)
______ functional capacity (6)
______ joint angles mobility (7)
______ gait (8)

______ proprioception (9)
______ motor control (10)

Which scales or standardized measurement do you use for the outcomes you evaluate.

23 Balance?
- ❑ Berg Scale (BBS) (1)
- ❑ Paediatric Berg Scale (PBBS) (2)
- ❑ Force place (3)
- ❑ Other: (4) ____________________
- ❑ I don't evaluate balance (5)

24 Posture?
- ❑ Photogrammetry, which software? (1) ____________________
- ❑ Visual subjective analysis (2)
- ❑ Other (3) ____________________
- ❑ I don't evaluate posture (4)

25 Gross motor function?
- ❑ Gross Motor Function Scale (GMFS) (1)
- ❑ Subjective analysis (2)
- ❑ other: (3) ____________________
- ❑ I don't evaluate gross motor function (4)

26 Spasticity?
- ❑ Ashworth Scale (1)
- ❑ subjective analysis (2)
- ❑ other: (3) ____________________
- ❑ I don't evaluate spasticity (4)

27 muscle strength?
- ❑ Dynamometer (1)
- ❑ subjective analysis (2)
- ❑ other: (3) ____________________
- ❑ I don't evaluate muscle strength (4)

28 functional capacities?
- ❑ International functional capacity scale (ICF) (1)
- ❑ subjective analysis (2)
- ❑ other: (3) ____________________
- ❑ I don't evaluate functional capacity (4)

29 joint angle mobility?

- ❑ goniometer (1)
- ❑ electric goniometer (2)
- ❑ subjective analysis of movement amplitude (3)
- ❑ other: (4) ____________________
- ❑ I don't evaluate joint angle mobility (5)

30 Gait?

- ❑ Gait validated tests (e.g. TC6, Shuttle walk test, 10MWT); which? (1) ____________________
- ❑ 3D systems (e.g.Codamotion, Vicon, GaITRite); which? (2) ____________________
- ❑ subjective analysis (3)
- ❑ other: (4) ____________________
- ❑ I don't evaluate gait (5)

31 Proprioception?

- ❑ Clinical Test of Sensory Integration and Balance (CTSIB) (1)
- ❑ subjective analysis (2)
- ❑ other: (3) ____________________
- ❑ I don't evaluate proprioception (4)

32 Motor control?

- ❑ Kinematics analysis of the movement; which software? (1) ____________________
- ❑ subjective analysis (2)
- ❑ other: (3) ____________________
- ❑ I don't evaluate motor control (4)

33 For the subsequent questions, consider those four big muscle groups of the lower limb: Hip Adductors (gracilis and adductors of the hip), Hips Abductors (gluteus medius and minimus, tensor fascia latae), Hip Flexors (iliopsoas, rectus femoris, tensor fascia latae) and Hip extensors (gluteus maximum, hamstrings).

	hip adductors (1)	hip abductors (2)	hip flexors (3)	hip extensors (4)
Which of these muscle groups would you prioritize generally on your session? (1)	❑	❑	❑	❑
Which of these muscle groups do you expect HPOT would have a major impact on reducing spasticity? (2)	❑	❑	❑	❑
Which of these muscle groups do you expect HPOT would have a major impact on increasing muscle strength? (3)	❑	❑	❑	❑
Which of these muscle groups do you expect HPOT would have a major impact on normalizing muscle tonus? (4)	❑	❑	❑	❑

34 Do you consider that HPOT is effective in improving synergism/the combined action of hip adductors and abductors?

❍ Yes (1)

❍ No (2)

35 Do you consider that HPOT is effective on improving the synergy / the combined action of hip flexors and extensors?

❍ Yes (1)
❍ No (2)

36 Do you consider that HPOT is effective on decrease variability on gait components (e.g. stride length) and because of that increase a skilled performance?

❍ Yes (1)
❍ No (2)

Answer If Do you consider that HPOT is effective on decrease variability on gait components (e.g. stride length) and because of that increase a skilled performance? Yes Is Selected

37 if yes, how do you evaluate that, please state: (you may choose more than one)

❑ Using standardized walking tests (6mwt, swt, 10mwt) – which? (1) ____________________
❑ Using biomechanics – analysis in 2D or 3D by image or video – which? (2) ____________________
❑ By measuring the length of the stride (3)
❑ By measuring the gait speed. (4)
❑ Other (5) ____________________

38 For the subsequent questions, please consider the following muscle groups for Trunk and Upper limb: Abdominals, Erectors of the spine (back big muscles), and Pectoralis

	abdominals (1)	erectors of the spine (2)	pectoralis (3)
Which of these muscle groups would you prioritize generally on your session? (1)	❑	❑	❑
Which of these muscle groups do you expect HPOT would have a major impact on reducing spasticity? (2)	❑	❑	❑
Which of these muscle groups do you expect HPOT would have a major impact on increasing muscle strength? (3)	❑	❑	❑
Which of these muscle groups do you expect HPOT would have a major impact on normalizing muscle tonus? (4)	❑	❑	❑

39 Do you consider that HPOT is efficient on improving the dissociation of shoulders and hips during gait, which is generally absent or impaired in CP patients?
❍ Yes (1)
❍ No (2)

Answer If Do you consider that HPOT is efficient on improving the dissociation of shoulders and hips during gait, which is generally absent or impaired in CP patients? Yes, Is Selected
40 If yes, how do you evaluate?
❑ Using biomechanics – analysis in 2D or 3D by image or video – to evaluate angles between hips and shoulders and gait performance– which? (1) ____________________
❑ Using videography (2)
❑ subjective analysis (3)
❑ Other (4) ____________________

41 When should the patient be discharged from hippotherapy treatment?
❑ When my patient has reached a "plateau" and it is no long physically progressing with the treatment (1)
❑ When my patient has done the treatment for 6 months (2)
❑ When my patient has done the treatment for 3 months (3)

Appendix 6: Gross Motor Function Classification System – Expanded and Revised (GMFCS – E & R)

BEFORE 2ND BIRTHDAY
LEVEL I: Infants move in and out of sitting and floor sit with both hands free to manipulate objects. Infants crawl on hands and knees, pull to stand and take steps holding on to furniture. Infants walk between 18 months and 2 years of age without the need for any assistive mobility device.
LEVEL II: Infants maintain floor sitting but may need to use their hands for support to maintain balance. Infants creep on their stomach or crawl on hands and knees. Infants may pull to stand and take steps holding on to furniture.
LEVEL III: Infants maintain floor sitting when the low back is supported. Infants roll and creep forward on their stomachs.
LEVEL IV: Infants have head control but trunk support is required for floor sitting. Infants can roll to supine and may roll to prone. LEVEL V: Physical impairments limit voluntary control of movement. Infants are unable to maintain antigravity head and trunk postures in prone and sitting. Infants require adult assistance to roll.

BETWEEN 2ND AND 4TH BIRTHDAY
LEVEL I: Children floor sit with both hands free to manipulate objects. Movements in and out of floor sitting and standing are performed without adult assistance. Children walk as the preferred method of mobility without the need for any assistive mobility device.

LEVEL II: Children floor sit but may have difficulty with balance when both hands are free to manipulate objects. Movements in and out of sitting are performed without adult assistance. Children pull to stand on a stable surface. Children crawl on hands and knees with a reciprocal pattern, cruise holding onto furniture and walk using an assistive mobility device as preferred methods of mobility.
LEVEL III: Children maintain floor sitting often by "W-sitting" (sitting between flexed and internally rotated hips and knees) and may require adult assistance to assume sitting. Children creep on their stomach or crawl on hands and knees (often without reciprocal leg movements) as their primary methods of self-mobility. Children may pull to stand on a stable surface and cruise short distances. Children may walk short distances indoors using a hand-held mobility device (walker) and adult assistance for steering and turning. **LEVEL IV:** Children floor sit when placed, but are unable to maintain alignment and balance without use of their hands for support. Children frequently require adaptive equipment for sitting and standing. Self-mobility for short distances (within a room) is achieved through rolling, creeping on stomach, or crawling on hands and knees without reciprocal leg movement.
LEVEL V: Physical impairments restrict voluntary control of movement and the ability to maintain antigravity head and trunk postures. All areas of motor function are limited. Functional limitations in sitting and standing are not fully compensated for through the use of adaptive equipment and assistive technology. At Level V, children have no means of independent movement and are transported. Some children achieve self-mobility using a powered wheelchair with extensive adaptations.

BETWEEN 4TH AND 6TH BIRTHDAY
LEVEL I: Children get into and out of, and sit in, a chair without the need for hand support. Children move from the floor and from chair sitting to standing without the need for objects for support. Children walk indoors and outdoors, and climb stairs. Emerging ability to run and jump.
LEVEL II: Children sit in a chair with both hands free to manipulate objects. Children move from the floor to standing and from chair sitting to standing but often require a stable surface to push or pull up on with their arms. Children walk without the need for a hand- held mobility device indoors and for short distances on level surfaces outdoors. Children climb stairs holding onto a railing but are unable to run or jump.
LEVEL III: Children sit on a regular chair but may require pelvic or trunk support to maximize hand function. Children move in and out of chair sitting using a stable surface to push on or pull up with their arms. Children walk with a hand-held mobility device on level surfaces and climb stairs with assistance from an adult. Children frequently are transported when traveling for long distances or outdoors on uneven terrain.
LEVEL IV: Children sit on a chair but need adaptive seating for trunk control and to maximize hand function. Children move in and out of chair sitting with assistance from an adult or a stable surface to push or pull up on with their arms. Children may at best walk short distances with a walker and adult supervision but have difficulty turning and maintaining balance on uneven surfaces. Children are transported in the community. Children may achieve self-mobility using a powered wheelchair.
LEVEL V: Physical impairments restrict voluntary control of movement and the ability to maintain antigravity head and trunk postures. All areas of motor function are limited. Functional limitations in sitting and standing are not fully compensated for

through the use of adaptive equipment and assistive technology. At Level V, children have no means of independent movement and are transported. Some children achieve self-mobility using a powered wheelchair with extensive adaptations. © Palisano, Rosenbaum, Bartlett & Livingston, 2007 Page 3 of 4

BETWEEN 6TH AND 12TH BIRTHDAY

Level I: Children walk at home, school, outdoors, and in the community. Children are able to walk up and down curbs without physical assistance and stairs without the use of a railing. Children perform gross motor skills such as running and jumping but speed, balance, and coordination are limited. Children may participate in physical activities and sports depending on personal choices and environmental factors.

Level II: Children walk in most settings. Children may experience difficulty walking long distances and balancing on uneven terrain, inclines, in crowded areas, confined spaces or when carrying objects. Children walk up and down stairs holding onto a railing or with physical assistance if there is no railing. Outdoors and in the community, children may walk with physical assistance, a hand-held mobility device, or use wheeled mobility when traveling long distances. Children have at best only minimal ability to perform gross motor skills such as running and jumping. Limitations in performance of gross motor skills may necessitate adaptations to enable participation in physical activities and sports**.**

Level III: Children walk using a hand-held mobility device in most indoor settings. When seated, children may require a seat belt for pelvic alignment and balance. Sit-to-stand and floor-to-stand transfers require physical assistance of a person or support surface. When traveling long distances, children use some form of wheeled mobility. Children may walk up and down stairs holding onto a railing with supervision or physical assistance. Limitations in walking may necessitate adaptations to enable participation in physical activities and sports including self-propelling a manual wheelchair or powered mobility.

Level IV: Children use methods of mobility that require physical assistance or powered mobility in most settings. Children require adaptive seating for trunk and pelvic control and physical assistance for most transfers. At home, children use floor mobility (roll, creep, or crawl), walk short distances with physical assistance, or use powered mobility. When positioned, children may use a body support walker at home or school. At school, outdoors, and in the community, children are transported in a manual wheelchair or use powered mobility. Limitations in mobility necessitate adaptations to enable participation in physical activities and sports, including physical assistance and/or powered mobility.

Level V: Children are transported in a manual wheelchair in all settings. Children are limited in their ability to maintain antigravity head and trunk postures and control arm and leg movements. Assistive technology is used to improve head alignment, seating, standing, and and/or mobility but limitations are not fully compensated by equipment. Transfers require complete physical assistance of an adult. At home, children may move short distances on the floor or may be carried by an adult. Children may achieve self- mobility using powered mobility with extensive adaptations for seating and control access. Limitations in mobility necessitate adaptations to enable participation in physical activities and sports including physical assistance and using powered mobility.

BETWEEN 12TH AND 18TH BIRTHDAY

Level I: Youth walk at home, school, outdoors, and in the community. Youth are able to walk up and down curbs without physical assistance and stairs without the use of a railing. Youth perform gross motor skills such as running and jumping but speed, balance, and coordination are limited. Youth may participate in physical activities and sports depending on personal choices and environmental factors.

Level II: Youth walk in most settings. Environmental factors (such as uneven terrain, inclines, long distances, time demands, weather, and peer acceptability) and personal preference influence mobility choices. At school or work, youth may walk using a hand- held mobility device for safety. Outdoors and in the community, youth may use wheeled mobility when traveling long distances. Youth walk up and down stairs holding a railing or with physical assistance if there is no railing. Limitations in performance of gross motor skills may necessitate adaptations to enable participation in physical activities and sports.

Level III: Youth are capable of walking using a hand-held mobility device. Compared to individuals in other levels, youth in Level III demonstrate more variability in methods of mobility depending on physical ability and environmental and personal factors. When seated, youth may require a seat belt for pelvic alignment and balance. Sit-to-stand and floor-to-stand transfers require physical assistance from a person or support surface. At school, youth may self-propel a manual wheelchair or use powered mobility. Outdoors and in the community, youth are transported in a wheelchair or use powered mobility. Youth may walk up and down stairs holding onto a railing with supervision or physical assistance. Limitations in walking may necessitate adaptations to enable participation in physical activities and sports including self-propelling a manual wheelchair or powered mobility.

Level IV: Youth use wheeled mobility in most settings. Youth require adaptive seating for pelvic and trunk control. Physical assistance from 1 or 2 persons is required for transfers. Youth may support weight with their legs to assist with standing transfers. Indoors, youth may walk short distances with physical assistance, use wheeled mobility, or, when positioned, use a body support walker. Youth are physically capable of operating a powered wheelchair. When a powered wheelchair is not feasible or available, youth are transported in a manual wheelchair. Limitations in mobility necessitate adaptations to enable participation in physical activities and sports, including physical assistance and/or powered mobility.

Level V: Youth are transported in a manual wheelchair in all settings. Youth are limited in their ability to maintain antigravity head and trunk postures and control arm and leg movements. Assistive technology is used to improve head alignment, seating, standing, and mobility but limitations are not fully compensated by equipment. Physical assistance from 1 or 2 persons or a mechanical lift is required for transfers. Youth may achieve self-mobility using powered mobility with extensive adaptations for seating and control access. Limitations in mobility necessitate adaptations to enable participation in physical activities and sports including physical assistance and using powered mobility.

OPERATIONAL DEFINITIONS

Body support walker – A mobility device that supports the pelvis and trunk. The child/youth is physically positioned in the walker by another person.

Hand-held mobility device – Canes, crutches, and anterior and posterior walkers that do not support the trunk during walking.

Physical assistance – Another person manually assists the child/youth to move.

Powered mobility – The child/youth actively controls the joystick or electrical switch that enables independent mobility. The mobility base may be a wheelchair, scooter or other type of powered mobility device.

Self-propels manual wheelchair – The child/youth actively uses arms and hands or feet to propel the wheels and move.

Transported – A person manually pushes a mobility device (e.g., wheelchair, stroller, or pram) to move the child/youth from one place to another.

Walks – Unless otherwise specified indicates no physical assistance from another person or any use of a hand-held mobility device. An orthosis (i.e., brace or splint) may be worn.

Wheeled mobility – Refers to any type of device with wheels that enables movement (e.g., stroller, manual wheelchair, or powered wheelchair).

GENERAL HEADINGS FOR EACH LEVEL

LEVEL I	-	Walks without Limitations
LEVEL II	-	Walks with Limitations
LEVEL III	-	Walks Using a Hand-Held Mobility Device
LEVEL IV	-	Self-Mobility with Limitations; May Use Powered Mobility
LEVEL V	-	Transported in a Manual Wheelchair

DISTINCTIONS BETWEEN LEVELS

Distinctions Between Levels I and II - Compared with children and youth in Level I, children and youth in Level II have limitations walking long distances and balancing; may need a hand-held mobility device when first learning to walk; may use wheeled mobility when traveling long distances outdoors and in the community; require the use of a railing to walk up and down stairs; and are not as capable of running and jumping.

Distinctions Between Levels II and III - Children and youth in Level II are capable of walking without a hand-held mobility device after age 4 (although they may choose to use one at times). Children and youth in Level III need a hand-held mobility device to walk indoors and use wheeled mobility outdoors and in the community.

Distinctions Between Levels III and IV - Children and youth in Level III sit on their own or require at most limited external support to sit, are more independent in standing transfers, and walk with a hand-held mobility device. Children and youth in Level IV function in sitting (usually supported) but self-mobility is limited. Children and youth in Level IV are more likely to be transported in a manual wheelchair or use powered mobility.

Distinctions Between Levels IV and V - Children and youth in Level V have severe limitations in head and trunk control and require extensive assisted technology and physical assistance. Self-mobility is achieved only if the child/youth can learn how to operate a powered wheelchair.

Appendix 7. Gross Motor Function Measure

GROSS MOTOR FUNCTION MEASURE (GMFM) SCORE SHEET

Version 1.0

Child's Name: ______________________________ ID #: __________

Assessment date: ______________ (year / month /day)

Date of birth: ______________ (year / month /day)

Chronological age: ______________ (years/months)

Evaluator's Name: ______________

GMFCS Level [1]

☐ I ☐ II ☐ III ☐ IV ☐ V

Testing Conditions (eg, room, clothing, time, others present)

____

The GMFM is a standardized observational instrument designed and validated to measure change in gross motor function over time in children with cerebral palsy. The scoring key is meant to be a general guideline. However, most of the items have specific descriptors for each score. It is imperative that the guidelines contained in the manual be used for scoring each item.

SCORING KEY
0 = does not initiate
1 = initiates
2 = partially completes
3 = completes
NT = Not tested [used for the GMAE scoring*]

It is now important to differentiate a true score of "0" (child does not initiate) from an item which is Not Tested (NT) if you are interested in using the GMFM-66 Ability Estimator Software.

*The GMFM-66 Gross Motor Ability Estimator (GMAE) software is available with the GMFM manual (2002). The advantage of the software is the conversion of the ordinal scale into an interval scale. This will allow for a more accurate estimate of the child's ability and provide a measure that is equally responsive to change across the spectrum of ability levels. Items that are used in the calculation of the GMFM-66 score are shaded and identified with an asterisk (*). The GMFM-66 is only valid for use with children who have cerebral palsy.

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[1] GMFCS level is a rating of severity of motor function. Definitions are found in Appendix I of the GMFM manual (2002).

Check (√) the appropriate score: if an item is not tested (NT), circle the item number in the right column

	Item	A: LYING & ROLLING	SCORE				NT
	1.	SUP, HEAD IN MIDLINE: TURNS HEAD WITH EXTREMITIES SYMMETRICAL	0 ☐	1 ☐	2 ☐	3 ☐	1.
*	2.	SUP: BRINGS HANDS TO MIDLINE, FINGERS ONE WITH THE OTHER	0 ☐	1 ☐	2 ☐	3 ☐	2.
	3.	SUP: LIFTS HEAD 45°	0 ☐	1 ☐	2 ☐	3 ☐	3.
	4.	SUP: FLEXES R HIP AND KNEE THROUGH FULL RANGE	0 ☐	1 ☐	2 ☐	3 ☐	4.
	5.	SUP: FLEXES L HIP AND KNEE THROUGH FULL RANGE	0 ☐	1 ☐	2 ☐	3 ☐	5.
*	6.	SUP: REACHES OUT WITH R ARM, HAND CROSSES MIDLINE TOWARD TOY	0 ☐	1 ☐	2 ☐	3 ☐	6.
*	7.	SUP: REACHES OUT WITH L ARM, HAND CROSSES MIDLINE TOWARD TOY	0 ☐	1 ☐	2 ☐	3 ☐	7.
	8.	SUP: ROLLS TO PR OVER R SIDE	0 ☐	1 ☐	2 ☐	3 ☐	8.
	9.	SUP: ROLLS TO PR OVER L SIDE	0 ☐	1 ☐	2 ☐	3 ☐	9.
*	10.	PR: LIFTS HEAD UPRIGHT	0 ☐	1 ☐	2 ☐	3 ☐	10.
	11.	PR ON FOREARMS: LIFTS HEAD UPRIGHT, ELBOWS EXT., CHEST RAISED	0 ☐	1 ☐	2 ☐	3 ☐	11.
	12.	PR ON FOREARMS: WEIGHT ON R FOREARM, FULLY EXTENDS OPPOSITE ARM FORWARD	0 ☐	1 ☐	2 ☐	3 ☐	12.
	13.	PR ON FOREARMS: WEIGHT ON L FOREARM, FULLY EXTENDS OPPOSITE ARM FORWARD	0 ☐	1 ☐	2 ☐	3 ☐	13.
	14.	PR: ROLLS TO SUP OVER R SIDE	0 ☐	1 ☐	2 ☐	3 ☐	14.
	15.	PR: ROLLS TO SUP OVER L SIDE	0 ☐	1 ☐	2 ☐	3 ☐	15.
	16.	PR: PIVOTS TO R 90° USING EXTREMITIES	0 ☐	1 ☐	2 ☐	3 ☐	16.
	17.	PR: PIVOTS TO L 90° USING EXTREMITIES	0 ☐	1 ☐	2 ☐	3 ☐	17.
		TOTAL DIMENSION A					

	Item	B: SITTING	SCORE				NT
*	18.	SUP, HANDS GRASPED BY EXAMINER: PULLS SELF TO SITTING WITH HEAD CONTROL	0 ☐	1 ☐	2 ☐	3 ☐	18.
	19.	SUP: ROLLS TO R SIDE, ATTAINS SITTING	0 ☐	1 ☐	2 ☐	3 ☐	19.
	20.	SUP: ROLLS TO L SIDE, ATTAINS SITTING	0 ☐	1 ☐	2 ☐	3 ☐	20.
*	21.	SIT ON MAT, SUPPORTED AT THORAX BY THERAPIST: LIFTS HEAD UPRIGHT, MAINTAINS 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	21.
*	22.	SIT ON MAT, SUPPORTED AT THORAX BY THERAPIST: LIFTS HEAD MIDLINE, MAINTAINS 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	22.
*	23.	SIT ON MAT, ARM(S) PROPPING: MAINTAINS, 5 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	23.
*	24.	SIT ON MAT: MAINTAINS, ARMS FREE, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	24.
*	25.	SIT ON MAT WITH SMALL TOY IN FRONT: LEANS FORWARD, TOUCHES TOY, RE-ERECTS WITHOUT ARM PROPPING	0 ☐	1 ☐	2 ☐	3 ☐	25.
*	26.	SIT ON MAT: TOUCHES TOY PLACED 45° BEHIND CHILD'S R SIDE, RETURNS TO START	0 ☐	1 ☐	2 ☐	3 ☐	26.
*	27.	SIT ON MAT: TOUCHES TOY PLACED 45° BEHIND CHILD'S L SIDE, RETURNS TO START	0 ☐	1 ☐	2 ☐	3 ☐	27.
	28.	R SIDE SIT: MAINTAINS, ARMS FREE, 5 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	28.
	29.	L SIDE SIT: MAINTAINS, ARMS FREE, 5 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	29.
*	30.	SIT ON MAT: LOWERS TO PR WITH CONTROL	0 ☐	1 ☐	2 ☐	3 ☐	30.
*	31.	SIT ON MAT WITH FEET IN FRONT: ATTAINS 4 POINT OVER R SIDE	0 ☐	1 ☐	2 ☐	3 ☐	31.
*	32.	SIT ON MAT WITH FEET IN FRONT: ATTAINS 4 POINT OVER L SIDE	0 ☐	1 ☐	2 ☐	3 ☐	32.
	33.	SIT ON MAT: PIVOTS 90°, WITHOUT ARMS ASSISTING	0 ☐	1 ☐	2 ☐	3 ☐	33.
*	34.	SIT ON BENCH: MAINTAINS, ARMS AND FEET FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	34.
*	35.	STD: ATTAINS SIT ON SMALL BENCH	0 ☐	1 ☐	2 ☐	3 ☐	35.
*	36.	ON THE FLOOR: ATTAINS SIT ON SMALL BENCH	0 ☐	1 ☐	2 ☐	3 ☐	36.
*	37.	ON THE FLOOR: ATTAINS SIT ON LARGE BENCH	0 ☐	1 ☐	2 ☐	3 ☐	37.
		TOTAL DIMENSION B					

	Item	C: CRAWLING & KNEELING	SCORE				NT
	38.	PR: CREEPS FORWARD 1.8m (6')	0 ☐	1 ☐	2 ☐	3 ☐	38.
*	39.	4 POINT: MAINTAINS, WEIGHT ON HANDS AND KNEES, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	39.
*	40.	4 POINT: ATTAINS SIT ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	40.
*	41.	PR: ATTAINS 4 POINT, WEIGHT ON HANDS AND KNEES	0 ☐	1 ☐	2 ☐	3 ☐	41.
*	42.	4 POINT: REACHES FORWARD WITH R ARM, HAND ABOVE SHOULDER LEVEL	0 ☐	1 ☐	2 ☐	3 ☐	42.
*	43.	4 POINT: REACHES FORWARD WITH L ARM, HAND ABOVE SHOULDER LEVEL	0 ☐	1 ☐	2 ☐	3 ☐	43.
*	44.	4 POINT: CRAWLS OR HITCHES FORWARD 1.8m (6')	0 ☐	1 ☐	2 ☐	3 ☐	44.
*	45.	4 POINT: CRAWLS RECIPROCALLY FORWARD 1.8m (6')	0 ☐	1 ☐	2 ☐	3 ☐	45.
*	46.	4 POINT: CRAWLS UP 4 STEPS ON HANDS AND KNEES/FEET	0 ☐	1 ☐	2 ☐	3 ☐	46.
	47.	4 POINT: CRAWLS BACKWARDS DOWN 4 STEPS ON HANDS AND KNEES/FEET	0 ☐	1 ☐	2 ☐	3 ☐	47.
*	48.	SIT ON MAT: ATTAINS HIGH KN USING ARMS, MAINTAINS, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	48.
	49.	HIGH KN: ATTAINS HALF KN ON R KNEE USING ARMS, MAINTAINS, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	49.
	50.	HIGH KN: ATTAINS HALF KN ON L KNEE USING ARMS, MAINTAINS, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	50.
*	51.	HIGH KN: KN WALKS FORWARD 10 STEPS, ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	51.

TOTAL DIMENSION C ☐

	Item	D: STANDING	SCORE				NT
*	52.	ON THE FLOOR: PULLS TO STD AT LARGE BENCH	0 ☐	1 ☐	2 ☐	3 ☐	52.
*	53.	STD: MAINTAINS, ARMS FREE, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	53.
*	54.	STD: HOLDING ON TO LARGE BENCH WITH ONE HAND, LIFTS R FOOT, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	54.
*	55.	STD: HOLDING ON TO LARGE BENCH WITH ONE HAND, LIFTS L FOOT, 3 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	55.
*	56.	STD: MAINTAINS, ARMS FREE, 20 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	56.
*	57.	STD: LIFTS L FOOT, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	57.
*	58.	STD: LIFTS R FOOT, ARMS FREE, 10 SECONDS	0 ☐	1 ☐	2 ☐	3 ☐	58.
*	59.	SIT ON SMALL BENCH: ATTAINS STD WITHOUT USING ARMS	0 ☐	1 ☐	2 ☐	3 ☐	59.
*	60.	HIGH KN: ATTAINS STD THROUGH HALF KN ON R KNEE, WITHOUT USING ARMS	0 ☐	1 ☐	2 ☐	3 ☐	60.
*	61.	HIGH KN: ATTAINS STD THROUGH HALF KN ON L KNEE, WITHOUT USING ARMS	0 ☐	1 ☐	2 ☐	3 ☐	61.
*	62.	STD: LOWERS TO SIT ON FLOOR WITH CONTROL, ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	62.
*	63.	STD: ATTAINS SQUAT, ARMS FREE	0 ☐	1 ☐	2 ☐	3 ☐	63.
*	64.	STD: PICKS UP OBJECT FROM FLOOR, ARMS FREE, RETURNS TO STAND	0 ☐	1 ☐	2 ☐	3 ☐	64.

TOTAL DIMENSION D ☐

Item		E: WALKING, RUNNING & JUMPING	SCORE				NT
*	65.	STD, 2 HANDS ON LARGE BENCH: CRUISES 5 STEPS TO R	0 ☐	1 ☐	2 ☐	3 ☐	65.
*	66.	STD, 2 HANDS ON LARGE BENCH: CRUISES 5 STEPS TO L	0 ☐	1 ☐	2 ☐	3 ☐	66.
*	67.	STD, 2 HANDS HELD: WALKS FORWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	67.
*	68.	STD, 1 HAND HELD: WALKS FORWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	68.
*	69.	STD: WALKS FORWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	69.
*	70.	STD: WALKS FORWARD 10 STEPS, STOPS, TURNS 180°, RETURNS	0 ☐	1 ☐	2 ☐	3 ☐	70.
*	71.	STD: WALKS BACKWARD 10 STEPS	0 ☐	1 ☐	2 ☐	3 ☐	71.
*	72.	STD: WALKS FORWARD 10 STEPS, CARRYING A LARGE OBJECT WITH 2 HANDS	0 ☐	1 ☐	2 ☐	3 ☐	72.
*	73.	STD: WALKS FORWARD 10 CONSECUTIVE STEPS BETWEEN PARALLEL LINES 20cm (8") APART	0 ☐	1 ☐	2 ☐	3 ☐	73.
*	74.	STD: WALKS FORWARD 10 CONSECUTIVE STEPS ON A STRAIGHT LINE 2cm (3/4") WIDE	0 ☐	1 ☐	2 ☐	3 ☐	74.
*	75.	STD: STEPS OVER STICK AT KNEE LEVEL, R FOOT LEADING	0 ☐	1 ☐	2 ☐	3 ☐	75.
*	76.	STD: STEPS OVER STICK AT KNEE LEVEL, L FOOT LEADING	0 ☐	1 ☐	2 ☐	3 ☐	76.
*	77.	STD: RUNS 4.5m (15'), STOPS & RETURNS	0 ☐	1 ☐	2 ☐	3 ☐	77.
*	78.	STD: KICKS BALL WITH R FOOT	0 ☐	1 ☐	2 ☐	3 ☐	78.
*	79.	STD: KICKS BALL WITH L FOOT	0 ☐	1 ☐	2 ☐	3 ☐	79.
*	80.	STD: JUMPS 30cm (12") HIGH, BOTH FEET SIMULTANEOUSLY	0 ☐	1 ☐	2 ☐	3 ☐	80.
*	81.	STD: JUMPS FORWARD 30 cm (12"), BOTH FEET SIMULTANEOUSLY	0 ☐	1 ☐	2 ☐	3 ☐	81.
*	82.	STD ON R FOOT: HOPS ON R FOOT 10 TIMES WITHIN A 60cm (24") CIRCLE	0 ☐	1 ☐	2 ☐	3 ☐	82.
*	83.	STD ON L FOOT: HOPS ON L FOOT 10 TIMES WITHIN A 60cm (24") CIRCLE	0 ☐	1 ☐	2 ☐	3 ☐	83.
*	84.	STD, HOLDING 1 RAIL: WALKS UP 4 STEPS, HOLDING 1 RAIL, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	84.
*	85.	STD, HOLDING 1 RAIL: WALKS DOWN 4 STEPS, HOLDING 1 RAIL, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	85.
*	86.	STD: WALKS UP 4 STEPS, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	86.
*	87.	STD: WALKS DOWN 4 STEPS, ALTERNATING FEET	0 ☐	1 ☐	2 ☐	3 ☐	87.
*	88.	STD ON 15cm (6") STEP: JUMPS OFF, BOTH FEET SIMULTANEOUSLY	0 ☐	1 ☐	2 ☐	3 ☐	88.

TOTAL DIMENSION E ☐

Was this assessment indicative of this child's "regular" performance? YES ☐ NO ☐

COMMENTS:

GMFM RAW SUMMARY SCORE

DIMENSION	CALCULATION OF DIMENSION % SCORES				GOAL AREA (indicated with ✓ check)
A. Lying & Rolling	Total Dimension A / 51	= ____ / 51	× 100 =	____ %	A. ☐
B. Sitting	Total Dimension B / 60	= ____ / 60	× 100 =	____ %	B. ☐
C. Crawling & Kneeling	Total Dimension C / 42	= ____ / 42	× 100 =	____ %	C. ☐
D. Standing	Total Dimension D / 39	= ____ / 39	× 100 =	____ %	D. ☐
E. Walking, Running & Jumping	Total Dimension E / 72	= ____ / 72	× 100 =	____ %	E. ☐

TOTAL SCORE = $\frac{\%A + \%B + \%C + \%D + \%E}{\text{Total \# of Dimensions}}$

= $\frac{\_\_ + \_\_ + \_\_ + \_\_ + \_\_}{5}$ = $\frac{\_\_\_\_}{5}$ = ____ %

GOAL TOTAL SCORE = $\frac{\text{Sum of \% scores for each dimension identified as a goal area}}{\text{\# of Goal areas}}$

= ____________ = ____ %

TESTING WITH AIDS/ORTHOSES

Indicate below with a check (✓) which aid/orthosis was used and what dimension it was first applied. (There may be more than one).

AID		DIMENSION	ORTHOSIS		DIMENSION
Rollator/Pusher	☐	____	Hip Control	☐	____
Walker	☐	____	Knee Control	☐	____
H Frame Crutches	☐	____	Ankle-Foot Control	☐	____
Crutches	☐	____	Foot Control	☐	____
Quad Cane	☐	____	Shoes	☐	____
Cane	☐	____	None	☐	____
None	☐	____	Other ____________ (please specify)	☐	____
Other ____________ (please specify)	☐	____			

RAW SUMMARY SCORE USING AIDS/ORTHOSES

DIMENSION	CALCULATION OF DIMENSION % SCORES			GOAL AREA (indicated with ✓ check)
F. Lying & Rolling	Total Dimension A / 51	= ____ / 51	× 100 = ____ %	A. ☐
G. Sitting	Total Dimension B / 60	= ____ / 60	× 100 = ____ %	B. ☐
H. Crawling & Kneeling	Total Dimension C / 42	= ____ / 42	× 100 = ____ %	C. ☐
I. Standing	Total Dimension D / 39	= ____ / 39	× 100 = ____ %	D. ☐
J. Walking, Running & Jumping	Total Dimension E / 72	= ____ / 72	× 100 = ____ %	E. ☐

TOTAL SCORE = (%A + %B + %C + %D + %E) / Total # of Dimensions

= (___ + ___ + ___ + ___ + ___) / 5 = ____ / 5 = ____ %

GOAL TOTAL SCORE = Sum of % scores for each dimension identified as a goal area / # of Goal areas

= ____________ = ______ %

Appendix 8: An example of PedsQL® - ages 8-12.

ID# ______________________

Date:______________________

PedsQL ™

Pediatric Quality of Life Inventory

Version 4.0

PARENT REPORT for **CHILDREN** (ages **8-12**)

DIRECTIONS

On the following page is a list of things that might be a problem for **your child**. Please tell us **how much of a problem** each one has been for **your child** during the **past ONE month** by circling:

0 if it is **never** a problem
1 if it is **almost never** a problem
2 if it is **sometimes** a problem
3 if it is **often** a problem
4 if it is **almost always** a problem

There are no right or wrong answers.
If you do not understand a question, please ask for help.

In the past ***ONE month,*** *how much of a* ***problem*** *has your child had with …*

PHYSICAL FUNCTIONING *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. Walking more than one block	0	1	2	3	4
2. Running	0	1	2	3	4
3. Participating in sports activity or exercise	0	1	2	3	4
4. Lifting something heavy	0	1	2	3	4
5. Taking a bath or shower by him or herself	0	1	2	3	4
6. Doing chores around the house	0	1	2	3	4
7. Having hurts or aches	0	1	2	3	4
8. Low energy level	0	1	2	3	4

EMOTIONAL FUNCTIONING *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. Feeling afraid or scared	0	1	2	3	4
2. Feeling sad or blue	0	1	2	3	4
3. Feeling angry	0	1	2	3	4
4. Trouble sleeping	0	1	2	3	4
5. Worrying about what will happen to him or her	0	1	2	3	4

SOCIAL FUNCTIONING *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. Getting along with other children	0	1	2	3	4
2. Other kids not wanting to be his or her friend	0	1	2	3	4
3. Getting teased by other children	0	1	2	3	4
4. Not able to do things that other children his or her age can do	0	1	2	3	4
5. Keeping up when playing with other children	0	1	2	3	4

SCHOOL FUNCTIONING *(problems with…)*	Never	Almost Never	Some-times	Often	Almost Always
1. Paying attention in class	0	1	2	3	4
2. Forgetting things	0	1	2	3	4
3. Keeping up with schoolwork	0	1	2	3	4
4. Missing school because of not feeling well	0	1	2	3	4
5. Missing school to go to the doctor or hospital	0	1	2	3	4

Appendix 9: STROBE statement – checklist of items that should be included in report of cohort studies – checklist of experimental study.

Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	vi
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Chapter 3 – start on pg89
Objectives	3	State specific objectives, including any pre-specified hypotheses	Chapter 6 – start on page 183
Methods			
Study design	4	Present key elements of study design early in the paper	Chapter 6 – start on page 183
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Chapter 6 – start on page 186
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	Chapter 6 – start on page 186
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Chapter 6 – start on page 185
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Chapter 6 – start on page 185
Bias	9	Describe any efforts to address potential sources of bias	Chapter 6 – start on page 203

Study size	10	Explain how the study size was arrived at	Chapter 6 – start on 183
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Chapter 6 – start on page 200
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	Chapter 6 – start on page 200
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	Chapter 7 – start on page 204
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	Chapter 7 – pg. 206
Outcome data	15*	Report numbers of outcome events or summary measures over time	Chapter 7 – starts on page 206

Appendix 10: Normality test of the data.

1- **GMFM**

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
total1	9	0.90374	1.414	0.599	0.27448
total2	9	0.95828	0.613	-0.773	0.78012
total3	9	0.93604	0.940	-0.103	0.54087
A1porc	9	0.85621	2.113	1.358	0.08718
A2porc	9	0.79292	3.042	2.121	0.01695
A3porc	9	0.65792	5.026	3.316	0.00046
B1porc	9	0.71895	4.129	2.825	0.00236
B2porc	9	0.78478	3.162	2.207	0.01367
B3porc	9	0.87961	1.769	1.013	0.15556
C1porc	9	0.92739	1.067	0.108	0.45686
C2porc	9	0.96746	0.478	-1.137	0.87214
C3porc	9	0.96018	0.585	-0.842	0.80021
D1porc	9	0.86090	2.044	1.293	0.09807
D2porc	9	0.88550	1.682	0.918	0.17926
D3porc	9	0.88686	1.662	0.896	0.18519
E1porc	9	0.82924	2.509	1.708	0.04379
E2porc	9	0.83627	2.406	1.621	0.05248
E3porc	9	0.83638	2.404	1.620	0.05264

2- MAS – lower limbs

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
quadr11	20	0.96889	0.736	-0.616	0.73121
quadr21	20	0.95514	1.062	0.121	0.45187
quadr31	19	0.93293	1.531	0.856	0.19604
harmsr11	20	0.96768	0.765	-0.540	0.70530
harmsr21	20	0.96665	0.789	-0.476	0.68314
harmsr31	18	0.92582	1.631	0.979	0.16388
gastror11	20	0.98510	0.353	-2.101	0.98217
gastror21	20	0.96455	0.839	-0.354	0.63823
gastror31	18	0.94336	1.245	0.439	0.33050
tibantr11	20	0.93452	1.550	0.883	0.18861
tibantr21	20	0.94404	1.325	0.566	0.28556
tibantr31	18	0.95167	1.062	0.121	0.45174
hipaddr11	20	0.92172	1.853	1.243	0.10695
hipaddr21	20	0.90988	2.133	1.527	0.06341
hipaddr31	18	0.94610	1.185	0.340	0.36711
hipabdr11	20	0.89744	2.428	1.787	0.03693
hipabdr21	20	0.89641	2.452	1.808	0.03534
hipabdr31	18	0.94522	1.204	0.372	0.35500
quadl11	20	0.93505	1.537	0.867	0.19302
quadl21	20	0.91459	2.022	1.419	0.07800
quadl31	18	0.98077	0.423	-1.723	0.95756
halmsl11	20	0.95470	1.072	0.141	0.44406
halmsl21	20	0.96097	0.924	-0.160	0.56340
halmsl31	18	0.92582	1.631	0.979	0.16388
gastlol11	20	0.98863	0.269	-2.645	0.99591
gastlol21	20	0.96172	0.906	-0.199	0.57880
gastlol31	18	0.92800	1.583	0.919	0.17906
tibantl11	20	0.93959	1.430	0.721	0.23551
tibantl21	20	0.96428	0.846	-0.338	0.63229
tibantl31	18	0.92800	1.583	0.919	0.17906
hipaddl11	20	0.94471	1.309	0.542	0.29380
hipaddl21	20	0.90988	2.133	1.527	0.06341
hipaddl31	18	0.94924	1.116	0.219	0.41318
hipabdl11	20	0.92832	1.697	1.065	0.14335
hipabdl21	20	0.89641	2.452	1.808	0.03534
hipabdl31	18	0.94906	1.120	0.226	0.41051

3 – MAS – upper limbs

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
bicepsr1g1	20	0.90810	2.175	1.566	0.05864
bicepsr2g1	20	0.95453	1.076	0.148	0.44102
bicepsr3g1	18	0.98897	0.243	-2.835	0.99771
tricepsr1g1	20	0.99503	0.118	-4.313	0.99999
tricepsr2g1	20	0.98663	0.316	-2.319	0.98980
tricepsr3g1	18	0.89935	2.212	1.589	0.05598
wristfl~r1g1	20	0.88917	2.623	1.944	0.02597
wristfl~r2g1	20	0.90321	2.291	1.671	0.04739
wristfl~r3g1	18	0.87381	2.774	2.042	0.02057
wristextr1g1	20	0.96851	0.745	-0.592	0.72306
wristextr2g1	20	0.92774	1.710	1.082	0.13971
wristextr3g1	18	0.84649	3.374	2.434	0.00746
shoulfl~r1g1	20	0.93916	1.440	0.735	0.23112
shoulfl~r2g1	20	0.93932	1.436	0.730	0.23277
shoulfl~r3g1	18	0.87830	2.675	1.970	0.02444
shouldetr1g1	20	0.88747	2.664	1.974	0.02417
shouldetr2g1	20	0.88179	2.798	2.074	0.01906
shouldetr3g1	18	0.82583	3.829	2.687	0.00360
shoulabdr1g1	20	0.97573	0.575	-1.117	0.86798
shoulabdr2g1	20	0.90163	2.329	1.703	0.04424
shoulabdr3g1	18	0.84890	3.321	2.403	0.00814
shoulda~r1g1	20	0.88747	2.664	1.974	0.02417
shoulda~r2g1	20	0.86054	3.301	2.407	0.00805
shoulda~r3g1	18	0.84890	3.321	2.403	0.00814
interotr1g1	20	0.92774	1.710	1.082	0.13971
interotr2g1	20	0.85440	3.446	2.494	0.00632
interotr3g1	18	0.84890	3.321	2.403	0.00814
extrotr1g1	20	0.95277	1.118	0.225	0.41109
extrotr2g1	20	0.88179	2.798	2.074	0.01906
extrotr3g1	18	0.99820	0.040	-6.464	1.00000
bicepsl1g1	20	0.95710	1.015	0.031	0.48766
bicepsl2g1	20	0.93918	1.440	0.734	0.23134
bicepsl3g1	18	0.98094	0.419	-1.741	0.95918
tricepsl1g1	20	0.99695	0.072	-5.296	1.00000
tricepsl2g1	20	0.98947	0.249	-2.800	0.99744

tricepsl3g1 |	18	0.89548	2.297	1.665	0.04796
wristfl~l1g1 |	20	0.99679	0.076	-5.193	1.00000
wristfl~l2g1 |	20	0.94252	1.361	0.621	0.26741
wristfl~l3g1 |	18	0.75116	5.470	3.401	0.00034
wristextl1g1 |	20	0.86285	3.246	2.373	0.00882
wristextl2g1 |	20	0.91385	2.039	1.436	0.07551
wristextl3g1 |	18	0.78287	4.773	3.128	0.00088
shoulfl~l1g1 |	20	0.99470	0.126	-4.183	0.99999
shoulfl~l2g1 |	20	0.95003	1.183	0.338	0.36750
shoulfl~l3g1 |	18	0.86924	2.874	2.113	0.01729
shouldetl1g1 |	20	0.94350	1.337	0.586	0.27903
shouldetl2g1 |	20	0.96495	0.830	-0.377	0.64676
shouldetl3g1 |	18	0.82323	3.886	2.717	0.00330
shoulabdl1g1 |	20	0.99710	0.069	-5.398	1.00000
shoulabdl2g1 |	20	0.96765	0.766	-0.538	0.70479
shoulabdl3g1 |	18	0.99820	0.040	-6.464	1.00000
shoulda~l1g1 |	20	0.96765	0.766	-0.538	0.70479
shoulda~l2g1 |	20	0.95505	1.064	0.125	0.45031
shoulda~l3g1 |	18	0.99820	0.040	-6.464	1.00000
interotl1g1 |	20	0.95718	1.014	0.027	0.48912
interotl2g1 |	20	0.92376	1.805	1.190	0.11706
interotl3g1 |	18	0.82323	3.886	2.717	0.00330
extrotl1g1 |	20	0.84866	3.582	2.572	0.00506
extrotl2g1 |	20	0.82239	4.204	2.894	0.00190
extrotl3g1 |	18	0.90713	2.041	1.428	0.07659

4 – Static Balance

Shapiro-Wilk W test for normal data

Variable |	Obs	W	V	z	Prob>z
InterSwayAP1 |	8	0.94941	0.705	-0.540	0.70532
InterSwayAP2 |	4	0.95857	0.478	-0.738	0.76988
InterSwayAP3 |	8	0.91640	1.165	0.250	0.40133
InterSwayML1 |	8	0.95182	0.671	-0.611	0.72952
InterSwayML2 |	4	0.89764	1.181	0.203	0.41941
InterSwayML3 |	8	0.74970	3.487	2.404	0.00811
InterSwayT~1 |	8	0.95240	0.663	-0.629	0.73542
InterSwayT~2 |	4	0.92031	0.919	-0.097	0.53869
InterSwayT~3 |	8	0.79957	2.792	1.906	0.02833

Shapiro-Wilk W test for normal data

Variable |	Obs	W	V	z	Prob>z

Variable	Obs	W	V	z	Prob>z
InterVelo~P1	8	0.94082	0.824	-0.303	0.61920
InterVelo~P2	4	0.95780	0.487	-0.723	0.76505
InterVelo~P3	8	0.93236	0.942	-0.095	0.53781
InterVelo~L1	8	0.95258	0.661	-0.635	0.73723
InterVelo~L2	3	0.85183	2.212	0.689	0.24533
InterVelo~L3	8	0.75690	3.387	2.336	0.00973
InterVelo~l1	8	0.94613	0.750	-0.446	0.67224
InterVelo~l2	4	0.91997	0.923	-0.092	0.53678
InterVelo~l3	8	0.79952	2.793	1.907	0.02829

5 – Dyamic Balance

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
SwaypathAP1	8	0.88730	1.570	0.769	0.22080
SwaypathML1	8	0.95848	0.578	-0.826	0.79552
SwayPathtot1	8	0.92062	1.106	0.164	0.43492
SwayVtot1	8	0.91873	1.132	0.203	0.41961
SwayVAP1	8	0.88767	1.565	0.764	0.22258
SwayVML1	8	0.95679	0.602	-0.769	0.77902
SwaypathAP2	9	0.81606	2.703	1.865	0.03110
SwaypathML2	9	0.91409	1.262	0.397	0.34554
SwayPathtot2	9	0.89188	1.589	0.811	0.20857
SwayVtot2	9	0.96676	0.488	-1.106	0.86571
SwayVAP2	9	0.91271	1.282	0.425	0.33534
SwayVML2	9	0.96770	0.475	-1.147	0.87434
SwaypathAP3	9	0.88324	1.715	0.955	0.16979
SwaypathML3	9	0.93228	0.995	-0.009	0.50339
SwayPathtot3	9	0.92235	1.141	0.222	0.41202
SwayVtot3	9	0.92475	1.106	0.169	0.43305
SwayVAP3	9	0.88273	1.723	0.963	0.16771
SwayVML3	9	0.92968	1.033	0.054	0.47829

6 – Quality of Life

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
Total1	9	0.97827	0.319	-1.693	0.95479
Total2	9	0.90346	1.418	0.605	0.27275

Total3	**9**	**0.92524**	**1.098**	**0.158**	**0.43741**
Physical1	**9**	**0.86293**	**2.014**	**1.264**	**0.10317**
Physical2	**9**	**0.93599**	**0.940**	**-0.101**	**0.54036**
Physical3	**9**	**0.92582**	**1.090**	**0.144**	**0.44259**
Emotional1	**9**	**0.98432**	**0.230**	**-2.115**	**0.98277**
Emotional2	**9**	**0.96377**	**0.532**	**-0.982**	**0.83686**
Emotional3	**9**	**0.93241**	**0.993**	**-0.012**	**0.50462**
Social1	**9**	**0.96388**	**0.531**	**-0.986**	**0.83794**
Social2	**9**	**0.99414**	**0.086**	**-3.260**	**0.99944**
Social3	**9**	**0.96823**	**0.467**	**-1.171**	**0.87916**
School1	**9**	**0.96028**	**0.584**	**-0.846**	**0.80130**
School2	**9**	**0.97213**	**0.410**	**-1.355**	**0.91228**
School3	**9**	**0.97894**	**0.309**	**-1.735**	**0.95862**

“I stand

On the sacrifices

Of a million women before me

Thinking

What can I do

To make this mountain taller

So the women after me

Can see further?”

Rupi Kaur

I hope this somehow, make you all see further! Marielle Franco, Presente!