ANGLIA RUSKIN UNIVERSITY

FACULTY OF SCIENCE AND ENGINEERING

AN INVESTIGATION INTO THE PREVALENCE OF PRIMARY AND SECONDARY EXERCISE ADDICTION, THEIR CORRELATES, AND DETECTION

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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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Acknowledgments

‘In 2018, a crack commando unit were sent to prison by a military court for a crime they didn’t commit. These men promptly escaped from a maximum service stockade to Anglia Ruskin University. Today, still wanted by the government they survive as soldiers of fortune, supervising and generally assisting doctoral students in their studies. If you have a problem, if no one else can help, and if you can find them… maybe you can hire The A-Team’.

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Abstract

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Introduction: Exercise addiction is a disorder where an exerciser loses control over exercise habits and acts compulsively, and can be a primary disorder, or secondary to an eating disorder. However, it is unknown if primary and secondary exercise addiction have different aetiologies. This thesis aims to examine differences between prevalence and correlates of primary and secondary exercise addiction and produces a novel screening tool for the detection of primary and secondary exercise addiction.

Methods: Chapter 2 examines existing literature to determine if exercise addiction (a) exists in the absence of eating disorders, and (b) yields different prevalence rates in populations with-vs-without eating disorders. Chapter 3 examines differences between exercise motivations and body dysmorphic disorder in populations with-versus-without eating disorders. Chapter 4 describes the creation and validation of a questionnaire able to stratify people at risk of primary or secondary exercise addiction.

Results: Chapter 2 reports that people with indicated eating disorders were 3.7 (95%CI 2.0-6.9) times more likely to be at risk of exercise addiction than people without indicated eating disorders. Chapter 3 reports that differing types of exercise motivation and body dysmorphic disorder were significant predictors of exercise addiction only in participants without indicated eating disorders (p=<0.05). These results suggest that primary and secondary exercise addiction have differing aetiologies, and the development of a tool able to stratify primary and secondary exercise addiction was warranted. Chapter 4 develops and pilots a new exercise addiction screening tool that was found to be reliable and valid.

Conclusions: Exercise addiction appears to have differing aetiologies dependant on eating disorder status, which could have important implications for exercise addiction treatment. The Secondary Exercise Addiction Scale is a valid and reliable tool for simple stratification of primary and secondary exercise addiction, and could be used in several contexts, including in research and in practice.

Keywords: exercise addiction; eating disorders; exercise dependence; pathological exercise; obligatory exercise; disordered eating

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Table of Abbreviations

AN	Anorexia nervosa
AUC	Area under the curve
BDD	Body dysmorphic disorder
BDDQ	Body dysmorphic disorder questionnaire
BMI	Body mass index
BN	Bulimia nervosa
CET	Compulsive exercise test
CFA	Maximum likelihood confirmatory factor analysis
CFI	Comparative fit index
CI	Confidence interval
CPAS	Commitment to physical activity scale
DSM-IV	Diagnostic and Statistical Manual for Mental Disorders IV
DSM-5	Diagnostic and Statistical Manual for Mental Disorders 5
EAI	Exercise addiction inventory
EAI-R	Revised exercise addiction inventory
EAT-40	Eating attitudes test 40
EAT-26	Eating attitudes test 26
EBQ	Exercise beliefs questionnaire
EDEQ	Eating disorder examination questionnaire
EDI-2	Eating disorder inventory 2
EDNOS	Eating disorder not otherwise specified
EDQ	Exercise dependence questionnaire
EDS	Exercise dependence scale
EDS-R	Revised exercise dependence scale
EFA	Exploratory factor analysis
ICC	Intra-class coefficient
IL-6	Interleukin 6
KMO	Kaiser-Meyer-Olkin
NOS	Newcastle-Ottawa scale
OEQ	Obligatory exercise questionnaire
OR	Odds ratio
PCA	Principal Component Analysis
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
QEDD	Questionnaire for eating disorders diagnosis
REI	Reasons for exercise inventory
RMSEA	Root mean square error of approximation
ROC	Radio operator characteristic
SD	Standard deviation
SEAS	Secondary exercise addiction scale
SMUIS	Social media use integration scale
STROBE	Strengthening of the reporting of observational studies in epidemiology
TLI	Tucker-Lewis index
WHO	World Health Organisation

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a) **Trott, M.,** Johnstone, J., Firth, J., Grabovac, I., Smith, L. 2020 Prevalence and correlates of body dysmorphic disorder in health club users in the presence vs absence of eating disorder symptomology. *Eating and Weight Disorders.* *https://doi.org/*10.1007/s40519-020-01018-y

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b) **Trott, M**; Jackson, S; Firth, J; Fisher, A; Johnstone, J; Mistry, A; Stubbs, Smith, L. 2020. Exercise addiction prevalence and correlates in the absence of eating disorder symptomology. A systematic review and meta-analysis. *Journal of Addiction Medicine.* DOI: 10.1097/ADM.0000000000000664

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c) **Trott M**., Jackson, S., Firth, J., Jacob, L., Grabovac, I., Mistry, A., Stubbs, B., Smith, L., 2020. A comparative meta-analysis of the prevalence of exercise addiction in adults with and without disordered eating. *Eating and Weight Disorders.* DOI: https://doi.org/10.1007/s40519-019-00842-1

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d) **Trott M**., Johnstone, J., Pardhan, S., Barnett, Y., Smith, L. 2021. Changes in body dysmorphic disorder, eating disorder, and exercise addiction symptomology during the COVID-19 pandemic: A longitudinal study of 319 health club users. *Psychiatry Research*. DOI: https://doi.org/10.1016/j.psychres.2021.113831

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Chapter 1: Introduction, background and rationale.

1.1 Chapter 1 abbreviations

Table 1.1: Chapter 1 abbreviations

BMI	Body mass index
CET	Compulsive exercise test
CPAS	Commitment to physical activity scale
EAI	Exercise addiction inventory
EAI-R	Revised exercise addiction inventory
EBQ	Exercise beliefs questionnaire
EDQ	Exercise dependence questionnaire
EDS	Exercise dependence scale
EDS-R	Revised exercise dependence scale
IL-6	Interleukin 6
OEQ	Obligatory exercise questionnaire
WHO	World Health Organisation

1.2 Introduction

'*We may begin running "just to stay in shape" but soon are seduced by the sense of clarity, energy, and self-esteem accompanying the daily run. Having achieved reasonable conditioning, we run farther and faster in an attempt to find our peak. It is at this point that our tragic flaw emerges. Our gluttony may once again conquer us.*'

(Bittker, 1977, p10-11)

Exercise can be defined as 'structured, intentional physical activity for improving health and fitness' (Garber et al., 2011). Benefits of regular exercise in adults (18 years and over) include lower risk of all-cause mortality, several types of non-communicable disease (Warburton and Bredin, 2017), improved cognitive function, and improvements in several areas of mental health (Ashdown-Franks, Sabiston and Stubbs, 2019). The UK Department of Health (2019) recommends that adults complete 150 minutes of moderate intensity physical activity per week (among other recommendations), guidelines to which 61% of adults are reported to adhere to. Despite the various positive health outcomes, exercise can become excessive to an extent where the exerciser experiences negative social and physiological symptoms, including training through injury, withdrawal symptoms, and the detriment of important social relationships through excessive exercise (Landolfi, 2013). Case studies have reported these people to have exercise related financial debts, trouble concentrating, with some individuals reporting that 'their life becomes unbearable' if they cannot exercise (Griffiths, 1997). Such an extreme relationship with exercise has been termed in several ways, including 'exercise addiction', 'exercise dependence', 'obligatory exercise', and 'excessive exercise', with the terms being used synonymously in the literature (Szabo et al., 2015).

In this thesis, the term exercise addiction will be used as an umbrella term, with the definition based on definitions by the American Psychiatric Association (2013), and Szabo et al., (2015):

A morbid pattern of behaviour in which the habitually exercising individual loses control over his or her exercise habits and acts compulsively, exhibits dependence, to the extent in which exercise significantly interferes with important activities, occurs in inappropriate times or settings, or continues despite injury or other medical complications.

1.3 Initial Conceptualisation

The study of exercise addiction can be traced back to 1970, when Baekeland (1970) attempted to recruit exercisers for a study exploring exercise deprivation and sleep patterns, which involved abstaining from exercise for one month. Whilst not having difficulty in finding subjects generally, Baekeland had difficulty recruiting participants who exercised for more than four times per week, despite there being a higher financial incentive. Whilst conducting the study, the participants who previously trained for more than 3 days per week suffered from sleep and psychological symptoms akin to withdrawal symptoms from known addictions (such as alcohol and substance addictions) (Baekeland, 1970). Glasser (1976) later categorised exercise addiction as a 'positive addiction', describing in this book how a positive addiction to exercise can inflict 'extreme pleasure, increased mental strength and mystical transcendence', can help overcome 'negative' addictions (such as drug abuse), and that a positive addiction to exercise can lead one to a 'positive and rewarding life'. Glasser did, paradoxically, comment that 'positively' addicted exercisers may suffer from symptoms of withdrawal upon cessation. Exercise addiction as a negative phenomenon was first postulated by Morgan (1979), who stated that exercise has the potential to become a 'negative addiction', particularly in runners. Morgan compared runners who continually exercise through injuries to the point of being treated by a physician for serious ailments to drug users, noting several anecdotal reports and case studies of exercise addiction from the medical profession, and described exercise addicted individuals (in the context of the runner) as:

1. 'The person must require daily exercise to cope and believe that he or she cannot live without daily running.'

and

2. 'If deprived of exercise, the person must manifest various withdrawal symptoms.'

(Morgan, 1979, p59)

The potential link between eating disorders and negative exercise behaviours was first described four years after Morgan commented on the potential negative effects of exercise, with one case study reporting psychological similarities between 'obligatory runners' and anorexic patients (Yates, Leehey and Shisslak, 1983). This study was widely criticised, however, for being much too general and failing to support their findings with device-based data (Blumenthal, O'Toole and Chang, 1984). Indeed, their results were contradicted in later

studies that objectively compared negative psychological symptoms between patients diagnosed with anorexia nervosa and 'obligatory runners' and found significant differences between the two groups, with 'negative runners' displaying normal psychological pathology (Blumenthal, O'Toole and Chang, 1984).

Exercise addiction in the context of general exercise (rather than in just runners) and eating disorders was conceptualised by de Coverley Veale (1987), who asserted that exercise addiction can be categorised into two sub-categories: primary and secondary. Primary exercise addiction was defined as having exercise addiction with no evidence of another disorder of which the exercise addiction could be a symptom, such as an eating disorder. In contrast, secondary exercise addiction was defined as demonstrating another primary condition by which the exercise addiction can be accounted for as a symptom, most commonly an eating disorder. Moreover, extended diagnostic criteria was proposed for exercise addiction, which included:

- Narrowing of repertoire leading to a stereotyped pattern of exercise with a regular schedule once or more daily.
- Salience with the individual giving increasing priority over other activities to maintaining the pattern of exercise.
- Increased tolerance to the amount of exercise performed over the years.
- Withdrawal symptoms related to a disorder of mood following the cessation of the exercise schedule.
- Relief or avoidance of withdrawal symptoms by further exercise.
- Subjective awareness of a compulsion to exercise.
- Rapid reinstatement of the previous pattern of exercise aid withdrawal symptoms after a period of abstinence.

With the following 'associated features':

- Either the individual continues to exercise despite a serious physical disorder known to be caused, aggravated or
- prolonged by exercise and is advised as such by a health professional, or the individual has arguments or
- difficulties with a partner, family, friends, or occupation.
- Self-inflicted loss of weight by dieting as a means towards improving performance.

Furthermore, de Coverley Veale (1987) stated that people with primary and secondary exercise addiction exercise for different reasons. In primary exercise addiction, de Coverley Veale asserts, the main reason for exercise is being ‘an end to itself’, with any associated dieting being to improve performance, while in secondary exercise addiction, the main reason for exercise is as a means to lose weight, with associated fears of ‘fatness’ being indicative of a primary eating disorder.

More recently, the diagnostic criteria for exercise addiction has been predominately based on Griffiths' (1996, 1997) adaptations of Brown's (1993) general components of addiction, which include:

a) Salience: Where exercise becomes the most important thing in the exerciser’s life.

b) Mood modification: A purpose of the exercise is to avoid negative affect, rather than just because of the positive affect that exercise induces.

c) Tolerance: An increasing amount of exercise is needed to achieve the reduction of negative affect.

d) Withdrawal symptoms: The presence of negative psychological symptoms upon cessation (usually enforced), including (but not limited to), guilt, anxiousness, sluggishness, depression and lack of energy.

e) Conflict: Where exercise creates either an interpersonal, psychosocial, or intrapsychic conflict.

f) Relapse: Upon cessation there is a likelihood of the exerciser falling back into the same exercise behaviours as before.

(Szabo, Griffiths and Demetrovics, 2016)

1.4 Aetiological conceptualisations

Many theoretical models have been proposed to explain exercise addiction, including the Sympathetic Arousal Hypothesis (Thompson and Blanton, 1987), the Cognitive Appraisal Hypothesis (Szabo, 1995), the Interleuken-6 (IL-6) model (Hamer and Karageorghis, 2007), Four Phase model (Freimuth, Moniz and Kim, 2011), Biopsychosocial model (McNamara and McCabe, 2012). Furthermore, (Egorov and Szabo, 2013) updated the Cognitive Appraisal Hypothesis with their Interactional Model of Exercise Addiction. These are discussed in detail below:

1.4.1 The Sympathetic Arousal Hypothesis (Thompson and Blanton, 1987)

The Sympathetic Arousal Hypothesis suggests that the more an individual becomes physiologically efficient at exercise, the resulting chronic lower sympathetic arousal concentration leads to an overall lowering of arousal concentration, which may lead some people to experience this as lethargy or a lack of energy overall. It is hypothesised that exercise addicts would then seek out more exercise because of its acute effects on increasing arousal (Thompson and Blanton, 1987). Recent evidence has added some support to this hypothesis: Lichtenstein, Jensen and Szabo (2020) found a positive association between exercise addiction and the use of nutritional supplements, including supplements that are well known to increase arousal concentration, such as caffeine, and the authors conclude that it is possible that caffeine use is higher in exercise addicted individuals to further increase arousal concentration. The main limitation of this model is its simplicity: it does not account for other potential causes of exercise addiction, such as traumatic life events, eating disorders or body image issues. It also does not account for why some people can have a life-long healthy relationship with exercise without the need for exercise (or other methods) to increase arousal concentration.

1.4.2 The Cognitive Appraisal Hypothesis (Szabo, 1995)

The Cognitive Appraisal Hypothesis states that it is possible that the exercise can become a primary source of stress alleviation, leading to negative psychological symptoms, including the addition of more stress, upon cessation. Limitations to this model include limited physiological processes, and also fails to explain the onset of exercise addiction (Szabo, Griffiths and Demetrovics, 2016).

1.4.3 The IL-6 Model (Hamer and Karageorghis, 2007)

This model proposes that a trigger can cause interleuken-6 (IL-6) concentrations to rise, possibly causing negative affect, which can be exacerbated in individuals with an already low mental health state. This model has been widely criticised as being overly simplistic and insufficient to fully account for the possible psychological reasons for exercise addiction (Szabo, Griffiths and Demetrovics, 2016). Furthermore, the model does not specify what 'trigger' might cause IL-6 concentrations to rise.

1.4.4 The Four Phase Model (Freimuth, Moniz and Kim, 2011)

The Four Phase Model (see Figure 1.1) describes exercise addiction as a four-stage continuum, with recreational, healthy exercise at one end of the spectrum and exercise addiction at the other end. This model has been reported as the most frequently used model in the exercise addiction literature (Lim, 2020), possibly because it does not constrain itself to diagnostic criteria, and it is very simple and easy to understand. The Four Phase Model encompasses some of the elements of the Cognitive Appraisal Hypothesis (e.g. both models state that for exercise behaviours to become unhealthy a person relies on exercise as a means of coping with stress), however also shares a limitation with the Cognitive Appraisal Hypothesis: it does not fully explain why some people go through this continuum and why some people do not.

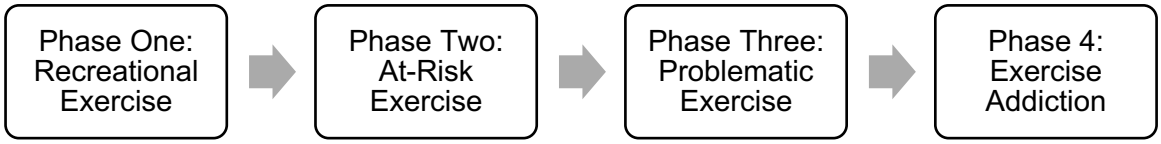

Figure 1.1 The Four Phase Model of Exercise Addiction (Freimuth, Moniz and Kim, 2011)

1.4.5 The Biopsychosocial Model (McNamara and McCabe, 2012)

The Biopsychosocial Model was developed to explain exercise addiction in elite athletes and was the first model to attempt at explaining the onset of exercise addiction in this population. The authors stated that the onset of exercise addiction in elite athletes could be due to biological factors, such as body mass index (BMI). It continues to describe how social and psychological processes interact to develop exercise addiction. Although this model has the potential to explain exercise addiction in athletes where there is a strong atheistic element (such as gymnastics), these populations also have significantly higher prevalence of eating disorders (Krentz and Warschburger, 2011; Sundgot-Borgen and Torstveit, 2004), which is not accounted for in this model and is a significant limitation. Moreover, several authors have questioned the generalisability of this model (Berczik et al., 2012; Szabo, Griffiths and Demetrovics, 2016).

1.4.6 The Interactive Model of Exercise Addiction (Egorov and Szabo, 2013)

The Interactive Model of Exercise Addiction (see Figure 1.2) describes how several complex and subjective factors can eventually lead to exercise addiction, such as personality, needs and values, exercise motivation, and perfectionism. It is the second model to incorporate the consideration that many people have a healthy relationship with exercise, suggests that exercise addiction could be part of a continuum (albeit a one-way one), and is also the only model that considers personality traits as a possible correlate. This model shares characteristics with the Cognitive Appraisal Hypothesis and the Four Phase model in that it states that a ‘sudden or progressively intolerable life-stress’, with exercise as a coping mechanism, is a major pre-cursor for potential exercise addiction.

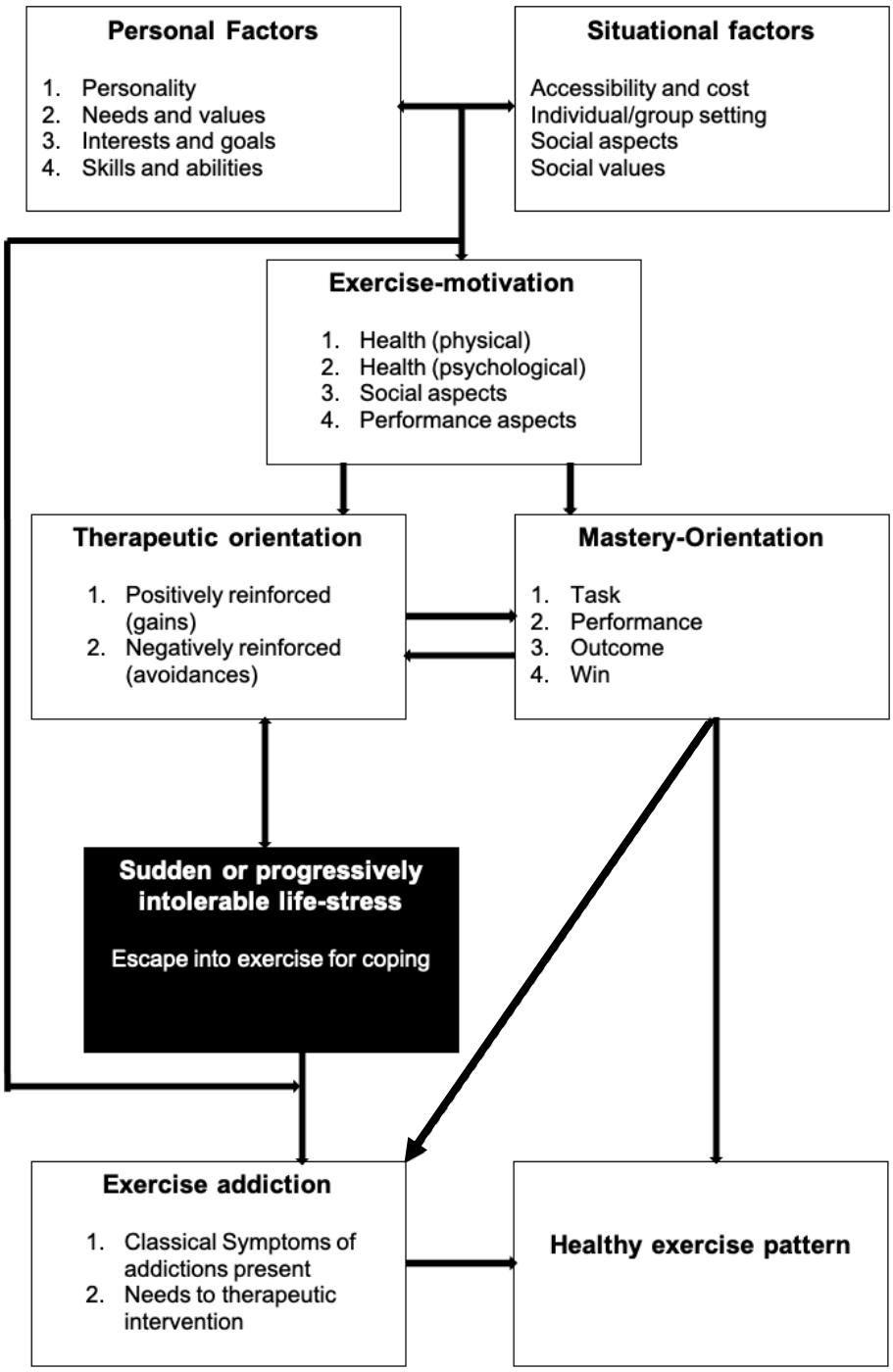

Figure 1.2: The Interactional Model of Exercise Addiction (Egorov and Szabo, 2013)

The disparities between these models indicate a lack of etiologic consensus amongst researchers in this field. Indeed, presently neither the World Health Organisation (WHO, 2019), or the American Psychiatric Association (2013) have any official diagnostic criteria for exercise addiction, with the American Psychiatric Association citing that the main reason of lack of diagnostic criteria being because of ‘a lack of peer-reviewed evidence’. Because of this, tools measuring symptoms of exercise addiction assess an individual being ‘at risk’ (Terry, Szabo and Griffiths, 2004; Symons Downs, Hausenblas and Nigg, 2004; Hausenblas and Symons Downs, 2002b; Pasman and Thompson, 1988), rather than being clinical diagnostic tools, which are discussed in the next section.

1.5 Measurement tools

Since de Coverley Veale's (1987) initial conceptualisation of exercise addiction, several screening measures have been developed for assessing risk of exercise addiction amongst several types of exercisers, including tools specific to running, and tools developed for general exercisers. Indeed, a recent systematic review has examined all the available exercise addiction tools for general exercisers (Álvaro Sicilia et al., 2021) which have been summarised in chronological order below:

1.5.1 Commitment to Physical Activity Scale (CPAS; Corbin et al., 1987)

The CPAS was developed as a general form of the Commitment to Running Scale (CRS; Carmack and Martens, 1979), with 11 items all loaded to one scale: physical activity commitment. This is a paucity of information, however, regarding the methodology of the development of this scale, apart from that the authors reworded parts of the CRS to adapt it for general exercisers. The CPAS is based on the conceptualisation that problematic exercise is part of a continuum, rather than a dichotomy, similar to the Four Phase Model of Exercise Addiction (Freimuth, Moniz and Kim, 2011).

1.5.2 Obligatory Exercise Questionnaire (OEQ; Pasman and Thompson, 1988)

The OEQ was developed as form of the Obligatory Running Questionnaire (Blumenthal, O'Toole and Chang, 1984), but for the generalised exercise population, rather than specifically for runner. The questionnaire contains 21 items all loaded onto one scale: obligatory exercise. There is a paucity of information on the methodology of development of this scale, and the scale does not appear to be based on any theoretical framework.

1.5.3 Exercise Dependence Questionnaire (EDQ; Ogden, Veale and Summers, 1997)

The EDQ was developed from semi-structured questionnaires and contains 29 items with eight sub-scales; interference with social / family / work life; positive reward; withdrawal symptoms; exercise for weight control; insight into problem; exercise for social reasons; exercise for health reasons; and stereotyped behaviour. Although the EDQ was reported as being broadly based on some of the Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) criteria for substance abuse (American Psychiatric Association, 2000), the scale also encompasses the measurement for exercise motivations and the methodology of conceptualisation have several limitations. Firstly, the questionnaire was developed using subjects who 'self-identified' as being addicted to exercise without any apparent guidance on

what constitutes exercise addiction, meaning that the group was likely to be highly heterogeneous. Secondly, the questionnaire does not appear to be based on any theoretical framework. Thirdly, the factor analysis of the scale failed to confirm their proposed model, making the validity of the questionnaire difficult to ascertain.

1.5.4 Exercise beliefs questionnaire (EBQ; Loumidis and Wells, 1998)

The EBQ was developed to measure exercise addiction (although the authors predominantly used the term 'exercise dependence', they also stated that exercise addiction can also be used interchangeably) with 21 items and four sub-scales: social desirability; physical appearance; mental and emotional function; and vulnerability to disease and ageing. The scale was developed using schema theory (Beck, 1978) as an underlying theoretical framework, theorising that exercise beliefs and exercise imagery can categorise people who are at risk of having a pathological relationship with exercise.

1.5.5 Exercise Dependence Scale (EDS; Hausenblas and Symons Downs, 2002)

The EDS was the first screening tool to exclusively use clinical diagnostic criteria to measure for exercise addiction. The scale has 30 items and seven sub-scales, which are based on the DSM-IV criteria for substance abuse (American Psychiatric Association, 2000). These subscales are tolerance; withdrawal; intention effects; lack of control; time; reduction in other activities; and continuance (Hausenblas and Symons Downs, 2002). Unlike previous scales, the EDS categorises participants into one of three categories: asymptomatic, symptomatic, and at risk. The development of the EDS is the first to be developed within an established theoretical framework and has a comprehensive development when compared with the previous exercise addiction scales.

1.5.6 Revised Exercise Dependence Scale (EDS-R; Symons Downs, Hausenblas and Nigg, 2004)

The EDS-R is a reduced version of the EDS, with the EDS-R being nine items shorter than the EDS, with 21 items across the seven sub-scales based on the DSM-IV criteria for substance abuse, with three items for each of the seven constructs. Like the EDS, the EDR-R categorises participants into one of three categories: asymptomatic, symptomatic, and at risk. Both the EDS and EDS-R both preclude the measurement of exercise addiction on a continuous spectrum. The EDS-R has strong psychometric properties when compared to the EDS and appears to be a valid shorter-form version of the EDS.

1.5.7 Exercise Addiction Inventory (EAI; Terry, Szabo and Griffiths, 2004)

The EAI was developed based on Brown's (1993) components of general behavioural addictions, and is the only short-form exercise addiction questionnaire available, comprising of six items, one items per sub-scales. The six sub-scales are salience; mood modification; tolerance; withdrawal; conflict; and relapse. There is a paucity of information on exactly how the EAI was developed, however several studies have shown the EAI to have strong psychometric properties (Terry, Szabo and Griffiths, 2004).

1.5.8 The Compulsive Exercise Test (CET; Meyer et al., 2011)

The CET is a 24-item tool across five sub-scales, including avoidance and rule-driven behaviour; exercise for weight control; mood improvement; lack of exercise enjoyment; and repetitive weekly pattern of exercise. The CET is one of two tools that exclusively examines exercise addiction as a secondary condition to an eating disorder, and was developed to assess factors of ‘excessive exercise’ (a diagnostic term used to diagnose several types of eating disorder) within the eating disorder domain, and has been validated in populations with both clinical and sub-clinical eating disorders (Harris, Hay and Touyz, 2020).

1.5.9 The Exercise and Eating Disorders (EED) questionnaire (Danielsen, Bratberg and Rø, 2012)

The EED is a 22-item scale with four sub-scales: compulsive exercise; positive and healthy exercise; awareness of bodily signals; and weight and shape exercise. The EED is the second tool that measures exercise addiction (the author’s use the term ‘compulsory exercise’) exclusively in the domain of eating disorders (Harris, Hay and Touyz, 2020). Validation studies have for this tool have been exclusively in populations with a clinical eating disorder, so its use outside of clinical settings is questionable.

1.5.10 The Exercise Addiction Inventory-Revised (EAI-R; Szabo et al., 2019)

The EAI-R is a revised version of the EAI, maintaining the original EAI’s six items across six sub-scales, based on Brown’s (1993) components of general behavioural addiction. The EAI-R, however, contains one key difference: the authors argue that the Likert scale used in the EAI (five-point scale, with ‘strongly agree’ to ‘strongly disagree’, with ‘neither agree or disagree’ in the middle) had the potential to inflate final exercise addiction scores if people

chose the middle option, and suggested a change to a six-point scale, so no neutral response could be made.

The absence of clinical diagnostic criteria for exercise addiction means that there is no consensus as to which exercise addiction questionnaire is the most appropriate, however the most commonly used in recent studies are the EAI and the EDS-R, which have also been described as 'broadly comparable' (Szabo et al., 2015; Berczik et al., 2012). Furthermore, no tool at present can differentiate between exercise addiction in people with potential eating disorders and those without - to categorise primary or secondary exercise addiction (in an eating disorder context), a second screening tool or clinical diagnosis is currently needed to ascertain whether or not the participant has any underlying eating pathology.

Interestingly, many of the existing tools treat exercise addiction as a dichotomy, with the authors providing cut-off points to differentiate between those at risk and those not at risk, rather than on a continuum. Considering that there are no official diagnostic criteria for exercise addiction, this is curious. Furthermore, some of the aetiological models of exercise addiction hypothesise that exercise addiction should be considered as a continuum rather than a dichotomy.

1.6 Prevalence

Several studies have reported the prevalence of exercise addiction in several different populations. To date, one meta-analysis examines the prevalence of exercise addiction (Di Lodovico, Poulnais and Gorwood, 2019). In this meta-analysis including 48 studies, exercise addiction prevalence rates ranged from 1.9% in the general population to 15.3% in 'mixed disciplines/ball games'. The key limitation of this review was that the authors did not attempt to stratify between populations with and without indicated eating disorders, which have been shown to respectively yield largely different prevalence rates (Bratland-Sanda et al., 2010). Primary studies have yielded very large ranges in exercise addiction prevalence differing according to type of exercise, with prevalence rates ranging from 0.3% in the general population (Mónok et al., 2012) to 52% in triathletes (Blaydon and Lindner, 2002). These large variations in prevalence rates can been attributed to two main reasons:

1. The heterogeneity in the tools used appear to yield different prevalence rates in the same population. For example, Cunningham, Pearman and Brewerton (2016) used both the EDS and the EAI in the same population and yielded significantly different prevalence rates (4.7% and 7.4% respectively).

2. Different populations appear to yield different prevalence rates when using the same exercise addiction measurement tools. For example, Di Lodovico and colleagues (2019) found exercise addiction rates that ranged from 1.9% in the general population to 15.3% in 'mixed disciplines/ball games'.

1.7 The problem

Despite the original conceptualisation suggesting two sub-categorisations of exercise addiction (primary and secondary), much of the literature exploring exercise addiction prevalence fails to sub-categorise between subjects with and without eating disorders. Indeed, primary evidence has shown that participants with indicated eating disorders have higher exercise addiction prevalence rates than those without indicated eating disorders (Dalle Grave, Calugi and Marchesini, 2008; Bratland-Sanda et al., 2010). This lack of stratification precludes the categorisation of possible primary or secondary exercise addiction; making accurate prevalence rates and aetiology difficult to establish (Symons Downs, MacIntyre and Heron, 2019). Furthermore, several correlates that have been shown to be associated with exercise addiction (such as body dysmorphic symptoms, anxiety, and personality) have also been consistently reported in eating disorder patients (Cassin and von Ranson, 2005; Pallister and Waller, 2008; Phillips, 2005). Without the stratification of indicated or no-indicated eating disorders, it is impossible to associate correlates independently and develop a greater understanding of the aetiology underlying this phenomenon.

Moreover, to categorise primary or secondary exercise addiction, a second screening measure would need to be administered. A single measurement tool that could determine exercise addiction in the absence or presence of indicated eating disorders would be of high value to researchers and clinicians for three main reasons:

1. Considering that excessive exercise is associated with eating disorders, including regularly presenting with injuries relating to exercise addiction (Mond and Calogero, 2009), a quick and easy questionnaire could assist in an earlier diagnosis of an eating disorder or potential primary exercise addiction.

2. It would assist researchers in attaining accurate prevalence rates and aetiology of exercise addiction with indicated vs no-indicated eating disorders, which currently is lacking in the literature base.

3. It would make the stratification of possible primary and secondary exercise addiction easier for researchers.

1.8 Aims

The aim of this thesis is to examine differences in exercise addiction within populations with versus without indicated eating disorders, and to develop a novel screening tool able to stratify between potential primary and potential secondary exercise addiction. The aim will be achieved by answering the following questions:

1. Are there differences between the prevalence of exercise addiction in populations with and without indicated eating disorders?

2. Do the currently used measurement tools used to screen for exercise addiction yield significantly different prevalence rates?

3. Do correlates of exercise addiction differ according to indicated or no-indicated eating disorders?

It is then the final aim of the thesis to create and validate a screening tool that is able to determine possible primary or secondary exercise addiction using one, short-form questionnaire.

This thesis will comprise of the following four chapters:

Chapter 2: This chapter describes two systematic reviews with meta-analyses that aim to identify the differences in the prevalence of exercise addiction in populations with and without indicated eating disorders. Moreover, the chapter systematically compares the differences in exercise addiction prevalence rates yielded using currently available measurement tools. This chapter also reports on all of the correlates of primary exercise addiction that have been reported in the literature to date.

Chapter 3: Chapter 3 explores, in the form of an original, large, primary study, differences between the prevalence, and novel correlates of, exercise addiction in populations with and without indicated eating disorders. Furthermore, due to the unique circumstances of the COVID-19 pandemic, this chapter also reports differences in exercise addiction, eating disorder, and body dysmorphic disorder prevalence during the COVID-19 pandemic.

Chapter 4: The aim of Chapter 4 is to demonstrate the creation and validation of a new screening tool for exercise addiction that is able to stratify between primary and secondary exercise addiction.

Chapter 5: Chapter 5 discusses the thesis, considering all the previously described studies in context, and highlighting the contribution each study has made to the field. Furthermore, Chapter 5 discusses directions for future research.

Positionality statement

This thesis examines several conditions, including exercise addiction, eating disorders, and body dysmorphic disorder. Considering this, positionality is important, as prior experience of the disorders could introduce bias into research (Coghlan and Brydon-Miller, 2014). I can confirm that I personally have never been addicted to exercise, had an eating disorder, or had body dysmorphic disorder. The risk of bias from a positionality perspective is therefore minimal.

Chapter 2: Systematic evaluation of the prevalence of exercise addition.

2.1 Publication details

The contents of this Chapter have been published in two peer-reviewed journal articles:

a) **Trott, M**; Jackson, S; Firth, J; Fisher, A; Johnstone, J; Mistry, A; Stubbs, Smith, L. 2020. Exercise addiction prevalence and correlates in the absence of eating disorder symptomology. A systematic review and meta-analysis. *Journal of Addiction Medicine.* DOI: 10.1097/ADM.0000000000000664

b) **Trott M**., Jackson, S., Firth, J., Jacob, L., Grabovac, I., Mistry, A., Stubbs, B., Smith, L., 2020. A comparative meta-analysis of the prevalence of exercise addiction in adults with and without disordered eating. *Eating and Weight Disorders.* DOI: https://doi.org/10.1007/s40519-019-00842-1

As of 21/3/2021, article a) has been cited four times, and article b) has been cited 16 times. For more details, see Chapter 8.

2.2 Chapter 2: abbreviations

Table 2.1: Chapter 2 abbreviations

AN	Anorexia nervosa
BDD	Body dysmorphic disorder
BMI	Body mass index
BN	Bulimia nervosa
CI	Confidence interval
EAI	Exercise addiction inventory
EAT-40	Eating attitudes test 40
EAT-26	Eating attitudes test 26
EDEQ	Eating disorder examination questionnaire
EDI-2	Eating disorder inventory 2
EDNOS	Eating disorder not otherwise specified
EDQ	Exercise dependence questionnaire
EDS	Exercise dependence scale
NOS	Newcastle-Ottawa scale
OEQ	Obligatory exercise questionnaire
OR	Odds ratio
QEDD	Questionnaire for eating disorders diagnosis
STROBE	Strengthening of the reporting of observational studies in epidemiology
PRISMA	Preferred reporting items for systematic reviews and meta-analyses
WHO	World health organisation

This Chapter will be examining the following questions that were postulated in Chapter 1:

1. Are there differences between the prevalence of exercise addiction in populations with and without indicated eating disorders?

2. Do the currently used measurement tools used to screen for exercise addiction yield significantly different prevalence rates?

2.3 Introduction

Chapter 1 of this thesis provided an introduction in the history of exercise addiction, current aetiological theories, and existing exercise addiction measurement tools. Chapter 1 also discussed prevalence rates, reporting that current estimates vary depending on the population being studied.

One population that has consistently yielded high prevalence rates is people with eating disorders, with prevalence rates in this population reportedly ranging from 29%-80% (Dalle Grave, Calugi and Marchesini, 2008; Bratland-Sanda et al., 2011). Of the different types of eating disorders, in-patients with clinically diagnosed restricting type anorexia nervosa (AN) have been shown to have higher prevalence rates of exercise addiction (80%) compared to binge/purging type AN (43.3%); purging type bulimia nervosa (BN; 39.3%); and eating disorders not otherwise specified (EDNOS; 31.9%) (Dalle Grave, 2009). Indeed, some authors have argued that exercise addiction exists exclusively as a secondary condition to an eating disorder (Bamber et al., 2003).

Patients with AN have been shown to have the highest mortality rates of all eating disorders (Smink, van Hoeken and Hoek, 2012; Sauchelli et al., 2016; Arcelus et al., 2011), as well as having an increased risk of osteopenia, osteoporosis, and related fractures (Solmi et al., 2016) which makes high prevalence rates of exercise addiction in this group of particular concern. It has been reported that subjects with indicated eating disorders and exercise addiction often present with stress fractures and engage in excessive exercising despite injury, with some subjects reporting exercising because it feels like a compulsion rather than for enjoyment (Klein et al., 2004; Laban et al., 1995). Considering that weight gain is one of the primary aims of treatment of patients with eating disorders (particularly AN) (Misra and Klibanski, 2011; Kaye et al., 1988), excessive exercise can result in longer periods to achieve the desired weight gain, which can be costly from a service provision perspective.

Interestingly, the prevalence rates in populations with eating disorders are notably higher than the prevalence rates reported in Chapter 1: Section 1.6 reporting aggregated exercise addiction prevalence rates. For example, a recent narrative systematic review (Di Lodovico, Poulnais and Gorwood, 2019) has estimated that the prevalence rates of exercise addiction range from 3% -14.2% depending on the population, however this review failed to report whether or not the populations had indicated eating disorders.

To determine if there are any differences between exercise addiction prevalence in populations with versus without indicated eating disorders, it is also important to establish the prevalence of exercise addiction in populations exclusively without indicated eating disorders. This has not been systematically aggregated to date. Nor have the correlates of exercise addiction in this population. This is of particular importance because several of the correlates of exercise addiction that have been reported in studies that have failed to distinguish between participants with and without indicated eating disorders have been consistently showed to be correlated with eating disorders. For example, several psychological correlates that have been associated with exercise addiction, such as anxiety, body dysmorphia, and personality (Lichtenstein et al., 2017), have also been associated with eating disorders (Phillips, 2005; Cassin and von Ranson, 2005; Pallister and Waller, 2008). Without stratifying primary and secondary exercise addiction it is impossible to associate these correlates with exercise addiction independently.

There have also been disparities reported in exercise addiction prevalence rates depending on the exercise addiction measurement tools being used. As an example, the two measurement tools that are based on similar theoretical structures (the Exercise Dependence Scale and the Exercise Addiction Inventory) have yielded significantly different prevalence rates in the same populations (Lease and Bond, 2013), indicating that they either may not be measuring the same domains of the exercise addiction, or that they yield different sensitivity and specificities. These differences in prevalence rates between tools have been reported in previous systematic reviews (Di Lodovico, Poulnais and Gorwood, 2019), however to date have not been reported in populations that have been screened for indicated eating disorders.

Therefore, the aims of this Chapter were to systematically review the existing literature examining exercise addiction prevalence in populations with and without indicated eating disorders, examine differences between exercise addiction measurement tools, and examine correlates of exercise addiction in the absence of indicated eating disorders. To achieve this aim, this Chapter answers the following questions:

1. Are there differences in exercise addiction prevalence between populations with versus without indicated eating disorders?

2. Are there differences in exercise addiction prevalence rates according to exercise addiction measurement tools?

3. What is the prevalence of exercise addiction in populations without indicated eating disorders?

4. Are exercise addiction prevalence rates different according to sub-populations without indicated eating disorders?

5. What are the reported correlates of exercise addiction in populations without indicated eating disorders?

Furthermore, it is hypothesised that:

1. H_0: There are no significant prevalence differences between populations with versus without indicated eating disorders.

   H_1: There are significant prevalence differences between populations with versus without indicated eating disorders.

2. H_0: There are no significant differences between exercise addiction prevalence according to which measurement tool is used.

   H_1: There are significant differences between exercise addiction prevalence according to which measurement tool is used.

3. H_0: There are no significant prevalence differences between exercise addiction prevalence without indicated eating disorders according to sub-populations.

   H_1: There are significant prevalence differences between exercise addiction prevalence without indicated eating disorders according to sub-populations.

2.4 Methodology

To answer the study questions and confirm or refute the hypotheses a systematic review approach was chosen, with added meta-analyses of prevalence rates and statistical comparisons of the aforementioned sub-groups. There are several reasons to justify a systematic literature review over other methods of review, including:

1. Allowing the review to be explicit and reproducible.

Systematic reviews allow all parts of the review process to be explicitly reproducible, which decreases potential subjectivity in all stages of the review process. Furthermore, it enables a complete saturation of the literature base that other types of review (e.g. scoping) may not have (Booth, Sutton and Papaioannou, 2016).

2. Being able to assess the quality of the included studies.

Another advantage to a systematic review is the use of tools to measure the risk of bias in the included studies. This is important as all research is subject to some level of bias and/or restrictions on reporting (e.g. some journal articles will not allow some sections of methodology to be published), and the use of a risk of bias tool allows that to be accounted for when synthesising the literature (Booth, Sutton and Papaioannou, 2016).

3. Systematic synthesis of the available data using meta-analytic techniques allow statistical findings to be reported, and allow the statistical analysis of the robustness and validity of any findings.

Meta-analyses have been consistently reported as a top-tier method of synthesising similar data using statistical methods (Hedges and Olkin, 2014; Booth, Sutton and Papaioannou, 2016). Furthermore, meta-analytic techniques allow the systematic statistical assessment of publication bias (Begg and Mazumdar, 1994; Duval and Tweedie, 2000; Egger et al., 1997) and heterogeneity (Higgins and Thompson, 2002; Higgins et al., 2003) - which would be difficult to quantify if a meta-analytic approach was not used.

4. It allows the review to follow pre-published protocols that align the review with similar studies.

The use of a systematic review over other types of review allow for the following of pre-published guides that ensure minimum reporting standards are met, including the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria and the recommendations in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Liberati et al., 2009; Von Elm et al., 2007). The following of these guidelines ensures that the quality of review is in line with other systematic reviews.

2.5 Methods

These systematic reviews were conducted according to the strengthening of the reporting of observational studies in epidemiology (STROBE) criteria and the recommendations in the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement (Liberati et al., 2009; Von Elm et al., 2007), and were pre-registered with the PROSPERO international prospective register of systematic reviews (registration number: CRD420180933).

2.5.1 Search strategy

Two similar searches were conducted: the first search (Study 1) was conducted to determine the prevalence of exercise addiction with versus without eating disorders, and the second study (Study 2) was conducted to determine the prevalence and correlates in people with exercise addiction exclusively without indicated eating disorders.

Two independent investigators (Mike Trott, Lee Smith) searched PsycINFO, Medline, SportDiscuss and Open Grey from inception to 31/12/18 for Study 1 and from inception to 30/04/19 for Study 2, for articles written in English. In both studies, the search terms (title of article) used were:

(exercise OR physical activity OR fitness OR sport OR sports)
and
(addiction OR dependence OR dependency OR compulsion OR addict)
or
(maladaptive OR excessive OR compulsive OR obligatory OR obsessive)
and
(exercise OR physical activity OR fitness OR exerciser OR exercisers OR sport OR sports)

These search terms were developed by the author in collaboration with a librarian with a specialist knowledge of sports science searches at Anglia Ruskin University. Any inconsistencies would have been resolved by discussion, with further disagreements resolved through discussion with a third reviewer (which was not required in either study). The reference lists of the articles included in the analysis were hand-searched to identify additional literature, and conference abstracts were also considered (no conference abstracts were included in the final review). Results of the search were imported into a reference manager (Mendeley Ltd, 2008) for the next stage.

2.5.2 Study selection

Titles and abstracts were independently assessed by two authors (Mike Trott, Lee Smith) for eligibility against the following respective inclusion and exclusion criteria.

Inclusion Criteria (Study 1)

1. Cross sectional or longitudinal studies
2. Written in English
3. In adults (≥18 years)
4. That measure the prevalence of exercise addiction in any population using a validated exercise addiction measurement tool with established cut-offs (as per original authors' guidelines) that define subjects as at risk of exercise addiction.
5. Screen for eating disorders using a validated measure (to exclude for exercise addiction with indicated eating disorders)
6. Non-elite athletes only (defined as not being national or international level athletes)

Exclusion Criteria (Study 1)

1. Studies that fail to screen for eating disorders using a validated measure (therefore precluding indicated/no indicated eating disorder categorisation).
2. Subjects who have scored above published cut-offs for eating disorders (including clinician diagnosed eating disorder)
3. Samples that include elite athletes (defined as national and international level athletes), as elite athletes have been shown to interpret exercise addiction measurement tools in such a way that indicates falsely high exercise addiction risk (Szabo et al., 2015).

Inclusion Criteria (Study 2)

Articles were included that met the following criteria:

1. Studies that reported an exercise addiction with and without indicated eating disorders odds ratios (ORs) or statistics sufficient to calculate an OR;
2. Written in English;
3. In adults (≥18 years);
4. That measured the prevalence of exercise addiction in any population using any validated measuring tool of exercise addiction with established cut-offs (as per original authors' guidelines) that define subjects as at risk of exercise addiction;
5. Tested for indicated eating disorders using a validated measure;

6. That used the same study population to determine exercise addiction prevalence rates in indicated and non-indicated eating disorder populations (to eliminate population bias).

Exclusion Criteria (Study 2)

1. Non-adults (<18 years)

2.5.3 Data extraction (Study 1)

The following information was extracted by the lead author (Mike Trott): demographic information (age, sex, BMI) and prevalence (total *n*, events (indicated exercise addiction) *n*, measuring instrument of exercise addiction, screening instrument of eating disorders). Missing information was obtained by contacting lead authors. If prevalence data were missing/incomplete (e.g. unknown eating disorder status) and the authors did not respond/have access to the data (two attempted contacts to authors over a one-month period), these studies were excluded. Studies with missing demographic data, but full prevalence data were included. Subjects failing to meet established cut-off for eating disorders and meeting established cut offs for exercise addiction were classified as at risk of exercise addiction. Subjects failing to meet established cut-offs for both eating disorders and exercise addiction were categorised as not at risk of exercise addiction. All participants scoring over the published cut-offs for eating disorders were excluded.

2.5.4 Data extraction (Study 2)

The method of data extraction in Study 2 was the same as Study 1, with the following differences: prevalence data were extracted as total exercise addiction with and without indicated eating disorders *n*, exercise addiction with and without indicated eating disorders events *n*, measuring instrument of exercise addiction, measuring instrument of eating disorders. Prevalence data was then converted into ORs. Studies with missing demographic data, but full exercise addiction with and without indicated eating disorders prevalence data, were included. Subjects were then categorised into two groups: subjects that failed to meet published cut-offs (as defined by the original author article) for eating disorders in the non-indicated eating disorders group, and subjects that scored over the published cut offs for eating disorders in the indicated eating disorders group. In both eating disorder status sub-groups, subjects that met the published cut-offs for exercise addiction were respectively categorised as at risk of exercise addiction.

2.5.5 Quality assessment

In both studies, included studies were assessed for quality by the lead author using the Newcastle-Ottawa Quality Assessment Scale (Wells et al., 2009) (NOS), modified for cross sectional studies (Modesti et al., 2016). The NOS has established content validity and inter-rater reliability and has a scoring system based on positive answers to questions regarding appropriateness of research design, recruitment strategy, response rate, representativeness of sample, objectivity/reliability of outcome determination, power calculation, and appropriate

statistical analyses, with points being assigned to positive answers, with a maximum quality score of 10, with higher scores indicting higher quality studies (see Appendix E for full scale and scoring criteria)

2.5.6 Meta-analyses

There are two types of model that can be used in meta-analyses: fixed and random effects. The fixed effect model assumes that there is 'one true' effect size across all studies, and that all respective populations' interventions (in this context measurement tools) are exactly the same, and thus any heterogeneity between studies is due to sampling error (Borenstein et al., 2009). The random effects model, by contrast, assumes that populations, interventions, and other variables are heterogeneous enough that there may not be 'one true' effect size, and thus the effect sizes would be distributed around a mean, rather than absolute (Borenstein et al., 2009). Given that populations and interventions in the studies included are likely to be highly heterogeneous in both review studies, a random-effects model was used in both Studies 1 and 2. Studies were weighted based on the inverse variance, calculating the prevalence rates with 95% confidence intervals (CIs) using Comprehensive Meta-Analysis Version 3 (Borenstein et al., 2013).

In Study 1, the meta-analysis was conducted using the following steps:

1. Prevalence rates for the total sample, population sub-groups, and exercise addiction measurement tool sub-groups were calculated with 95% CIs using total *n*s and event *n*s.

2. Heterogeneity was assessed with the Cochran *Q* (Cochran, 1954) and I^2 statistics (Higgins and Thompson, 2002). I^2 values of 25%, 50%, and 75% suggested low, moderate, and high heterogeneity, respectively (Higgins et al., 2003).

3. Publication bias was assessed with a visual inspection of funnel plots and with the Begg-Mazumdar Kendall's tau (Begg and Mazumdar, 1994) and Egger bias test (Egger et al., 1997). As per recommendations from Fu et al. (2011) and Sterne, Egger, & Moher (2008), these tests were only conducted if the number of studies exceeded 10.

4. If the Egger bias test was significant, to adjust for potential publication bias, the trim-and-fill adjusted analysis was used to remove the most extreme small studies from the positive side of the funnel plot and effect sizes re-calculated, until the funnel plot was symmetrical with the new effect size (Duval and Tweedie, 2000).

5. To detect whether the observed effect was overly influenced by any one individual study, a sensitivity analysis was calculated around the primary analyses, using a one-study removed method.

6. Two subgroup analyses were conducted: one analysing prevalence rates according to type of population, and the other stratified by exercise addiction measurement tool. Note that the first subgroup analysis (according to population type) was only conducted on studies that used the EAI and the EDS as an exercise addiction measurement tool, because they have been reported as 'broadly comparable' and measure similar constructs of exercise addiction (Szabo et al., 2015).

In Study 2, the meta-analysis was conducted in the following steps:

1. Respective prevalence rates for the group with and without indicated eating disorders were calculated with 95% CIs using total *n*s and event *n*s.

2. ORs of exercise addiction comparing those with and without indicated eating disorders were calculated with 95% CIs using a mixed effects analysis.

3. Heterogeneity was assessed with the Cochran *Q* (Cochran, 1954) and I^2 (Higgins and Thompson, 2002) statistics for all analyses.

4. Sub-group analysis comparing prevalence rates and ORs of exercise addiction in populations with and without indicated eating disorders by exercise addiction measurement tool.

5. Publication bias was assessed with a visual inspection of funnel plots and with the Begg-Mazumdar Kendall's tau (Begg and Mazumdar, 1994) and Egger bias test (Egger et al., 1997). As per recommendations from Fu et al. (2011) and Sterne,

Egger and Moher. (2008), these tests were only conducted if the number of studies exceeded ten.

6. If the Egger bias test was significant, to adjust for potential publication bias, the trim-and-fill adjusted analysis was used to remove the most extreme small studies from the positive side of the funnel plot and effect sizes re-calculated, until the funnel plot was symmetrical with the new effect size (Duval and Tweedie, 2000).

7. To detect whether the observed effect was overly influenced by any one individual study, a sensitivity analyses was calculated around the primary analyses, using a one-study removed method.

2.5.7 Narrative synthesis of correlates of exercise addiction without indicated eating disorders.

For the correlates of exercise addiction without indicated eating disorders, a narrative synthesis was conducted of all the available evidence within the included articles. Correlates that failed to stratify between indicated/no indicated eating disorders were excluded.

2.6 Results

2.6.1 Study 1

The initial literature search yielded 1,541 results, of which there were 425 duplicates, which were removed, leaving 1,069 studies screened using the title and abstract. From the 1,116 titles and abstracts screened, 235 studies were selected for full-text review. Of the 235 studies reviewed, 13 studies (Hausenblas and Symons Downs, 2002b; Lease and Bond, 2013; Bamber, Cockerill and Carroll, 2000; Blaydon and Lindner, 2002; Blaydon, Linder and Kerr, 2004; De Young and Anderson, 2010; Di Lodovico, Dubertret and Ameller, 2018; Gapin, Etnier and Tucker, 2009; Grandi et al., 2011; Menczel et al., 2017; Meulemans et al., 2014; Müller et al., 2015; Serier et al., 2018) were eligible for inclusion. Descriptive statistics for included studies are shown in Table 2.2. Reasons for exclusion and a PRISMA flowchart are shown in Figure 2.1. Of the thirteen studies, four studies used the EDS (Hausenblas and Symons Downs, 2002b), two studies used the EAI (Terry, Szabo and Griffiths, 2004), four studies used the EDQ (Ogden, Veale and Summers, 1997), and three studies used the OEQ (Pasman and Thompson, 1988). For the eating disorder screening, three studies used the Eating Attitudes Test-26 (Garner et al., 1982), two studies used the Eating Attitudes Test-40 (Garner and Garfinkel, 1979), three studies used the Eating Disorder Examination Questionnaire (Fairburn and Beglin, 1994), one study used the Eating Disorder Inventory-2 (Garner, 1991), two studies used the Questionnaire for Eating Disorders Diagnosis (Mintz et al., 1997), and two studies used the SCOFF Questionnaire (Morgan, Reid and Lacey, 1999). For the EDS and EAI sub-population analysis, three sub-populations were identified. Amateur competitive athletes (subjects who exercised in a competitive sporting context), general exercisers (subjects who exercised in a non-sporting context, such as people who use health clubs and non-specified ‘exercisers’), and university students. Table 2.3 shows full population information. The mean NOS score for all of the included studies was 6.29 $\pm$ 1.2 (range: 4-8) - full NOS scoring is shown in Table 2.4.

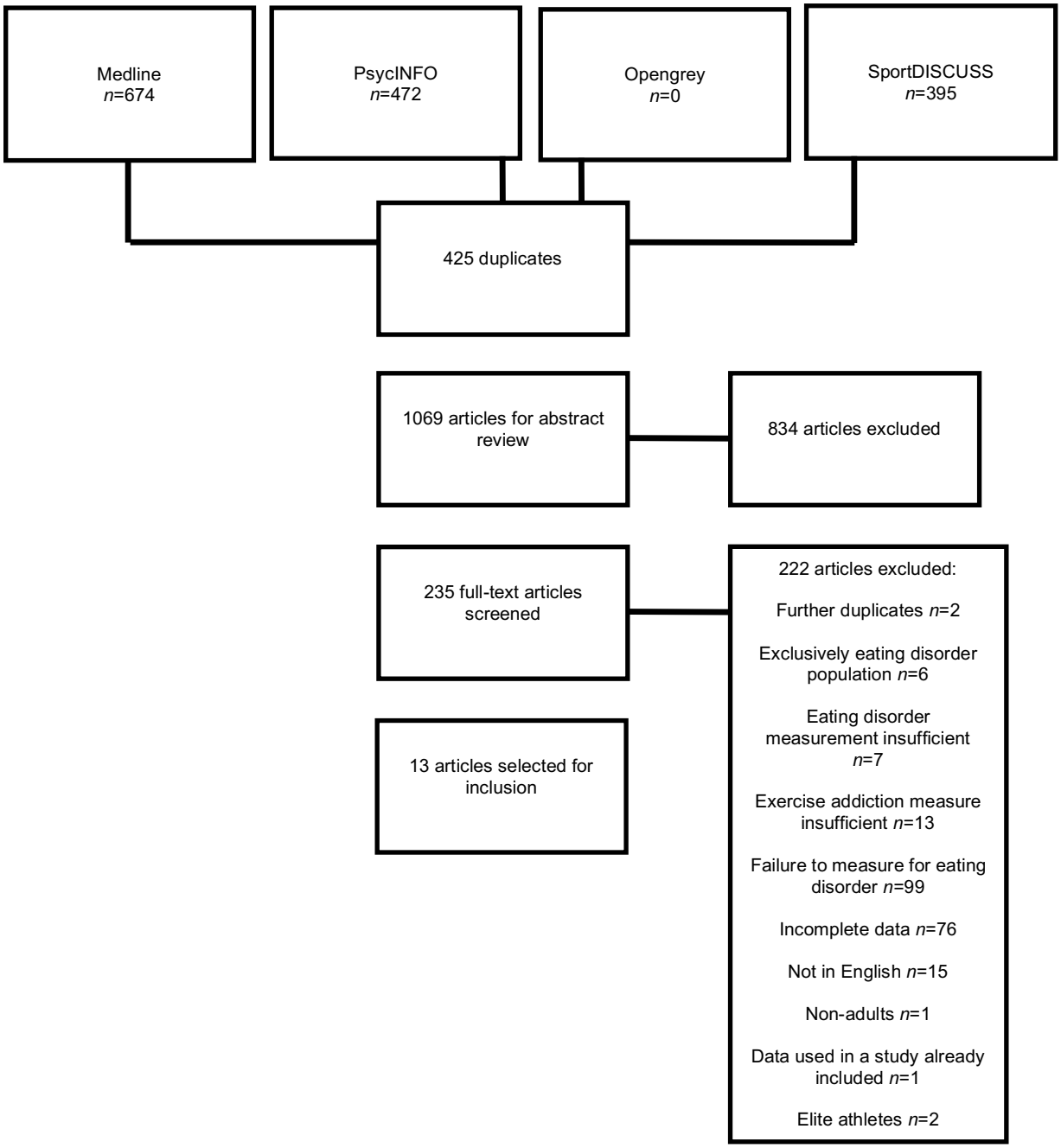

Figure 2.1: PRISMA flowchart of included studies (Chapter 2: Study 1)

Table 2.2: Descriptive statistics for included studies in Study 1

Author	Year	Population	Country	Total *n*	Events *n*	M Age	BMI	Sex (percentage female)	Exercise addiction measure	Eating disorder measure	NOS Score
Bamber *et. al.*	2000	General exercisers (non-athletes)	UK	153	43	NR	NR	100	EDQ	EDE-Q	7
Blaydon and Lindner	2002	Amateur competitive athletes (amateur triathletes)	Multi-national	65	23	NR	NR	NR	EDQ	EAT-40	7
Blaydon *et. al.*	2004	Amateur competitive athletes (multiple sports)	UK	296	58	NR	NR	27.70	EDQ	EAT-40	8
De Young and Anderson	2010	University students (undergraduate and graduate)	NR	207	66	19	24.2	49.28	OEQ	EDE-Q	4
Di Lodovico *et. al.*	2018	Amateur competitive athletes (runners)	NR	129	11	30.39	NR	46.51	EAI	SCOFF	6
Gapin *et. al.*	2009	General exercisers (non-athletes)	USA	28	9	32.43	23.37	100	EAI	QEDD	6
Grandi *et. al.*	2011	Health club users	Italy	79	32	30	21.6	57.00	EDQ	EDI-2	7
Hausenblas *et. al.*	2002	Undergraduate students	USA	373	39	20.32	NR	48.39	EDS	QEDD	4
Lease and Bond	2013	Health club users	Australia	227	47	23	23.35	100	OEQ	EAT-26	6
Menczel *et. al.*	2017	Health club users	Hungary	1346	30	32.18	23.63	56.70	EDS	SCOFF	6
		Amateur competitive exercisers (self-identified)	Hungary	93	2	29.35	23.41	26.90	EDS	SCOFF	6
Meulemans *et. al.*	2014	Physically active population (undergraduate students)	USA	480	13	19.76	22.14	54.12	EDS-R	EAT-26	7
Müller *et. al.*	2015	Health Club users	Germany	111	7	26.5	22.54	36.94	EDS-G	EDE-Q	6
Serier *et. al.*	2018	Women seeking help for body-dissatisfaction	USA	48	20	36.23	NR	100	OEQ	EAT-26	8

EDQ = Exercise Dependence Questionnaire; EDS = Exercise Dependence Scale; OEQ= Obligatory Exercise Questionnaire; EAI = Exercise Addiction Inventory; EDE-Q = Eating Disorders Examination Questionnaire; EDE= Eating Disorders Examination; EAT = Eating Attitudes Test; QEDD = Questionnaire for Eating Disorders Diagnosis

Table 2.3: Study 1 description of sub-populations

Sub-group	Populations included in sub-group
Generally active population (3 studies)	- Women who were regularly physically active (Gapin et al.) - Fitness centre members (Menczel et al.) - Habitual exercisers recruited at fitness clubs (Muller et al.)
Amateur competitive athletes (2 studies)	- Runners recruited from running specific social media pages (Di Lodovico et al.) - Self-identified 'amateur competitive exercisers' (Menczel et al.)
University students (2 studies)	- Non-specified undergraduate students (Hausenblas and Symons Downs) - Students in various undergraduate and graduate classes (Meulemans et al.)

Table 2.4: Scoring of studies using the Newcastle-Ottawa Quality Assessment Scale in Chapter 2:Study 1

Study	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure (risk factor)	The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.	Assessment of the outcome	Statistical test	Total score
Di Lodovico *et. al.*	1	0	0	2	1	1	1	6
Gapin *et. al.*	1	0	0	2	1	1	1	6
Hausenblas and Symons Downs	0	0	0	2	0	1	1	4
Menczel *et. al.*	1	0	0	2	1	1	1	6
Meulemans *et. al.*	1	0	0	2	2	1	1	7
Müller *et. al.*	1	0	0	2	2	1	1	6
Bamber *et. al.*	1	0	0	2	2	1	1	7
Blaydon and Lindner	1	0	0	2	2	1	1	7
Blaydon *et. al.*	1	1	0	2	2	1	1	8
De Young and Anderson	1	1	0	0	0	1	1	4
Grandi *et. al.*	1	0	0	2	2	1	1	7
Lease and Bond	1	0	0	2	2	1	1	6
Serier *et. al.*	1	0	1	2	2	1	1	8

Meta-analysis results

2.4.1.1 Prevalence proportions of exercise addiction without indicated eating disorders across different settings.

As shown in Table 2.5, the highest prevalence of exercise addiction was among the general exercisers (8.1%, 95% CI=1.5-34.2%), university students (5.5%; 95%CI=1.4-19.1%), with amateur competitive athletes (5.0%, 95% CI=1.3-17.3%) yielding the lowest prevalence rate. Forest plots for all sub-groups are shown in Figure 2.2. The average pooled prevalence rate was 6.2% (95% CI 3.0--12.6).

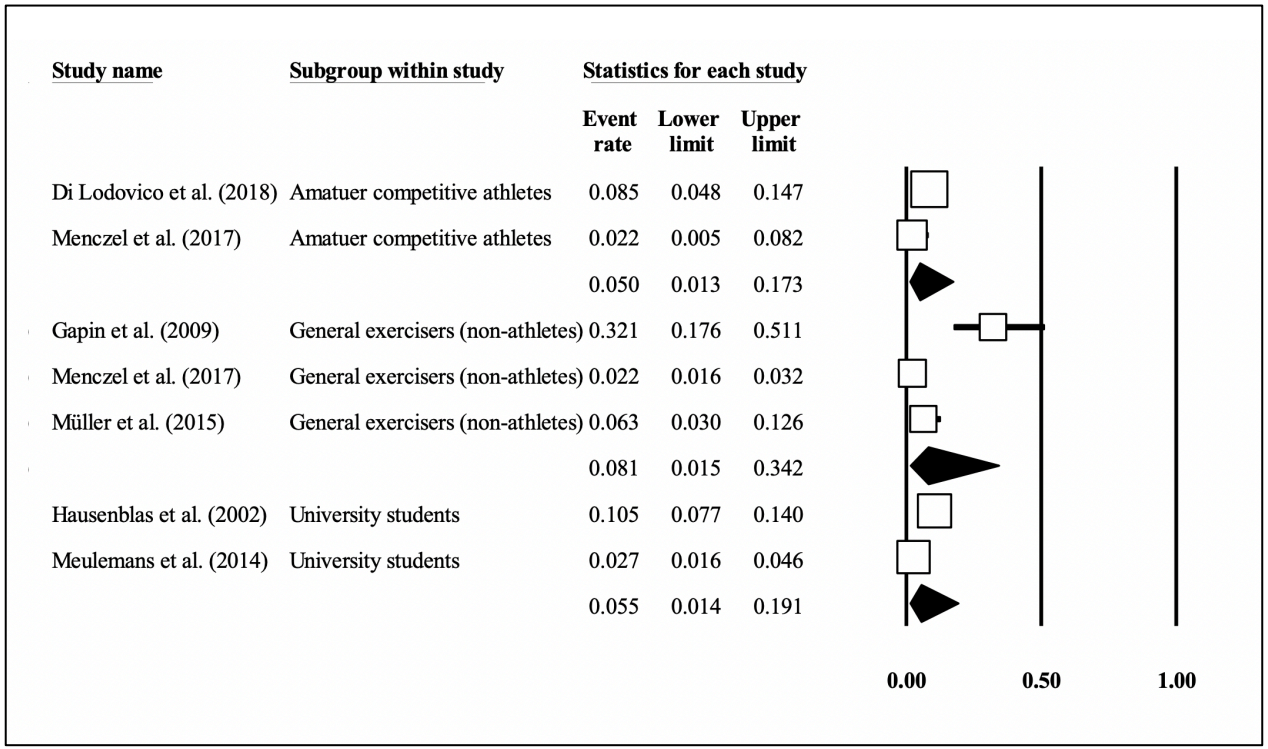

Figure 2.2: Forest plot showing exercise addiction without indicated eating disorders prevalence rates by sub-population group

Table 2.5: Prevalence of exercise addiction in participants without indicated eating disorders across different settings

				Meta-analysis		Heterogeneity	Publication Bias	
Sub-group	**Number of studies (number of sub-samples)**	**Number of subjects**	**Total events**	**Event Rate**	**95% CI**	**I^2**	**Egger bias and P-value**	**Trim-and-fill (95%CI) [number of trimmed studies]**
Amateur competitive athletes	2	222	13	5.0%	1.3-17.3%	70.765	NA (too few studies)	NA (Egger bias not significant)
University students	3	853	52	5.5%	1.4-19.1%	94.761	7.718 *p*=0.308	NA (Egger bias not significant)
General exercisers (non-athletes)	2	1485	46	8.1%	1.5-34.2%	95.856	NA (too few studies)	NA (Egger bias not significant)
Average across groups	6 (7)	2560	111	6.2%	3.0--12.6%	92.545	1.016 *p*=0.800	NA (Egger bias not significant)

NA=Not applicable; CI=confidence interval

2.4.1.2 Sensitivity analysis

The overall prevalence rates were not changed by the sensitivity analysis, with prevalence rates ranging from 4.6-7.5%, with no studies having a large effect on the magnitude of results. See Table 2.6 and Figure 2.3 for full details.

Table 2.6: Primary exercise addition prevalence stratified by sub-population with the removal of one study

Study name	Event rate if study removed	95% CI
Di Lodovico (2018)	5.9%	2.5-13.3%
Gapin et al (2009)	4.6%	2.3-9.1%
Hausenblas et al. (2002)	5.6%	2.4-12.7%
Menczel et al. (2017) (General exercisers/non-athletes)	7.5%	3.7-14.6%
Menczel et al. (2017) (Amateur competitive athletes)	7.0%	3.2-14.7%
Meulemans et al. (2014)	7.2%	3.1-15.6%
Muller et al. (2015)	6.2%	2.7-13.7%

CI=confidence interval

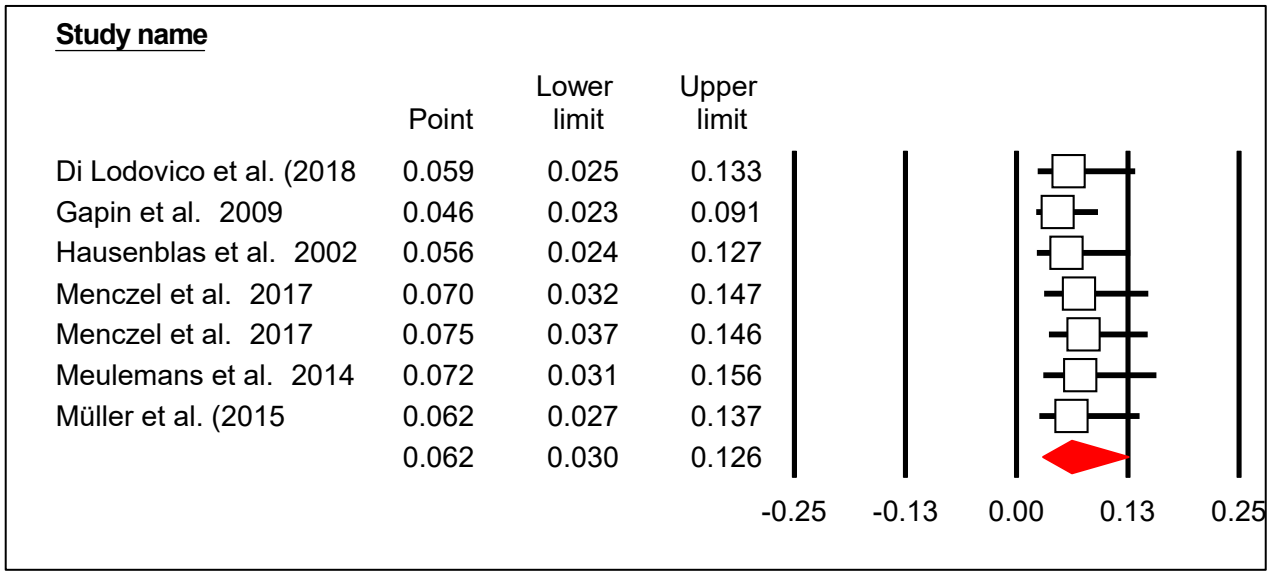

Figure 2.3: Primary exercise addition prevalence stratified by sub-population with the removal of one study

2.4.1.3 Prevalence proportions of exercise addiction without indicated eating disorders across differing measuring tools

As shown in Table 2.7, the highest prevalence of exercise addiction was among participants using the OEQ (29.9%, 95% CI=20.2-41.9%), followed by the EDQ (29.7%, 95% CI=20.9-40.3%), the EAI (17.1%, 95% CI=4.50.3%), with the EDS showing the lowest prevalence rate (4.1%, 95% CI= 1.8-8.9). Forest plots for all sub-groups are shown in Figure 2.4.

Table 2.7: Prevalence of exercise addiction in non-eating disordered subjects by measurement tool

				Meta-analysis		Heterogeneity	Publication Bias	
Sub-group	**Number of Studies**	**Number of subjects**	**Total events**	**Event Rate**	**95% CI**	**I^2**	**Egger bias and P-value**	**Trim-and-fill (95%CI) [number of trimmed studies]**
Obligatory Exercise Questionnaire	3	482	133	29.9%	20.2-41.9%	83.004	4.012 *p*=0.65	NA (Egger bias not significant)
Exercise Dependence Questionnaire	4	593	156	29.7%	20.9-40.3%	82.944	8.907 *p*=0.08	NA (Egger bias not significant)
Exercise Addiction Inventory	2	157	20	17.1%	4.0-50.3%	90.042	NA (not enough studies)	NA (Egger bias not significant)
Exercise Dependence Scale	5	2403	91	4.1%	1.8-8.9%	91.912	-1.903 *p*=0.69	NA (Egger bias not significant)

NA=Not applicable; CI=confidence interval

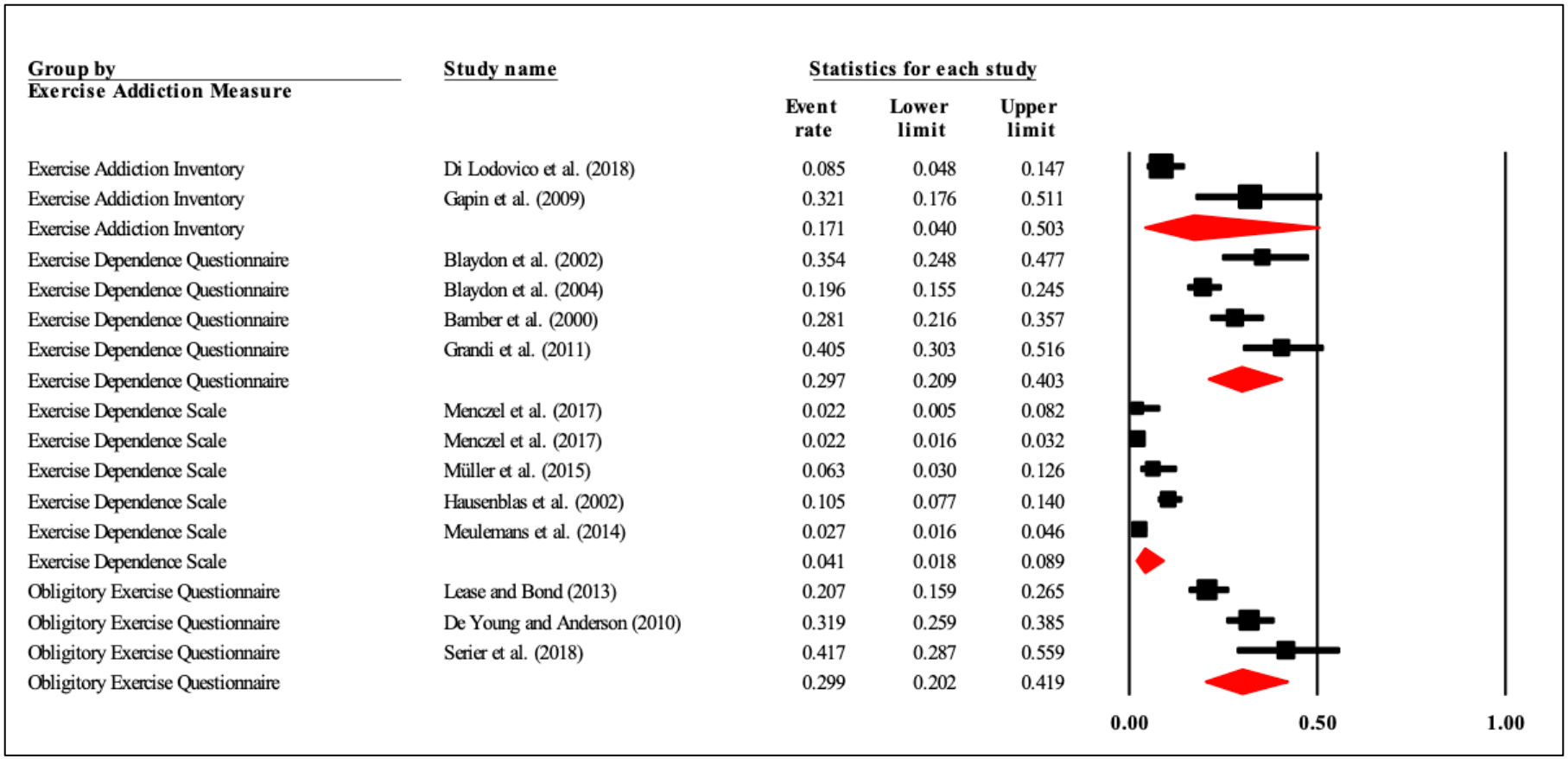

Figure 2.4: Forest plot showing non-eating disordered exercise addiction prevalence rates by measurement tool

2.4.1.4 Sensitivity analysis

Regarding the EDQ, EDS and OEQ, the removal of any one study did not change the magnitude of results. Note that because there were only two studies that used the EAI, no sensitivity analysis was conducted. See Table 2.8 and Figures 2.5, 2.6 and 2.7 for full details.

Table 2.8: Primary exercise addition prevalence stratified by exercise addiction measurement tool with the removal of one study

Exercise addiction measurement tool	Study name	Event rate if study removed	95% CI
Exercise Dependence Questionnaire	Bamber et al. (2000)	30.6%	18.0-47.0%
	Blaydon et al. (2002)	28.2%	18.3-40.9%
	Blayden et al. (2004)	33.9%	26.6-42.0%
	Grandu et al. (2011)	26.5%	18.6-36.3%
Exercise Dependence Scale	Hausenblas et al. (2002)	3.0%	1.9-4.7%
	Menczel et al. (2017)	4.5%	1.8-10.5%
	Menczel et al. (2017)	4.9%	2.1-10.9%
	Meulemans et al (2014)	4.5%	1.7-11.6%
	Muller et al. (2015)	3.6%	1.4-9.3%
Obligatory Exercise Questionnaire	De Young and Anderson (2010)	29.5%	13.5-52.9%
	Lease and Bond (2013)	34.9%	26.7-44.1%
	Serier et al. (2018)	26.0%	16.5-38.3%

CI=confidence interval

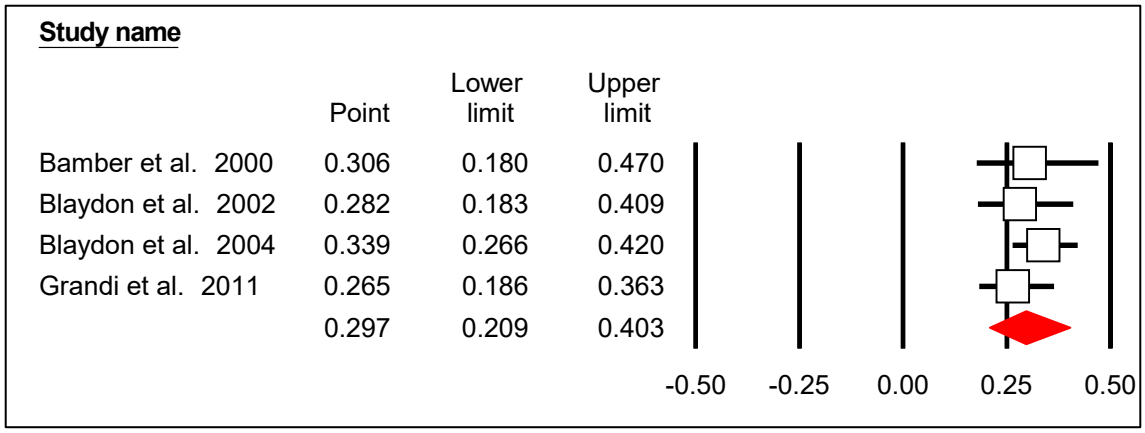

Figure 2.5: Primary exercise addition prevalence using the Exercise Dependence Questionnaire with the removal of one study

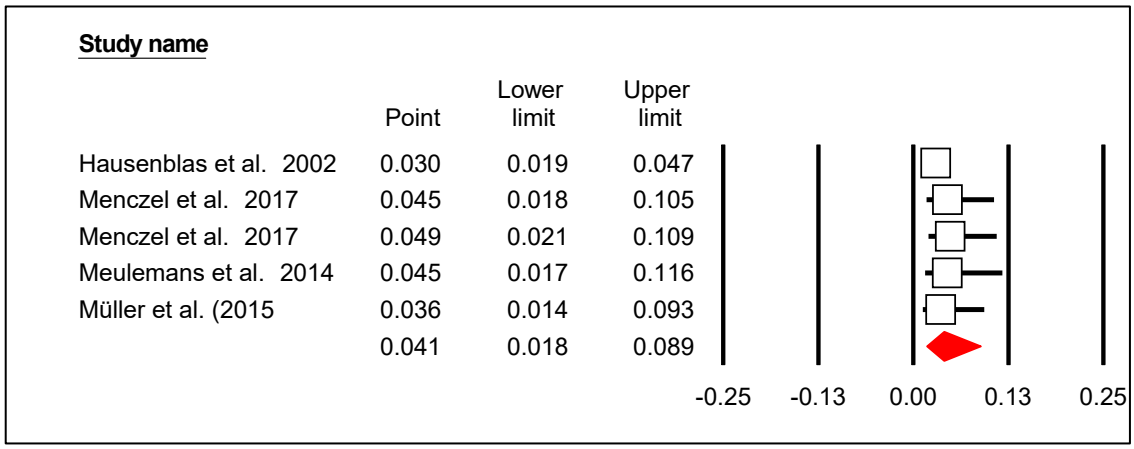

Figure 2.6: Primary exercise addition prevalence using the Exercise Dependence Scale with the removal of one study

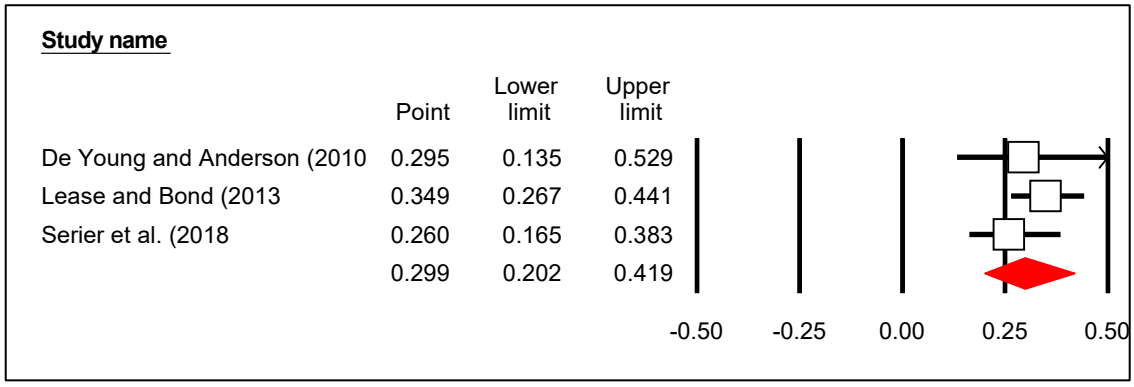

Figure 2.7: Primary exercise addition prevalence using the Obligatory Exercise Questionnaire with the removal of one study

2.4.1.5 Measured correlates of exercise addiction without indicated eating disorders.

All data including p-values, 95% CIs and demographic data have been reported where available. All studies were cross-sectional in study design.

Wellbeing

Menczel et al. (2017) reported, in their study of both health users and amateur competitive exercisers, correlations between exercise addiction without associated eating disorders and wellbeing using the WHO Well-Being Questionnaire (Susánszky et al., 2006). They found a statistically significant negative correlation between exercise addiction amateur competitive exercisers and wellbeing ($r= -0.204$, $p=0.049$; no reported adjustments), with no such correlation being found in recreational exercisers, with no other statistically significant correlations.

Self-esteem

Menczel et al. (2017) explored self-esteem and exercise addiction without indicated eating disorders using the Rosenberg self-esteem scale (Rosenberg, 2015) and found that having exercise addiction was a significant correlate of higher self-esteem scores ($F=13.211$, $p<0.001$; no reported adjustments).

Physiological correlates

Gapin et al. (2009) explored, in their study comprising of regularly active women, differences in frontal brain asymmetry in exercise addiction vs a non-exercise addiction control group. Their regression analysis found that exercise dependence was a suggestive predictor of frontal brain asymmetry ($F (1,27) = 6.4$, $p=0.05$; no reported adjustments), with greater left frontal brain activity correlated with higher exercise addiction scores.

2.6.2 Study 2

The literature search yielded 1375 results, of which 369 were removed as duplicates, leaving 1,006 studies screened using title and abstract. From the 1,006 titles and abstracts screened, 223 studies were selected for full-text review. Of the 223 studies reviewed, nine studies were eligible for inclusion. Reasons for exclusion are shown in Figure 2.8 and descriptive statistics for included studies are shown in Table 2.9. From the nine included studies, there were a total of 2,140 participants. 1,732 subjects scored below published eating disorder cut-offs and were categorised as the non-indicated eating disorder group, of which 342 scored above exercise addiction cut-offs are were defined as exercise addicted. 408 subjects scored above the published eating disorder cut-offs and were categorised as the indicated eating disorder group, of which 225 scored above exercise addiction cut-off and were defined as being at risk of exercise addiction. The methods of measuring exercise addiction were the EDQ (Ogden, Veale and Summers, 1997), the EDS (Hausenblas and Symons Downs, 2002b), the OEQ (Pasman and Thompson, 1988), and the EAI (Terry, Szabo and Griffiths, 2004). The methods of measuring for indicated eating disorders were the Eating Attitudes Test 40 (Garner and Garfinkel, 1979), the Eating Attitudes Test 26 (Garner et al., 1982), the Eating Disorder Examination Questionnaire (Fairburn and Beglin, 1994), the Eating Disorder Inventory-2 (Garner, 1991), and the SCOFF Questionnaire (Morgan, Reid and Lacey, 1999). The mean NOS score for all included studies was 6.67 $\pm$ 1.2 (range: 4-8) - full NOS scoring is shown in Table 2.10.

Table 2.9: Descriptive statistics of included articles in Study 2

Author	EA odds Ratio (95% CI)	Sub-group	Total *n*	Mean Age	BMI	Sex (% female)	Country	Population	Exercise addiction measure	Exercise addiction measure reliability (Cronbach's alpha)	Eating disorder measure
Bamber *et. al.*	4.934 (2.365-10.294)	Non-indicated ED	153	NR	NR	100	UK	Various (aerobic dance classes; university and community sports centres; university cross country and athletics clubs and local running clubs)	EDQ	0.84	EDE-Q
		Indicated ED	41	NR	NR	100					
Blaydon and Lindner	2.067 (1.078-3.962)	Non-indicated ED	113	NR	NR	32.69	Multi-national	Triathletes	EDQ	NR	EAT-40
		Indicated ED	58	NR	NR	40.54					
Blaydon and Lindner	4.742 (2.900-7.752)	Non-indicated ED	296	NR	NR	27.70	UK	Amateur competitive exercisers	EDQ	NR	EAT-40
		Indicated ED	86	NR	NR	52.33					
De Young and Anderson	6.836 (2.402-19.455)	Non-indicated ED	207	19	24.2	49.28	NR	Undergraduate students that engage in 'physical exercise at least occasionally'	OEQ	0.89	EDE-Q
		Indicated ED	21	20	23.94	80.95					
Di Lodovico, Dubertret, & Ameller	4.172 (1.432-12.157)	Non-indicated ED	129	30.39	NR	46.51	NR	Runners	EAI	NR	SCOFF
		Indicated ED	25	26.72	NR	84.00					
Grandi *et. al*.	0.490 (0.186-1.287)	Non-indicated ED	79	30	21.6	57.00	Italy	Health club users	EDQ	0.92	EDI-2
		Indicated ED	28	NR	NR	NR					
Lease and Bond	16.687 (8.593-32.404)	Non-indicated ED	227	23	23.35	100	Australia	Health club users	OEQ	NR	EAT-26
		Indicated ED	75	21	22.78	100					
Meulemans *et. al.*	3.884 (1.206-12.508)	Non-indicated ED	480	19.76	22.14	54.12	USA	Various undergraduate and graduate students	EDS-R	NR	EAT-26
		Indicated ED	41	19.7	22.07	75.61					

Serier *et. al.*	2.450 (0.865-6.939)	Non-indicated ED	48	36.23	NR	100	USA	Women seeking help for body-dissatisfaction	OEQ	0.88	EAT-26
		Indicated ED	22	29.86	NR	100					

EDQ = Exercise Dependence Questionnaire; EDS = Exercise Dependence Scale; OEQ= Obligatory Exercise Questionnaire; EAI = Exercise Addiction Inventory; EDE-Q = Eating Disorders Examination Questionnaire; EAT 26 = Eating Attitudes Test 26; EAT 40 = Eating Attitudes Test 40 EDI-2 = Eating Disorders Inventory 2; NR=not reported; ED=eating disorder

Table 2.10: Scoring of studies using the Newcastle-Ottawa Quality Assessment Scale in Study 2

Study	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure (risk factor)	The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.	Assessment of the outcome	Statistical test	Total score
Bamber *et. al.*	1	0	0	2	2	1	1	7
Blaydon and Lindner	1	0	0	2	2	1	1	7
Blaydon *et. al.*	1	1	0	2	2	1	1	8
De Young and Anderson	1	1	0	0	0	1	1	4
Di Lodovico *et. al.*	1	0	0	2	1	1	1	6
Grandi *et. al.*	1	0	0	2	2	1	1	7
Lease and Bond	1	0	0	2	2	1	1	6
Meulemans *et. al.*	1	0	0	2	2	1	1	7
Serier *et. al.*	1	0	1	2	2	1	1	8

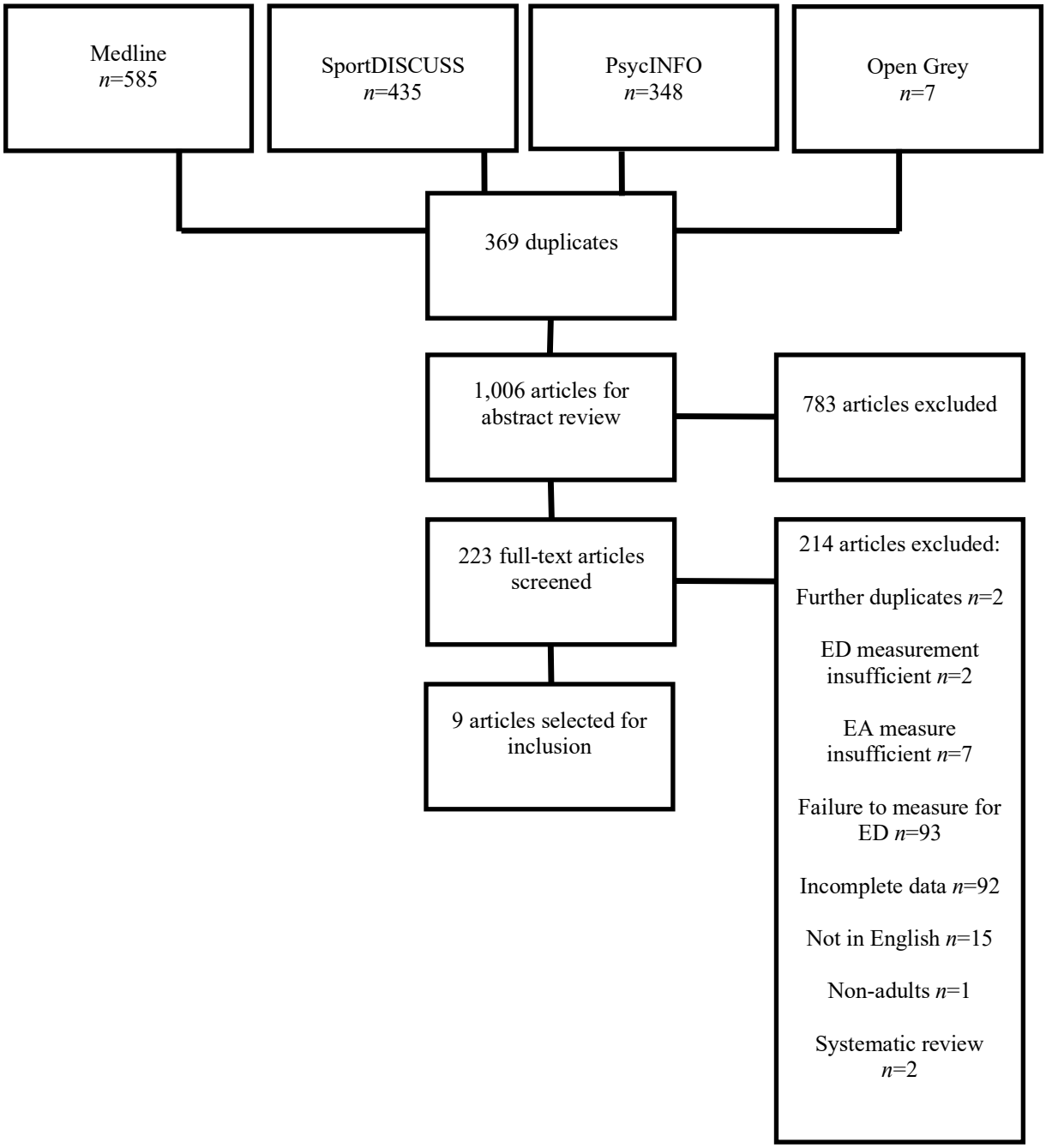

Figure 2.8: PRISMA flowchart of included studies in Chapter 2: Study 2

Meta-analysis results

2.4.2.1 Prevalence rates of exercise addiction in populations with and without indicated eating disorders

The prevalence of exercise addiction in populations without indicated eating disorders (22.5%, 95% CI = 14.3-33.6%; I^2 = 94.605; 9 studies, n=1822; Egger bias = -4.712 p=0.431; trim-and-fill adjustment not required) was lower (p=0.002) than for EA in populations with indicated eating disorders (51.9%, 95% CI = 36.3-67.2%; I^2 = 87.215; 9 studies, n=393; Egger bias = -3.666 p=0.167; trim-and-fill adjustment not required). Full meta-analysis data and forest plots for exercise addiction in both non and indicated eating disorders are shown in Table 2.11 and Figure 2.9.

Table 2.11: Prevalence of exercise addiction populations without and with indicated eating disorders.

				Meta-analysis			Heterogeneity	Publication Bias	
Sub-group	Number of Studies	Number of subjects	Total events	Event Rate	95% CI	Difference between groups	I^2	Egger bias and P-value	Trim-and-fill (95%CI) [number of studies trimmed]
Non-indicated eating disorder	9	1822	346	22.5%	14.3-33.6%	*p*=0.002	94.605	-4.712 *p*=0.431	NA
Indicated eating disorder	9	393	219	51.9%	36.3-67.2%		87.215	-3.666 *p*=0.167	NA

NA=not applicable; CI=confidence interval

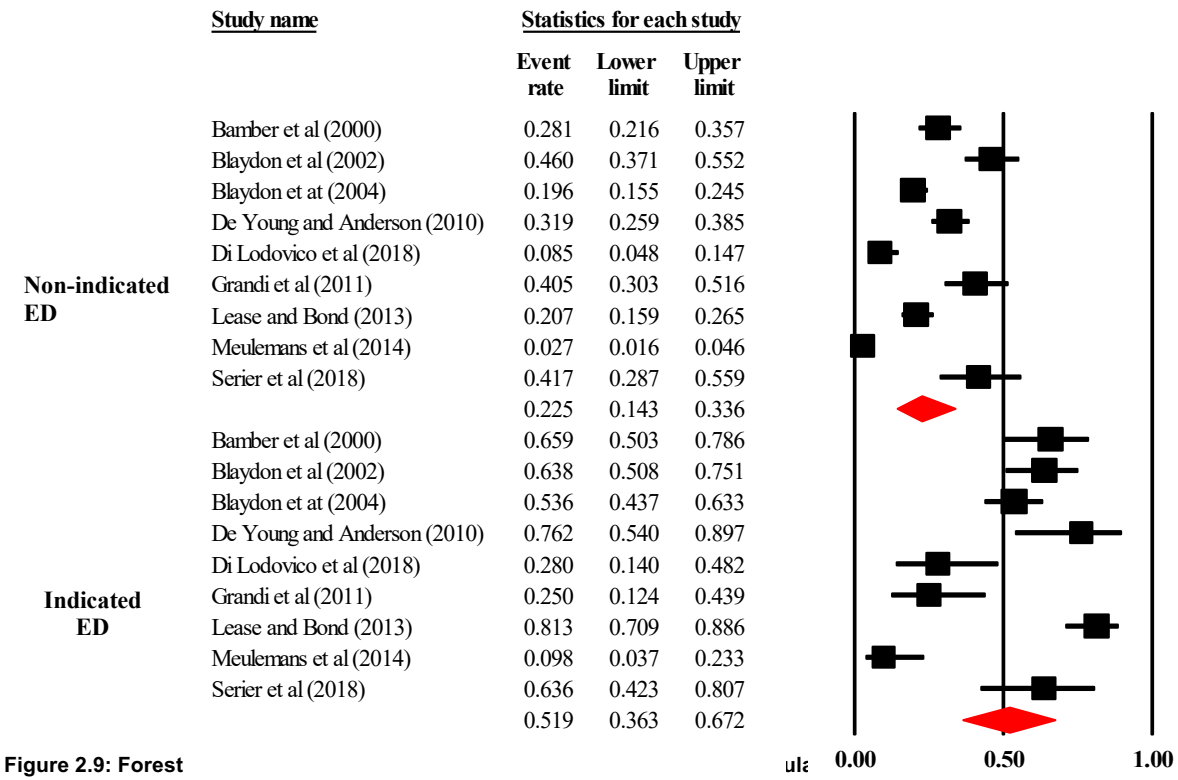

Figure 2.9: Forest

Figure 2.9: Forest plot showing prevalence rates of exercise addiction in populations without and with indicated eating disorders. ED=eating disorder

2.4.2.2 Odds ratios of exercise addiction in populations with and without indicated eating disorders

The pooled OR of exercise addiction in populations with indicated eating disorders compared to those without indicated eating disorders was 3.71 (95% CI 2.00-6.89; I^2 = 81.159; *p*=<0.001; Egger bias = 2.054 *p*=0.480; trim-and-fill adjustment not required). The meta-analysis forest plot is shown in Figure 2.10.

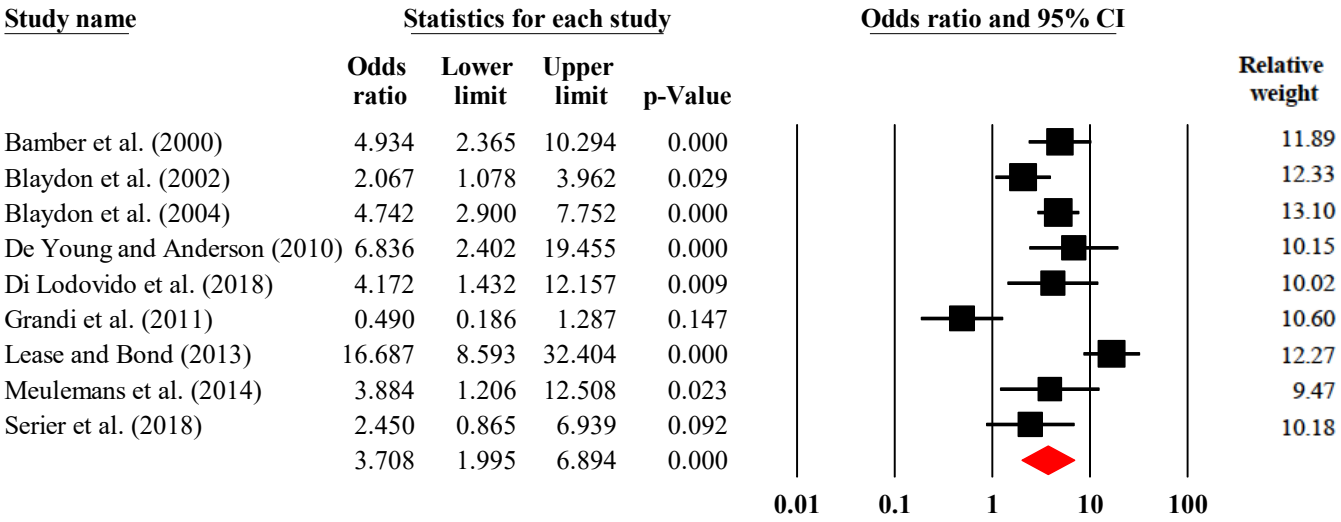

Figure 2.10: Forest plot showing odds ratios of exercise addiction in populations without vs with indicated eating disorders

2.4.2.3 Sensitivity analysis

The direction or significance of the ORs was not changed by the sensitivity analysis, with point estimates ranging from 3.019-4.755. One study (Grandi et al., 2011) had a large effect of the magnitude of the result, with the removal of this study yielding an estimate of 4.755 (95% CI 2.875-7.863; *p*=<0.001). More details can be found in Table 2.12 and Figure 2.11.

Table 2.12: Odds ratios of exercise addition in populations without vs with indicated eating disorders with one study removed.

Study name	Odds ratio if study removed	95% CI
Bamber et al. (2000)	3.56	1.75-7.24
Blaydon et al. (2002)	4.02	2.03-7.94
Blaydon et al. (2004)	3.56	1.66-7.60
De Young and Anderson (2010)	3.45	1.76-6.79
Di Lodovico et al. (2018)	3.65	1.85-7.22
Grandi et al. (2011)	4.75	2.88-7.86
Lease and Bond (2013)	3.02	1.77-5.15
Meulemans et al. (2014)	3.68	1.87-7.25
Serier et al. (2018)	3.88	1.97-7.63

CI=confidence interval

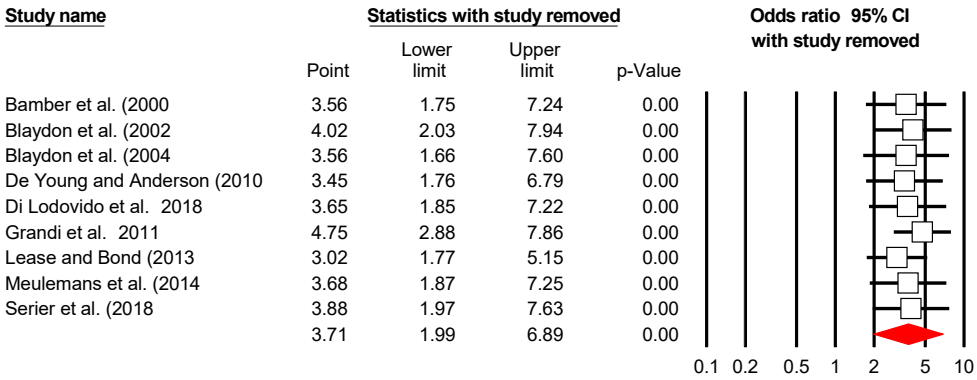

Figure 2.11: Odds ratios of exercise addition in populations without vs with indicated eating disorders with one study removed.

2.4.2.4 Sub-group analysis of exercise addiction prevalence in populations with and without indicated eating disorders by exercise addiction measurement type.

As shown in Table 2.13, the prevalence of exercise addiction among subjects with indicated eating disorders was highest when measured with the OEQ (75.7%; 95% CI = 64.2-84.4%; I2 = 31.73; 3 studies, n=118; Egger bias = --2.925 p=0.51; trim-and-fill adjustment not required), followed by the EDQ (53.3%; 95% CI = 38.6-67.5%; I2 = 76.25; 4 studies, n=224; Egger bias = -2.738 p=0.59; trim-and-fill adjustment not required), the EAI (28.0%; 95% CI = 14.0-48.2%; I2 = 0; 1 study, n=25), with the EDS yielding the lowest prevalence rate (9.8%; 95 CI 3.7-23.3%; I2 = 0; 1 study; n= 41). The prevalence of exercise addiction among subjects without indicated eating disorders was highest when measured with EDQ (32.4% 95% CI = 21.0-46.4%; I2 = 90.760; 4 studies; n= 641; Egger bias = 14.90 p=0.18; trim-and-fill adjustment not required), followed by the OEQ (29.9% 95% CI = 20.2-41.9%; I2 = 83.004; 3 studies; n= 482; Egger bias = 4.02 p=0.65; trim-and-fill adjustment not required); the EAI (8.5% 95% CI = 4.8-14.7%; I2 = 0; 1 study; n=129), with the EDS yielding the lowest prevalence rate (2.7% 95% CI = 1.6-4.6%; I2 = 0; 1 study; n=480).

Table 2.14 shows that the OR of exercise addiction among subjects with indicated vs no-indicated eating disorders was highest when measured with the OEQ (6.9; 95%CI 2.2-21.8), followed by the EAI (4.2; 95%CI = 1.4-12.2), the EDS (3.9; 95%CI = 1.2-12.5), with the EDQ yielding the lowest OR (2.4; 95CI 1.0-5.7).

Table 2.13: Prevalence of exercise addiction with and without indicated eating disorders by exercise addiction measurement type

					Meta-analysis		Heterogeneity	Publication Bias	
Population	Exercise addiction measurement tool	Number of studies	Number of subjects	Total events	Prevalence (%)	95% CI	I^2	Egger bias and P-value	Trim-and-fill (95%CI) [number of studies trimmed]
Indicated eating disorder	OEQ	3	118	91	75.7	64.2-84.4	31.73	--2.925 *p*=0.51	NA
	EDQ	4	224	123	53.3	38.6-67.5	76.25	-2.738 *p*=0.59	NA
	EAI	1	25	7	28.0	14.0-48.2	0	NA	NA
	EDS	1	41	4	9.8	3.7-23.3	0	NA	NA
Non-indicated eating disorder	EDQ	4	641	185	32.4	21.0-46.4	90.76	14.90 *p*=0.18	NA
	OEQ	3	482	133	29.9	20.2-41.9	83.00	4.02 *p*=0.65	NA
	EAI	1	129	11	8.5	4.8-14.7	0	NA	NA
	EDS	1	480	13	2.7	1.6-4.6	0	NA	NA

NA=not applicable; OEQ=obligatory exercise questionnaire; EDQ=exercise dependence questionnaire; EAI-exercise addiction inventory; EDS=exercise dependence scale; CI=confidence interval

Table 2.14: Odds ratios of risk of exercise addiction with and without indicated eating disorders by exercise addiction measurement type

			Meta-analysis	Heterogeneity	Publication Bias	
Exercise addiction measurement tool	Number of studies	Number of subjects	Odds ratio (95% CI)	I^2	Egger bias and P-value	Trim-and-fill (95%CI) [number of studies trimmed]
Obligatory exercise questionnaire	3	600	6.9 (2.2-21.8)	84.903	-7.389 *p*=0.219	NA
Exercise addiction inventory	1	154	4.2 (1.4-12.2)	0	NA	NA
Exercise dependence scale	1	521	3.9 (1.2-12.5)	0	NA	NA
Exercise dependence questionnaire	4	865	2.4 (1.0-5.7)	79.141	-7.234 *p*=0.296	NA

CI=confidence interval

2.7 Discussion

In this Chapter, two systematic reviews with several meta analyses were conducted: Study 1 included 13 studies in total, with six of those studies using either the EAI or EDS to measure exercise addiction. Of these six studies, prevalence rates of exercise addiction varied depending on the population, with the lowest prevalence among amateur competitive athletes (5.0%), followed by university students (5.5%), with general exercisers yielding the highest prevalence rates (8.1%). It should be noted, however, that all subgroups had low numbers of individual studies and further estimates are needed to produce reliable results for specific populations. The meta-analysis in Study 1 also demonstrated that overall exercise addiction prevalence rates differed depending on the measurement tool, with the OEQ yielding the highest prevalence rates (29.9%), followed by the EDQ (29.7%), the EAI (17.1%), with the EDS showing the lowest prevalence rate (4.1%). A number of potential correlates were also assessed, showing significant differences between exercise addiction and non- exercise addicted control groups. Exercise addiction subjects were more likely to have lower overall wellbeing (only in amateur competitive athletes), higher anxiety concentration, and have higher concentrations of frontal brain activity. Study 2 included nine studies and demonstrated that the OR of exercise addiction in populations with vs without indicated eating disorders was 3.7. The sensitivity analysis showed that the direction and significance of the findings were unchanged when one study was removed. The ORs also differed largely in both populations depending on the exercise addiction measurement tool being used.

2.7.1 Stratified exercise addiction prevalence rates in participants without indicated eating disorders

Regarding the results of Study 1, in particular the stratified prevalence estimates according to the type of population, exercise addiction prevalence rates were found to be lower than similar aggregated exercise addiction prevalence results reported a recent meta-analysis by Di Lodovico and colleagues (Di Lodovico, Poulnais and Gorwood, 2019), who reported the prevalence of exercise addiction in amateur competitive athletes ranging from 10.4-15.3% compared with this study's prevalence of 5% (the other types of population were not broadly comparable with Di Lodovico and colleagues). This lower prevalence rate concurs with the current literature suggesting that subjects without eating disorder symptomology score lower on measures of exercise addiction than their eating disorder symptomology counterparts (Bratland-Sanda et al., 2010; Dalle Grave, Calugi and Marchesini, 2008), meaning that

exercise addiction studies that do not adjust/stratify for eating disorders could have skewed overall exercise addiction prevalence rates if participant also had a (non-screened) eating pathology. It also provides further evidence of a possible aetiological difference in exercise addiction in indicated and no-indicated eating disorders populations. One possible reason for this is that people with eating disorders have been consistently reported to have a compulsion towards exercise, with the main goal to lose weight (Klein et al., 2004; Laban et al., 1995), which could manifest in positive responses to several of the questions asked in all of the current exercise addiction measurement tools.

2.7.2 Exercise addiction prevalence in indicated vs no-indicated eating disorders populations.

In Study 2, it was found that participants who had indicated eating disorders had a pooled exercise addiction prevalence of 51.9% and those without indicated eating disorders had a significantly lower pooled prevalence of 22.5%. Furthermore, participants who had indicated eating disorders were just under four times more likely to be at risk of exercise addiction, with observed prevalence rates in participants with indicated eating disorders comparing well with exercise addiction studies conducted on clinical eating disorder populations. For example, Study 2 reported exercise addiction (in the presence of indicated eating disorders) prevalence at 51.9%, and clinical eating disorder populations reporting 31.9-80% dependent on type of eating disorder (Dalle Grave and Grave, 2008; Klein et al., 2004). One possible reason is that excessive exercise has been consistently shown to be an inherent part of several types of eating disorders, and is indeed part of the diagnostic criteria for several types of eating disorders (American Psychiatric Association, 2013), with patients demonstrating aversions to weight gain and showing obsessions towards not gaining weight (Davis et al., 1997). Furthermore, eating disorder subjects have been shown to score higher on addictive personality measures and obsessive-compulsive behaviours (Davis and Claridge, 1998).

Given that exercise addiction can be secondary to an eating disorder (de Coverley Veale, 1987) and with the results of this study suggesting that subjects who show eating disorder symptomology have significantly higher prevalence of exercise addiction, this adds to the evidence suggesting that practitioners working with eating disorder patients should consider monitoring exercise levels a priority, as eating disorder patients have been shown to suffer from serious medical conditions as a result of excessive exercise, such as fractures, increased rates of cardiovascular disease in younger patients and increased overall mortality (Solmi et al., 2016).

The large difference in exercise addiction prevalence observed between indicated and non-indicated eating disorder groups adds to evidence reported in Study 1 suggesting that eating disorder symptomology should be screened for in all studies that measure exercise addiction. As with Study 1, the meta-analysis in Study 2 excluded 93 studies that failed to measure eating disorder symptomology, which not only in concurrent with Study 1, but also agrees with recent literature that suggests that exercise addiction researchers have not readily distinguished between eating disorder status as standard practice (Symons Downs, MacIntyre and Heron, 2019).

2.7.3 Exercise addiction prevalence differences according to exercise addiction measurement tool

Both Studies 1 and 2 reported differing exercise addiction prevalence rates depending on the measurement tool used. In both studies, the EDS and EAI each yielded considerably lower prevalence rates than the EDQ and OEQ, respectively. Furthermore, the EDS consistently yielded the lowest exercise addiction prevalence rates across all studies. It is difficult to ascertain, however whether or not a lower prevalence rate equates to a more accurate measurement tool - future research should focus on the validation of these tools against a clinical measure, such as a medical interview. Because both the EDS and EAI both broadly measure the same domains of exercise addiction, it is therefore difficult to recommend a specific measurement tool. It is the author's view that the EAI and EDS be used until such clinical studies are conducted, as they both are based on underlying theories of addiction and have been described as comparable by several authors (Berczik et al., 2012; Szabo et al., 2015). Because the EAI is shorter (six questions compared to the 21 questions in the EDS), it is recommended that the EAI be used if time is a limiting factor, such as in conjunction with several other questionnaires or in practical applications, such as at gyms or sporting facilities. Furthermore, the EAI provides a score on a continuous scale, as well as having a dichotomous cut-off point, whereas the EDS only yields a categorised result (asymptomatic, symptomatic, and at risk of exercise addiction). Because to date there is no clinical diagnostic criteria for exercise addiction, it is arguably more useful to use a tool in which both continuous and dichotomous data can be yielded, therefore the EAI is recommended.

Currently, to measure exercise addiction and screen for eating disorders in exercise addiction research, two questionnaires are needed. Future work to create a new tool that can effectively screen for eating disorders and exercise addiction in one single tool would be

beneficial. Because currently different tools need to be chosen and justified by authors for exercise addiction and eating disorders respectively, each justification is likely to be subjective, and yield several different tools being used (as the current literature reviews have shown). Consequently, the results yielded regarding secondary and primary exercise addiction will be highly heterogeneous if different tools were being used for each – which is highlighted by the high heterogeneity shown in both reviews. The creation and validation of a new tool able to measure for both exercise addiction and eating disorders has the potential to standardise future research, which would allow easier synthesis of data, and potentially more evidence to use as justification that primary and secondary exercise addiction should be considered as a clinical disorder. This would benefit researchers by only having to use one tool to categorise exercise addiction with and without indicated eating disorders, and could also be beneficial in both a clinical and public health settings by highlighting at-risk subjects earlier, which could inform (in eating disordered subjects) specialised nursing observation and bathroom supervision to regulate exercise addiction behaviours be implemented earlier in treatment. Moreover, earlier categorisation of exercise addiction with an indicated eating disorders has the potential to allow practitioners such as general practitioners, physiotherapists, and health practitioners to therapeutically explore exercise addiction at an earlier point.

2.8 Limitations

While both Study 1 and Study 2 of this Chapter were the first to respectively measure exercise addiction prevalence rates in adults without indicated eating disorders and exercise addiction prevalence rates in populations with and without indicated eating disorders, the findings should be considered within the limitations of these studies.

1. In both studies, the heterogeneity of population groups and measurement tools means this should only be considered a broad overview. Secondly, in the meta-analyses, there were high heterogeneity that could not be explained (e.g. by further sub-group analysis), possibly because of the low number of studies included.
2. Moreover, the low number of studies and respective sample sizes limits the statistical power of prevalence rates and conclusions.
3. Demographic data was missing in several studies: a complete set of demographic data would have added statistical power to potential meta-regressions. As such we are unsure whether demographics are true moderators of exercise addiction prevalence.

4. The use of questionnaires for testing for eating disorders has limited applications to clinical diagnoses and limited sensitivity and specificity to clinical diagnoses. Moreover, in Study 2, the use of these eating disorder questionnaires precluded the sub-categorisation of different types of eating disorders, which is relevant as previous research has shown prevalence rates to differ depending on the type of eating disorder (Dalle Grave, 2009).
5. All the studies included assumed that exercise addiction exists as a dichotomy, which is difficult to confirm given that there are no diagnostic criteria for exercise addiction. Furthermore, it is likely that exercise addiction exists on a spectrum, as suggested by Freimuth, Moniz and Kim (2011).
6. Lastly, there is the potential for eating disorder under-reporting in the exercising population. Several studies have shown that questionnaire-based eating disorder screening tools can increase the occurrence of false-negative results, particularly in athletic populations (Sundgot-Borgen and Torstveit, 2004).

2.9 Conclusion and directions for future research

These two studies supported the rejection of the null in all three hypotheses. Exercise addiction appears to be prevalent in exercisers with and without indication of eating disorders, with exercise addiction being significantly more prevalent in populations with indicated eating disorders than without. This adds novel evidence to the literature base and suggests that practitioners working with eating disordered subjects should closely monitor exercise levels. However, even in those showing no indicated eating disorders, exercise addiction is of notable prevalence – exercise addiction should not be discounted entirely on the basis of no indicated eating disorder behaviours. Moreover, some negative psychological symptoms are associated with exercise addiction independent of eating disorders.

The evidence reported in this Chapter indicates that exercise addiction is more prevalent in populations with indicated eating disorders, however it is currently unclear as to whether correlates of exercise addiction are different according to eating disorder status, meaning that we are unable to determine whether exercise addiction correlates (such as those reported in this Chapter) are unique to eating disorders or exercise addiction in the absence of eating disorders. It is therefore recommended that correlates be explored indicated eating disorders vs no indicated eating disorder populations. For example, conditions such as body dysmorphic disorder (BDD) have been independently correlated with both exercise addiction and eating disorders (Grandi et al., 2011), however the relationships between BDD, exercise addiction and eating disorders together have not been examined to date. This would add further novel evidence that exercise addiction has differing aetiologies in populations with and without indicated eating disorders, and therefore should be treated by researchers and practitioners separately.

Furthermore, it is likely that exercise addiction measurement tools are measuring different domains of the same phenomenon, making the direct comparison of results difficult. Because of the very small number of studies included, and the heterogeneity of the measurement tools and studies, more primary studies using homogenous measurement tools would be beneficial. It is recommended that all future exercise addiction prevalence research include an eating disorder screen to add clarity to sub-populations and identify possible secondary exercise addiction. Because there is currently no exercise addiction measurement tool that incorporates an effective screen for eating disorders, the creation and validation of such tool could make the stratification of exercise addiction easier. In the absence of such a consolidatory tool, it is recommended that either the EAI or EDS be used

as a means of exercise addiction measurement, as well as an eating disorder screening tool to stratify primary and secondary exercise addiction.

2.10 Chapter 2: novel contributions and take-home messages

- Exercise addiction prevalence is significantly different in populations with vs without eating disorders.
- People with indicated eating disorders are 3.7x more likely to have exercise addiction than people with no indicated eating disorders.
- The type of exercise significantly effects exercise addiction prevalence rates.
- Exercise addiction prevalence rates differ significantly according to exercise addiction measurement tool.

Chapter 3: Differences between the prevalence, and novel correlates of exercise addiction in populations with and without indicated eating disorders: two primary studies.

3.1 Publication details

The contents of this Chapter have been published in three peer-reviewed journal articles:

a) **Trott, M.,** Johnstone, J., Firth, J., Grabovac, I., Smith, L. 2020 Prevalence and correlates of body dysmorphic disorder in health club users in the presence vs absence of eating disorder symptomology. *Eating and Weight Disorders.* *https://doi.org/*10.1007/s40519-020-01018-y

b) **Trott M;** Yang, L; Jackson, S; Firth, J; Gillvray, C; Stubbs, B; Smith, L. 2020. Prevalence and correlates of exercise addiction in the presence vs absence of indicated eating disorders. *Frontiers in Sport and Active Living*. https://doi.org/10.3389/fspor.2020.00084

c) **Trott M**., Johnstone, J., Pardhan, S., Barnett, Y., Smith, L. 2021. Changes in body dysmorphic disorder, eating disorder, and exercise addiction symptomology during the COVID-19 pandemic: A longitudinal study of 319 health club users. *Psychiatry Research*. DOI: https://doi.org/10.1016/j.psychres.2021.113831

Article b) has been cited in three publications.

3.2 Chapter 3: abbreviations

Table 3.1: Chapter 3 abbreviations

BDD	Body dysmorphic disorder
BDDQ	Body dysmorphic disorder questionnaire
BMI	Body mass index
EAI	Exercise addiction inventory
EAT-26	Eating attitudes test 26
IL-6	Interleukin 6
REI	Reasons for exercise inventory
SD	Standard deviation
SMUIS	Social media use integration scale
WHO	World Health Organisation

This Chapter will be examining the following question that was postulated in Chapter 1:

- Do correlates of exercise addiction differ according to indicated or no-indicated eating disorders?

3a. Study 1: Differences between the prevalence and novel correlates of exercise addiction in populations with and without indicated eating disorders.

3a.1 Introduction

Chapter 2 of this thesis provided evidence that exercise addiction prevalence rates differ largely depending on two factors: the presence or absence of indicated eating disorders, and the method of exercise addiction measurement. Furthermore, Chapter 2 reported on correlates of exercise addiction that have been published to date in relation to the prevalence of primary exercise and secondary addiction. One limitation of Chapter 2 was that it reported no studies that were able to examine if there were any differences in correlates between populations with and without indicated eating disorders, mainly because the studies do not exist at present. It was also suggested in Chapter 2 that the creation and validation of a single measurement tool that can be used to screen for exercise addiction and eating disorders would be helpful to both practitioners and researchers, as exercise addiction may have differing aetiologies in populations with vs without indicated eating disorders. Before such a tool could be created, however, it would be prudent to ascertain if there is more evidence to suggest that exercise addiction displays differing aetiologies in populations with vs without indicated eating disorders.

Chapter 1 described the many theoretical models have been proposed to explain exercise addiction, including the Sympathetic Arousal Hypothesis (Thompson and Blanton, 1987), the Cognitive Appraisal Hypothesis (Szabo, 1995), the IL-6 model (Hamer and Karageorghis, 2007), Four Phase Model (Freimuth, Moniz and Kim, 2011), and the Biopsychosocial Model (McNamara and McCabe, 2012). Most recently, Egorov and Szabo (2013) updated the Cognitive Appraisal Hypothesis with their Interactional Model of exercise addiction (see Chapter 1: Section 1.4.6: Figure 1.2), which describes a broad range of variables being conducive to developing exercise addiction, along with the acknowledgment that the connections of several variables may be two-way.

One of the key determinants of exercise addiction in the Interactional Model is ‘sudden or progressively intolerable life-stress’. The presence of an eating disorder could be considered as an intolerable life stress, with evidence from Chapter 2 broadly supporting this theory, in that the presence of an eating disorder could be classified as one of these intolerable life stresses, hence the increased prevalence of exercise addiction. Further evidence to support the theoretical Interactional Model is sparse, predominantly because the majority of exercise addiction literature fails to screen for the presence or absence of eating disorders (Symons Downs, MacIntyre and Heron, 2019; Di Lodovico, Poulnais and Gorwood, 2019; Marques et

al., 2019). Indeed, both systematic reviews carried out in Chapter 2 excluded a large number of studies because of their failure to screen for eating disorders (see Figures 2.1 and 2.8).

Another medical condition that could be characterised as an 'intolerable life-stress' is the presence of Body Dysmorphic Disorder (BDD); a condition in which a person is concerned about real or perceived physical defects (such as body shape, skin or hair), as repulsive (Buhlmann et al., 2009; American Psychiatric Association, 2013). Previous studies have shown BDD to be a predictor of exercise addiction in populations without indicated eating disorders (Grandi et al., 2011), however the strength of this association in populations with indicated eating disorders are unknown. Several other correlates have been shown to be associated with BDD. For example, Fardouly and Vartanian (2016) found a positive correlation between time spent on social media and negative body feelings ; Conner, Johnson and Grogan (2004) found that heterosexual women and homosexual men demonstrate the highest levels of body dissatisfaction. This suggests there could be potential links between exercise addiction, social media use, sexuality and BDD. These links, however, have not been empirically explored to date.

Another key component of the Interactional Model of exercise addiction is 'exercise-motivation': the Interactional Model suggests that the specific reasons why people exercise could be a determining factor for exercise addiction. Indeed, it has been suggested that participants with exercise addiction are motivated to exercise for different reasons depending on the presence or absence of an eating disorder, with subjects with no indicated eating disorders exercising 'as an end to itself', and indicated eating disorders subjects exercising to achieve another goal, such as weight loss (de Coverley Veale, 1987). Despite this, there is a paucity of studies that have explored motivations for exercise in the context of exercise addiction, with the few studies that have examined this suggesting that exercise addicted participants scored significantly higher in measures for 'exercising for mood modification' and 'exercising for enjoyment' compared to a non- exercise addicted control group (Serier et al., 2018). One limitation of this study is its very selective population (women with high levels of body dissatisfaction) and a low sample size (n=70). Despite these limitations, however, these results broadly support the Interactional Model. The author found no studies examining differences in exercise motivation in indicated vs non-indicated eating disorders in the context of exercise addiction.

Furthermore, at the beginning of the Interactional Model are 'personal' and 'situational' factors. Of these, the amount of leisure time physical activity has been consistently shown to positively correlate with exercise addiction risk (Kovacsik et al., 2018).

One unique job that could be related to exercise addiction is being a fitness instructor (especially group fitness instructors). Fitness instructors are regularly required to exercise as part of their job, and have been noted at being at higher risk of fitness related injuries, especially when coupled with obligatory exercise tendencies (Thompson, Case and Sargent, 2001). Indeed, leisure exercise time has been strongly associated with exercise addiction scores in many studies (Allegre, Therme and Griffiths, 2007; Adams, Miller and Kraus, 2003; Hausenblas and Symons Downs, 2002b; Costa et al., 2013), which may make fitness instructors at higher risk of exercise addiction. These risks, and whether being a fitness instructor directly correlates with increased exercise addiction risk, however, is yet to be explored.

Identifying the extent to which these variables are associated with exercise addiction has the potential to support, refute, or suggest modifications to the Interactional Model of exercise addiction (Egorov and Szabo, 2013). Furthermore, identifying how much these associations differ between subjects with and without indicated would allow researchers to further understand if there are any differences in the two populations, and therefore have suggested different aetiology. The aim of this primary study, therefore, was to examine the extent in which correlates normally associated with exercise and exercise addiction differ depending on eating disorder status. To address this aim, this chapter will aim to answer the following questions:

1. To what extent are eating disorder status, BDD, reasons for exercise, social media use and fitness instructor status associated with exercise addiction in line with the Interactional Model?

2. Do the associations between these variables and exercise addiction differ according to eating disorder status?

Furthermore, it is hypothesised that:

1. H_0: None of the measured correlates will be significantly different when stratified between populations with vs without an indicated eating disorder.
   H_1: Some of the measured correlates will be significantly different when stratified between populations with vs without an indicated eating disorder.

2. H_0: In the total sample, eating disorder status (a condition that could be considered a 'sudden or progressively intolerable life-stress' according to the Interactional Model of Exercise Addiction) is not associated with exercise addiction.
   H_1: In the total sample, eating disorder status is associated with exercise addiction.

3. H_0: In the total sample, BDD status (another condition that could be considered a 'sudden or progressively intolerable life-stress' according to the Interactional Model of Exercise Addiction) is not associated with exercise addiction.
   H_1: In the total sample, BDD status is associated with exercise addiction.

4. H_0: In the total sample, exercise motivation (which is explicitly mentioned in the Interactional Model of Exercise Addiction as being a potentially causal factor) is not associated with exercise addiction.
   H_1: In the total sample, exercise motivation is associated with exercise addiction.

This study has the potential to expand the understanding of exercise addiction and produce a novel contribution to the exercise addiction literature. Moreover, this study has the potential to inform practitioners, such as physicians and fitness industry workers who work with health club users.

3a.2 Methodology

According to Saracci's (Saracci, 2010) description of epidemiological study types, the aims, questions and hypotheses of this study indicate that this study falls in the category of 'aetiological epidemiology', defined as a study that examines 'hazardous or beneficial factors influencing health conditions' (Saracci, 2010). Furthermore, because the aims, questions and hypotheses do not warrant interventions, the study design needed to be observational in nature. There are several types of observational study design, including cross-sectional, case-control, and cohort studies (prospective and retrospective), all of which have their own strength and limitations, which are discussed below.

- Cross-sectional

Cross-sectional studies predominantly involve recruiting a study sample that is representative of the desired study population, and measuring desired correlates at a single point in time (Thiese, 2014). Moreover, because the data is collected after enrolment, the data can be classified as retrospective. Strengths of the cross sectional design include the ability to determine point prevalence and study associations of multiple exposures and outcomes (Wang and Cheng, 2020). One key limitation to a cross-sectional study design is that temporal relationships cannot be determined due to the data points being collected at one point in time (Thiese, 2014).

- Case-control

Case-control studies involve recruiting a sample with the disease 'case' of interest, and matching these (based on any potentially confounding criteria, such as age and/or BMI) cases with 'controls' who do not have evidence of the disease (Saracci, 2010). In the case of this study, the presence and absence of an indicated eating disorder would be considered as the respective 'cases' and 'controls'. One key strength of this study design is the minimisation of potential confounding factors. One key limitation of this study design is the inability to establish prevalence in a population, due to the selective sampling procedure.

- Cohort studies

Cohort studies involve recruiting study participants that have the exposure status of interest and following the participants through time to identify whether participants develop the outcome of interest (Thiese, 2014). Considering the aims and questions of this study, a

cohort with indicated eating disorders could be recruited and then followed through time to ascertain whether or not they also develop exercise addiction, whilst measuring for changes in the correlates, such as motivations for exercise. One strength of this is the longitudinal nature of the study design, which allows for both point-prevalence and period-prevalence to be determined, as well as potential temporal relationships (Thiese, 2014). One key limitation to this study design is the cost and time it takes to recruit and follow a cohort through time.

- Qualitative

Qualitative studies aim to explore and provide deeper insights into a research question by collecting data on participant's experiences, perceptions, and behaviour (Tenny et al. 2021). Unlike quantitative research, the method of data collection in qualitative research does not involve the collection of numerical data – instead is predominantly involved in asking participants open-ended questions so that a richness of data can be gathered (Tenny et al. 2021). Although qualitative research can yield a richness of data from which thematic analysis can be analysed, it is also relatively time consuming, meaning that fewer participants are typically analysed than in quantitative studies, which makes the generalisability of results challenging.

Considering the aims, questions, and hypotheses of this study, a cross-sectional design was deemed the most appropriate. Although a case-control study could have matched the two populations, it was decided that because little is currently known about the differences between factors in populations with vs without indicated eating disorders, it would have been difficult to justify what correlates each 'case' and 'control' group would be matched against. Furthermore, the choosing of a case-control study design would preclude exercise addiction prevalence rates from being determined, which, although not an explicit aim of this study, would limit the interpretation of the results. The main reason why a cohort study was not chosen for this study was because of the limited literature surrounding the time periods in which exercise addiction (or any of the other correlates) develops within a cohort. Indeed, to the author's knowledge, no such information currently exists. Regarding the possibility of a qualitative research design, although this could have yielded a rich dataset, it would have been impossible to infer statistical differences between groups. Considering that these differences were part of the aims of the study, a qualitative design was deemed to be inappropriate.

3a.3 Methods

Study participants were recruited via an international group fitness e-newsletter and through Facebook, Instagram and Twitter from 8/4/19 to 31/7/19 through social media influencers and through the author's personal social media accounts. Social media influencers included two females with >10,000 followers on Instagram. These females had both experienced eating disorders in the past and are active advocators of healthy eating behaviours. Participants provided informed consent to prior to taking part in the survey, including the right to withdraw and access to further support if any of the topics were distressing. To be eligible for the study participants were required to be adult (>18 years) health club users. Participants were oriented to an online battery of questions hosted through an academic survey website (Jisc Online Surveys, 2020). Other academic survey websites are available that are arguably more user-friendly and could provide more data analytic functions, such as Qualtrics, however at the time the survey was conducted the only platform Anglia Ruskin University had available for use was Jisc Online Surveys. In the survey, measures including measures of age, sex, ethnicity, socio-economic status, life-limiting illness status, exercise addiction, leisure-time physical activity frequency, reasons for exercise, eating disorders, BDD, social media use, body mass index (BMI), and sexuality were included. Ethical approval was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-03).

As there were several (>70) items plus demographics, the survey was initially piloted using a sample of colleagues at Anglia Ruskin University and Queen's University Belfast. The primary aim of this pilot study was to find any typographical errors, ascertain levels of participant burden, and time-taken to complete the survey. After informal talks with all participants, no participants indicated any typographical errors or indicated any participant burden.

3a.3.1 Participants

1864 participants completed the questionnaire. Of these, 199 (10.7%) failed to confirm that they were health club users (by answering positively to the question 'are you a health club user') and were excluded from further analysis. The rationale behind only including health club users was to make the population more homogenic. Of the remaining 1,665 participants, the mean age was 35.7 years (SD=10.9), mean self-reported BMI was 23.9 kg/m^2 (SD=3.9) and 1,428 (85.0%) participants were female. Full demographic information is shown in Table 3.2.

Table 3.2: Descriptive characteristics

Variable	Total sample	Indicated exercise addiction	No indicated exercise addiction	Indicated eating disorders	No indicated eating disorders
N	1,665	511 (30.7%)	1154 (69.3%)	279 (16.8%)	1,386 (83.2%)
Age (years)	35.72 (10.92)	34.47 (10.41)	36.28 (11.10)	33.22 (10.24)	36.22 (10.99)
BMI (kg/m^2)	23.91 (3.93)	23.64 (4.22)	24.02 (3.79)	23.26 (4.75)	24.04 (3.73)
Sex (female)	85.00% (*n*=1,428)	89.4% (*n*=457)	84.10 (*n*=971)	96.40% (*n*=269)	83.60% (*n*=1159)
EAI Total	21.23 (4.31)	25.91 (1.73)	19.17 (3.40)	23.63 (4.55)	20.75 (4.10)
Indicated eating disorder (yes)	16.80% (*n*=279)	32.90% (*n*=168)	9.60% (*n*=111*)*	NA	NA
EAT-26[b] Total	13.40 (12.43)	20.07 (14.83)	10.45 (9.86)	35.90 (9.47)	8.87 (6.7)
Fitness instructor (yes)	42.76% (*n*=712)	42.90% (*n*=219)	42.70% (*n*=493	36.6% (*n*=102)	44.00% (*n*=610)
Exercise hours for leisure (h/wk)	6.46 (4.04)	7.78 (4.50)	5.87 (3.67)	7.75 (4.72)	6.19 (3.84)
Life limiting illness (yes)	1.14% (*n*=19)	0.60% (*n*=3)	1.40% (*n*=16)	1.40% (*n*=4)	1.10% (*n*=15)
Sexuality					
Heterosexual	88.00% (*n*=1,477)	87.10% (*n*=445)	89.40% (*n*=1032)	90.30% (*n*=251)	89.00% (*n*=1226)
Homosexual	4.62% (*n*=77)	4.50% (*n*=23)	4.70% (*n*=54)	2.20% (*n*=6)	5.20% (*n*=71)
Bisexual	4.50% (*n*=75)	5.70% (*n*=29)	4.00% (*n*=46)	5.80% (*n*=16)	4.30% (*n*=59)

Prefer not to say	2.16% (*n*=36)	2.20 (*n*=11)	1.40% (*n*=16)	1.80% (*n*=5)	1.60% (*n*=22)
Ethnicity					
White	91.23% (*n*=1,519)	92.80% (*n*=474)	90.6% (*n*=1045)	92.10% (*n*=256)	91.30% (*n*=1263)
Black or African American	0.72% (*n*=12)	0.40% (*n*=2)	0.90% (*n*=10)	1.10% (*n*=3)	0.70% (*n*=9)
Hispanic or Latino	1.62% (*n*=27)	1.00% (*n*=5)	1.90% (*n*=22)	1.10% (*n*=3)	1.70% (*n*=24)
Asian	3.78% (*n*=63)	3.30% (*n*=17)	4.00% (*n*=46)	4.00% (*n*=11)	3.80% (*n*=52)
Relationship status					
Single	28.89% (*n*=481)	34.10% (*n*=174)	26.60% (*n*=307)	34.40% (*n*=96)	27.90% (*n*=385)
In a relationship	32.01% (*n*=533)	31.10% (*n*=159)	32.40% (*n*=374)	34.80% (*n*=97)	31.60% (*n*=436)
Married	37.40% (*n*=630)	33.90% (*n*=173)	39.60 (*n*=457)	29.40% (*n*=82)	39.70% (*n*=548)
Widowed	0.24% (*n*=4)	0.20% (*n*=1)	0.30% (*n*=3)	0.00% (*n*=0)	0.30% (*n*=4)
Other	1.02% (*n*=17)	0.80 (*n*=4)	0.70% (*n*=8)	1.40% (*n*=4)	0.60% (*n*=8)
Homeowner status (yes)	57.36% (*n*=955)	53.40% (*n*=273)	59.10% (*n*=682)	49.10% (*n*=137)	59.00% (*n*=818)
BDD status (indicated)	30.51% (*n*=508)	48.70% (*n*=249)	22.40% (*n*=259)	76.70% (*n*=214*)*	21.20% (*n*=294)
REI subscales					
Weight control	4.64 (1.27)	5.00 (1.30)	4.48 (1.23)	5.55 (1.13)	4.46 (1.22)

Fitness	5.88 (0.96)	6.05 (0.94)	5.81 (0.96)	5.82 (1.17)	5.89 (0.91)
Mood	5.35 (1.36)	5.81 (1.19)	5.14 (1.39)	5.71 (1.33)	5.27 (1.36)
Health	5.99 (1.02)	6.10 (1.03)	5.94 (1.01)	5.80 (1.26)	6.03 (0.95)
Attractiveness	4.68 (1.57)	5.13 (1.55)	4.48 (1.54)	5.46 (1.52)	4.52 (1.53)
Enjoyment	4.55 (1.51)	4.83 (1.52)	4.43 (1.49)	4.45 (1.76)	4.57 (1.45)
Tone	4.52 (1.51)	4.70 (1.53)	4.44 (1.50)	4.80 (1.54)	4.90 (1.20)
SMUIS subscales					
Social integration and emotional connection	2.59 (1.12)	2.82 (1.16)	2.49 (1.08)	2.94 (1.27)	2.52 (1.07)
Integration into social routines	4.11 (1.18)	4.24 (1.20)	4.05 (1.17)	4.32 (1.21)	4.07 (1.17)

Data is presented as mean (standard deviation), unless otherwise stated. EAI=Exercise Addiction Inventory; EAT-26=Eating Attitude Test; BDD=Body dysmorphic disorder; REI=Reasons for Exercise Inventory; SMUIS=Social Media Use Integration Scale

3a.3.2 Measures

Exercise addiction

The Exercise Addiction Inventory (EAI) (Terry, Szabo and Griffiths, 2004) is a six-item questionnaire that assesses each component of Brown's components of general addiction (Brown, 1993) in an exercise context. Each question is scored on a Likert scale of 1-5, with a higher score indicating higher risk of exercise addiction. Subjects who score ≥24 are classified as 'at risk' of exercise addiction. The EAI has been shown to have good reliability and validity across physically active populations (Griffiths et al., 2015; Lichtenstein and Jensen, 2016; Terry, Szabo and Griffiths, 2004), and shows good internal reliability in the current study (α=0.74).

Note: Despite having a cut-off score, the EAI was used in this study as a continuous variable indicating severity of exercise addiction risk because there are no clinically recognised diagnostic criteria for exercise addiction (American Psychiatric Association, 2013). Furthermore, this is in line with the Four Phase Model of exercise addiction (Freimuth, Moniz and Kim, 2011).

Social media use

Social media use was measured using the Social Media Use Integration Scale (SMUIS) (Jenkins-Guarnieri, Wright and Johnson, 2013), a ten-item questionnaire with two sub-scales: social integration and emotional connection and integration into social routines. Each question is scored on a Likert scale of 1-6, with higher scores in each sub-scale indicating higher levels of its respective sub-scale. The SMUIS has shown good validity across several age ranges (Jenkins-Guarnieri, Wright and Johnson, 2013; Maree, 2017), and shows excellent internal consistency in the current study (social integration and emotional connection sub-scale Cronbach's α=0.88 ; integration into social routines sub-scale Cronbach's α=0.81).

Reasons for exercise

Reasons for exercise was measured using the Reasons for Exercise Inventory (REI) (Silberstein et al., 1988), a 24-item questionnaire with seven sub-scales: weight control, fitness, mood, health, attractiveness, enjoyment, and tone. Each question is scored on a Likert scale of 1-7, with higher scores in each sub-scale indicating higher levels in the

respective sub-scale. The REI has been validated across several populations (Cash, Novy and Grant, 1994; Silberstein et al., 1988) and in the current study shows good internal consistency (Cronbach's αs: weight control α=0.61; fitness α=0.83; mood α=0.86; health α=0.86; attractiveness α=0.85; enjoyment α=0.82; tone α=0.79).

Body dysmorphic disorder

BDD was measured using the Body Dysmorphic Disorder Questionnaire (BDDQ) (Phillips, 2005), a questionnaire based on the DSM-IV (American Psychiatric Association, 2000) diagnostic criteria for BDD. Classification of BDD is made based on answering positively to questions one and two, at least one part of question three and indicating spending one or more hours each day thinking about their appearance. The questionnaire has excellent reported sensitivity (94%) and specificity (90%) in non-clinical community populations (Brohede et al., 2013).

Eating disorder symptoms

Eating disorder symptomology was measured using the Eating Attitudes Test 26 (EAT-26) (Garner et al., 1982), a 26-item questionnaire scored on a Likert scale of 1-6. A score of ≥20 is sufficient to be classified as having possible pathological eating behaviours. The EAT-26 has been well validated in athletic populations (Doninger, Enders and Burnett, 2005; Pope et al., 2015), and has shown excellent internal consistency in the current study (Cronbach's α=0.91).

Health club user

Participants were required to answer yes/no to indicate whether they were a current health club user.

Fitness instructor status

Participants were required to answer yes/no to indicate if they were currently a fitness instructor.

Leisure-time physical activity

Participants were required to indicate how many hours per week they participated in physical activity (if the subject was a fitness instructor, this did not include exercise hours as part of work).

Note that all survey questions are also shown in Appendix F.

3a.3.3 Data analysis

All data were analysed using SPSS Version 26 (IBM Corp., 2019).

The analysis of the data was conducted in two ways:

1. With exercise addiction being a continuous variable, as suggested by Freimuth and colleagues (2011).

2. With exercise addition being a dichotomous variable, using the original author's cut-off point of ≥24 as being classified as 'at risk' of exercise addiction (Terry, Szabo and Griffiths, 2004).

Although the EAI has a cut-off point that dichotomises participants as either 'at risk' or not at risk from exercise addiction (Terry et al. 2004), the EAI was used as a continuous variable, with higher scores indicating higher pathology towards exercise addiction. The main reason for this decision was because there is no evidence that the EAI (or any other exercise addiction tool) is a sufficient diagnostic tool for exercise addiction, mainly because there are no diagnostic criteria for the condition to date.

A hierarchical multiple linear regression was run on the total sample to determine if the addition of variables significantly added to the total model with EAI score (as a continuous variable) as the dependent variable. A multiple regression is a technique that allows the modelling of a linear relationship between the dependent (in this case total EAI score) and several independent variables; using several explanatory variables to predict the independent variable (Field, 2013; Cramer and Howitt, 2021). It is more robust than a standard linear regression as it allows the addition of more than one independent variable. The decision to choose a hierarchical (also known as step-wise) regression over a standard multiple regression was mainly because a hierarchical regression allow for the selective adding of independent variables, which allows the researcher to choose to include or exclude variables in the next version of the models, thereby providing more information,

whereas a standard multiple regression is more explorative by simply adding all of the independent variables into one model (Cramer and Howitt, 2021).

In this study, the variables were added in the following order:

Model 1: Age, gender, BMI, ethnicity, life limiting illness
Model 2: Eating disorder status (in total sample only)
Model 3: BDD status
Model 4: Reasons for exercise (all items)
Model 5: Fitness instructor status
Model 6: Social media use (all items)
Model 7: Sexuality
Model 8: Exercise hours for leisure
Model 9: Relationship status

And was conducted across three groups:

1. Total sample
2. Participants with indicated eating disorders (defined as scoring ≥20 in the EAT-26)*
3. Participants with no indicated eating disorders (defined as scoring <20 in the EAT-26)*

*Note that with the two sub samples stratified by eating disorder status, Model 2 (eating disorder status) was not applicable, therefore Model 2 in these sub-samples were BDD status, Model 3 BDD status, etc.

The reason for this ordering of variables was because it follows the theoretical order of variables according to the Interactional Model of Exercise Addiction (Egorov and Szabo, 2013).

In order to explore whether associations varied according to eating disorder status, we repeated the multivariable analysis (Model 9) in a series of linear regression models adding the interaction term (eating disorder status*respective variable) between eating disorder status and each potential correlate in turn (e.g. in the first analysis we included all variables in Model 9 with the addition of the variable ‘eating disorder status*age’; in the second analysis we included all variables in Model 9 with the addition of the variable ‘eating disorder status*gender’, etc).

Exercise addiction prevalence was also calculated in all the total sample and both indicated and non-indicated eating disorder populations.

In all analyses, any missing data was tested for randomness via Little's MCAR test (Little, 1988), and if confirmed random, deleted listwise from all regression analyses.

3a.4 Results

3a.4.1 Exercise addiction and eating disorder prevalence

The prevalence of exercise addiction, as defined by a score of ≥24 on the EAI in the total sample was 30.7% (95%CI=28.5%-33.0%), 60.2% (95%CI=54.2%-66.0%) in the population who had an indicated eating disorder, and 24.7% (95%CI=22.5%-27.1%) in the population who had no indicated eating disorders. The prevalence of indicated eating disorders was 16.8% (95%CI=15.0%-18.6%), with the remaining 83.2% (95%CI=81.4%-84.8%) with no indicated eating disorders.

3a.4.2.1 Regression assumption testing

There are several assumptions that need to be met before a dataset is considered suitable for multiple regression (Field, 2013; Cramer and Howitt, 2021) - these are discussed below.

There was linearity in all samples as assessed by partial regression plots and a plot of studentised residuals against the predicted values. There was independence of residuals in all populations, as assessed by a Durbin-Watson statistic of 2.108, 1.087, and 2.036 in the total sample, indicated eating disorder and no indicated eating disorder samples respectively. Homoscedasticity was as assessed by visual inspection of a plot of studentised residuals versus unstandardised predicted values, with evidence of homoscedasticity in all three samples. There was no evidence of multicollinearity in any sample, as assessed by tolerance values greater than 0.1. There were 23 studentised deleted residuals greater than ±3 standard deviations, which were kept in the analysis. The assumption of normality was met, as assessed by a Q-Q Plot. The Little's MCAR test confirmed that all missing data was random (p=0.07), and therefore were listwise deleted from all regression analyses.

3a.4.2.2 Hierarchical multiple regression: total sample

In the total sample, each model significantly added to the total R^2, apart from Models 5, 7 and 9 (the respective addition of fitness instructor status, sexuality, and relationship status into the previous model). The final multiple regression model (Model 9) was statistically significant (F(29, 1500) =16.227, p=<0.001, adj. R^2=0.224). The variables BMI, life limiting illness, being a fitness instructor, exercise hours for leisure, eating disorder status, REI 'mood' and 'enjoyment' subscales, SMUIS social integration and emotional connection subscale, BDD status, ethnicity black and Asian (vs white as the reference value) added

significantly to the prediction (p=<0.05). Full coefficient results and changes in R^2 are shown in Tables 3.3 and 3.4.

Table 3.3: Hierarchical regression in the total sample Models 1-8 (exercise addiction inventory scores as the dependent variable)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2
	0.027	NA	0.079	0.052	0.098	0.019	0.180	0.082	0.180	0.000	0.184	0.004	0.184	0.000	0.226	0.042
Variable	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*
Age	-0.106 (-0.156; -0.056)	<0.001	-0.084 (-0.133; -0.036)	0.001	-0.056 (-0.105; -0.006)	0.027	-0.044 (-0.093; 0.005)	0.081	-0.045 (-0.094; 0.004)	0.073	-0.038 (-0.087; 0.012)	0.138	-0.036 (-0.086; 0.014)	0.156	-0.046 (-0.095; 0.002)	0.061
Sex	-0.052 (-0.103; -0.002)	<0.001	-0.022 (-0.071; 0.027)	0.385	-0.005 (-0.054; 0.044)	0.843	0.020 (-0.029; 0.069)	0.417	0.020 (-0.029; 0.068)	0.432	0.021 (-0.028; 0.070)	0.404	0.023 (-0.030; 0.075)	0.392	0.004 (-0.047; 0.055)	0.881
BMI	-0.064 (-0.115; -0.014)	0.012	-0.055 (-0.104; -0.006)	0.027	-0.067 (-0.115; -0.018)	0.007	-0.071 (-0.118; -0.025)	0.003	-0.071 (-0.118; -0.025)	0.003	-0.074 (-0.121; -0.028)	0.002	-0.074 (-0.121; -0.028)	0.002	-0.049 (-0.094; -0.003)	0.037
Ethnicity: White vs Hispanic	-0.013 (-0.062; 0.037)	0.613	-0.011 (-0.059; 0.037)	0.659	-0.011 (-0.059; 0.036)	0.643	-0.016 (-0.061; 0.030)	0.494	-0.017 (-0.063; 0..029)	0.465	-0.013 (-0.058; 0.033)	0.585	-0.016 (-0.062; 0.030)	0.500	-0.011 (-0.056; 0.033)	0.614
Ethnicity: White vs black	-0.091 (-0.140; -0.041)	<0.001	-0.099 (-0.147; -0.051)	<0.001	-0.094 (-0.142; -0.046)	<0.001	-0.066 (-0.112; -0.020)	0.005	-0.066 (-0.112; -0.020)	0.005	-0.065 (-0.111; -0.019)	0.006	-0.068 (-0.113; -0.022)	0.004	-0.071 (-0.115; -0.026)	0.002
Ethnicity: White vs Asian	-0.020 (-0.070; 0.029)	0.423	-0.021 (-0.070; 0.027)	0.388	-0.015 (-0.063; 0.033)	0.530	-0.026 (-0.072; 0.020)	0.270	-0.025 (-0.071; 0.021)	0.290	-0.027 (-0.073; 0.019)	0.253	-0.029 (-0.075; 0.017)	0.216	-0.045 (-0.090; 0.000)	0.050
Ethnicity: White vs 'other'	0.001 (-0.049; 0.051)	0.970	0.005 (-0.043; 0.053)	0.842	0.009 (-0.039; 0.057)	0.708	-0.005 (-0.050; 0.041)	0.843	-0.004 (-0.050; 0.042)	0.855	-0.004 (-0.050; 0.041)	0.855	-0.004 (-0.050; 0.041)	0.850	-0.005 (-0.050; 0.039)	0.817

Life limiting illness	-0.040 (-0.089; 0.010)	0.120	-0.046 (-0.094; 0.003)	0.065	-0.041 (-0.089; 0.007)	0.096	-0.046 (-0.092; 0.000)	0.048	-0.046 (-0.092; 0.000)	0.050	-0.048 (-0.094; -0.002)	0.041	-0.051 (-0.097; -0.005)	0.031	-0.055 (-0.100; -0.011)	0.015
Eating disorder status			0.233 (0.185; 0.282)	<0.001	0.163 (0.109; 0.217)	<0.001	0.135 (0.082; 0.188)	<0.001	0.136 (0.083; 0.189)	<0.001	0.135 (0.083; 0.188)	<0.001	0.134 (0.081; 0.187)	<0.001	0.106 (0.054; 0.158)	<0.001
BDD status					0.162 (0.107; 0.218)	<0.001	0.123 (0.069; 0.178)	<0.001	0.123 (0.068; 0.178)	<0.001	0.117 (0.062; 0.172)	<0.001	0.119 (0.064; 0.174)	<0.001	0.112 (0.058; 0.165)	<0.001
REI weight control							0.067 (0.012; 0.122)	0.018	0.067 (0.012; 0.122)	0.018	0.065 (0.010; 0.120)	0.020	0.064 (0.009; 0.119)	0.023	0.060 (0.006; 0.113)	0.030
REI fitness							0.067 (0.007; 0.127)	0.028	0.065 (0.005; 0.125)	0.035	0.062 (0.002; 0.122)	0.043	0.060 (0.000; 0.120)	0.052	0.043 (-0.016; 0.102)	0.154
REI mood							0.205 (0.150; 0.260)	<0.001	0.205 (0.150; 0.260)	<0.001	0.202 (0.147; 0.257)	<0.001	0.201 (0.146; 0.256)	<0.001	0.200 (0.147; 0.254)	<0.001
REI health							-0.051 (-0.115; 0.014)	0.122	-0.050 (-0.115; 0.014)	0.125	-0.036 (-0.101; 0.029)	0.281	-0.035 (-0.101; 0.030)	0.288	-0.021 (-0.084; 0.043)	0.521
REI attractiveness							0.048 (-0.008; 0.104)	0.096	0.050 (-0.007; 0.106)	0.084	0.034 (-0.023; 0.091)	0.236	0.038 (-0.019; 0.095)	0.195	0.049 (-0.007; 0.105)	0.084
REI enjoyment							0.105 (0.054; 0.156)	<0.001	0.101 (0.049; 0.152)	<0.001	0.094 (0.042; 0.146)	<0.001	0.095 (0.043; 0.146)	<0.001	0.070 (0.019; 0.121)	0.007

REI tone				-0.038 (-0.086; 0.010)	0.121	-0.040 (-0.088; 0.008)	0.105	-0.040 (-0.088; 0.008)	0.099	-0.041 (-0.089; 0.007)	0.092	-0.044 (-0.091; 0.002)	0.063
Fitness instructor status						0.024 (-0.023; 0.071)	0.323	0.018 (-0.029; 0.065)	0.460	0.017 (-0.030; 0.064)	0.485	0.063 (0.016; 0.110)	0.009
SMUIS social integration and emotional connection								0.086 (0.024; 0.148)	0.006	0.085 (0.023; 0.148)	0.007	0.084 (0.024; 0.145)	0.006
SMUIS integration into social routines								-0.024 (-0.084; 0.036)	0.430	-0.024 (-0.084; 0.036)	0.436	-0.004 (-0.063; 0.065)	0.884
Sexuality: Heterosexual vs homosexual										0.013 (-0.062; 0.087)	0.739	-0.013 (-0.086; 0.059)	0.723
Sexuality: Heterosexual vs bisexual										0.024 (-0.042; 0.089)	0.481	0.001 (-0.063; 0.065)	0.983
Sexuality: Heterosexual vs										0.045 (-0.010; 0.099)	0.106	0.032 (-0.021; 0.085)	0.242

'prefer not the say'										
Exercise hours for leisure (h/wk)									0.217 (0.170; 0.264)	<0.001

Data is presented as mean (standard deviation), unless otherwise stated. EAI=Exercise Addiction Inventory; EAT-26=Eating Attitude Test; BDD=Body dysmorphic disorder; REI=Reasons for Exercise Inventory; SMUIS=Social Media Use Integration Scale

Table 3.4: Hierarchical regression in the total sample Model 9 (exercise addiction inventory scores as the dependent variable)

Variable	R^2	ΔR^2
	0.224	-0.002
Age	β (95%CI)	*p*
Sex	-0.042 (-0.102; 0.017)	0.165
BMI	0.004 (-0.048; 0.055)	0.888
Ethnicity: White vs Hispanic	-0.048 (-0.094; -0.002)	0.039
Ethnicity: White vs black	-0.011 (-0.056; 0.033)	0.620
Ethnicity: White vs Asian	-0.071 (-0.116; -0.027)	0.002
Ethnicity: White vs 'other'	-0.048 (-0.094; -0.003)	0.038
Life limiting illness	-0.006 (-0.051; 0.039)	0.795
Eating disorder status	-0.055 (-0.100; -0.010)	0.017
BDD status	0.106 (0.054; 0.159)	<0.001**
REI weight control	0.111 (0.057; 0.164)	<0.001**
REI fitness	0.060 (0.006; 0.114)	0.030
REI mood	0.044 (-0.015; 0.103)	0.144
REI health	0.199 (0.146; 0.253)	<0.001**
REI attractiveness	-0.021 (-0.085; 0.043)	0.523
REI enjoyment	0.049 (-0.007; 0.106)	0.085
REI tone	0.068 (0.017; 0.119)	0.009
Fitness instructor status	-0.044 (-0.091; 0.003)	0.068
SMUIS social integration and emotional connection	0.063 (0.016; 0.111)	0.009
SMUIS integration into social routines	0.083 (0.023; 0.144)	0.007
Sexuality: Heterosexual vs homosexual	-0.003 (-0.061; 0.056)	0.932
Sexuality: Heterosexual vs bisexual	-0.013 (-0.086; 0.061)	0.735
Sexuality: Heterosexual vs 'prefer not the say'	0.002 (-0.062; 0.066)	0.950

Exercise hours for leisure (h/wk)	0.031 (-0.022; 0.085)	0.248
Relationship status: Single vs 'in a relationship'	0.214 (0.167; 0.262)	<0.001**
Relationship status: Single vs married	0.001 (-0.075; 0.035)	0.969
Relationship status: Single vs widowed	-0.020 (-0.088; 0.038)	0.477
Relationship status: Single vs 'other'	-0.025 (-0.033; 0.058)	0.442
Relationship status: Single vs 'in a relationship'	0.013 (-0.033; 0.058)	0.586

Data is presented as mean (standard deviation), unless otherwise stated. EAI=Exercise Addiction Inventory; EAT-26=Eating Attitude Test; BDD=Body dysmorphic disorder; REI=Reasons for Exercise Inventory; SMUIS=Social Media Use Integration Scale

3a.4.2.3 Hierarchical multiple regression: Indicated eating disorders

In the sample including only participants with indicated eating disorders, only Models 5 and 7 significantly added to the total R^2, (the respective addition of reasons for exercise, and social media use). The final multiple regression model (Model 8) was statistically significant (F(26, 232) =3.123, p=<0.001, adj. R^2=0.176). The variables BMI, ethnicity (all but 'other', with white being the reference value), life limiting illness, SMUIS integration and emotional connection, and exercise levels significantly to the prediction (p=<0.05). Full coefficient results and changes in R^2 are shown in Table 3.5.

Table 3.5: Hierarchical regression in the participants with indicated eating disorders (exercise addiction inventory scores as the dependent variable)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2
	0.155	NA	0.157	0.002	0.188	0.031	0.193	0.005	0.219	0.026	0.234	0.016	0.256	0.022	0.259	0.003
Variable	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*
Age	-0.033 (-0.07; 0.04)	0.586	-0.019 (-0.066; 0.049)	0.768	-0.025 (-0.074; 0.05)	0.716	-0.006 (-0.067; 0.060)	0.922	-0.001 - (0.064: 0.063)	0.981	0.008 (-0.06; 0.067)	0.909	0.006 (-0.060; 0.066)	0.929	0.030 (-0.058; 0.085)	0.706
Sex	0.079 (-0.968; 4.918)	0.187	0.081 (-0.923; 4.975)	0.177	0.087 (-0.805; 5.175)	0.151	0.081 (-0.959; 5.035)	0.181	0.066 (-1.31; 4.638)	0.271	0.07 (-1.371; 4.885)	0.269	0.059 (-1.610; 4.582)	0.345	0.058 (-1.657; 4.572)	0.357
BMI	-0.225 (-0.329; -0.100)	<0.001	-0.229 (-0.332; -0.103)	<0.001	-0.22 (-0.327; -0.092)	<0.001	-0.221 (-0.328; -0.092)	<0.001	-0.233 (-0.339; -0.105)	<0.001	-0.219 (-0.327; -0.090)	<0.001	-0.191 (-0.301; -0.062)	0.002	-0.188 (-0.299; -0.059)	0.003
Ethnicity: White vs Hispanic	-0.108 (-9.519; 0.255)	0.063	-0.103 (-9.338; 0.509)	0.078	-0.119 (-10.025; -0.119)	0.044	-0.122 (-10.168; -0.260)	0.039	-0.123 (-10.173; -0.333)	0.036	-0.117 (-9.933; -0.116)	0.044	-0.119 (-9.947; -0.249)	0.039	-0.118 (-9.936; -0.132)	0.044
Ethnicity: White vs black	-0.29 (-17.35; -7.418)	<0.001	-0.289 (-17.319; -7.375)	<0.001	-0.265 (-16.383; -6.246)	<0.001	-0.261 (-16.231 - 6.090)	<0.001	-0.279 (-17.023; -6.815)	<0.001	-0.304 (-18.217; -7.692)	<0.001	-0.317 (-18.763; -8.329)	<0.001	-0.319 (-18.881; -8.384)	<0.001
Ethnicity: White vs Asian	-0.102 (-4.945; 0.311)	0.083	-0.091 (-4.777; 0.637)	0.133	-0.107 (-5.166; 0.297)	0.08	-0.105 (-5.125; 0.334)	0.085	-0.114 (-5.287; 0.133)	0.062	-0.115 (-5.316; 0.116)	0.06	-0.141 (-5.920; -0.479)	0.021	-0.139 (-5.896; -0.390)	0.025
Ethnicity: White vs 'other'	-0.037 (-5.637; 2.855)	0.519	-0.036 (-5.593; 2.911)	0.535	-0.043 (-5.937; 2.692)	0.459	-0.05 (-6.210: 2.452)	0.393	-0.034 (-5.601; 3.020)	0.556	-0.032 (-5.491; 3.100)	0.584	-0.027 (-5.272; 3.218)	0.634	-0.037 (-5.721; 2.945)	0.528

Life limiting illness	-0.06 (-6.617; 2.108)	0.309	-0.06 (-6.602; 2.131)	0.314	-0.077 (-7.293; 1.556)	0.202	-0.082 (-7.493; 1.370)	0.174	-0.106 (-8.370; 0.484)	0.08	-0.125 (-9.136; -0.142)	0.043	-0.133 (-9.385; -0.489)	0.029	-0.130 (-9.367; -0.290)	0.037
BDD status			0.047 (-0.828; 1.865)	0.448	0.054 (-0.807; 2.002)	0.403	0.058 (-0.772; 2.037)	0.376	0.058 (-0.756; 2.025)	0.369	0.074 (-0.582; 2.209)	0.252	0.064 (-0.678; 2.084)	0.317	0.054 (-0.820; 2.007)	0.409
REI weight control					0.004 (-0.504; 0.536)	0.95	0.002 (-0.511; 0.529)	0.973	0.024 (-0.420; 0.617)	0.708	0.020 (-0.440; 0.602)	0.759	0.009 (-0.478; 0.554)	0.884	0.008 (-0.487; 0.557)	0.894
REI fitness					0.111 (-0.267; 1.125)	0.225	0.126 (-0.215; 1.189)	0.173	0.099 (-0.313; 1.082)	0.278	0.086 (-0.368; 1.032)	0.351	0.100 (-0.304; 1.082)	0.27	0.101 (-0.308; 1.088)	0.272
REI mood					0.094 (-0.205; 0.845)	0.231	0.092 (-0.212; 0.838)	0.241	0.091 (-0.210; 0.833)	0.24	0.080 (-0.255; 0.798)	0.310	0.056 (-0.331; 0.716)	0.469	0.056 (-0.337; 0.719)	0.477
REI health					-0.015 (-0.780; 0.671)	0.881	-0.020 (-0.800; 0.651)	0.840	0.018 (-0.661; 0.791)	0.859	0.030 (-0.618; 0.835)	0.769	0.021 (-0.643; 0.794)	0.836	0.020 (-0.649; 0.795)	0.842
REI attractiveness					-0.041 (-0.535; 0.287)	0.553	-0.048 (-0.558; 0.266)	0.486	-0.08 (-0.659; 0.177)	0.257	-0.061 (-0.606; 0.236)	0.388	-0.050 (-0.569; 0.265)	0.474	-0.046 (-0.564; 0.284)	0.516
REI enjoyment					0.021 (-0.321; 0.433)	0.770	0.036 (-0.286; 0.478)	0.623	0.040 (-0.273; 0.482)	0.586	0.040 (-0.270; 0.483)	0.579	0.034 (-0.282; 0.462)	0.634	0.028 (-0.304; 0.451)	0.702
REI tone					0.056 (-0.180; 0.501)	0.354	0.068 (-0.149; 0.541)	0.265	0.090 (-0.087; 0.601)	0.143	0.087 (-0.095; 0.595)	0.155	0.091 (-0.082; 0.600)	0.136	0.089 (-0.091; 0.598)	0.148

Fitness instructor status				-0.076 (-1.910; 0.460)	0.229	-0.095 (-2.105; 0.283)	0.134	-0.094 (-2.093; 0.297)	0.140	-0.064 (-1.811; 0.588)	0.316	-0.066 (-1.846; 0.570)	0.299
SMUIS social integration and emotional connection						0.214 (0.212; 1.306)	0.006	0.198 (0.149; 1.252)	0.012	0.202 (0.169; 1.259)	0.010	0.205 (0.177; 1.274)	0.009
SMUIS integration into social routines						-0.165 (-1.203; -0.038)	0.036	-0.150 (-1.153; 0.022)	0.059	-0.131 (-1.075; 0.091)	0.098	-0.125 (-1.056; 0.119)	0.118
Sexuality: Heterosexual vs homosexual								0.065 (-2.967; 5.023)	0.612	0.040 (-3.327; 4.588)	0.754	0.037 (-3.478; 4.642)	0.777
Sexuality: Heterosexual vs bisexual								0.121 (-2.165; 7.057)	0.297	0.081 (-2.950; 6.238)	0.481	0.083 (-3.004; 6.354)	0.481
Sexuality: Heterosexual vs ‘prefer not the say’								0.141 (-0.879; 10.288)	0.098	0.144 (-0.728 ;10.304)	0.088	0.134 (-1.222; 10.122)	0.123
Exercise hours for leisure (h/wk)										0.163 (0.039; 0.276)	0.009	0.155 (0.030; 0.270)	0.014
Relationship status: Single vs ‘in a relationship’												-0.050 (-1.804; 0.852)	0.480

Relationship status: Single vs married								-0.067 (-2.226; 0.851)	0.379
Relationship status: Single vs widowed								-0.026 (-5.447; 3.515)	0.671

Data is presented as mean (standard deviation), unless otherwise stated. EAI=Exercise Addiction Inventory; EAT-26=Eating Attitude Test; BDD=Body dysmorphic disorder; REI=Reasons for Exercise Inventory; SMUIS=Social Media Use Integration Scale

3a.4.2.4 Hierarchical multiple regression: No-indicated eating disorders

In the sample with participants who had no indicated eating disorders, each model significantly added to the total R^2, apart from Models 4, 6 and 8 (the respective addition of reasons for exercise, sexuality, and relationship status). The final multiple regression model (Model 8) was statistically significant (F(27, 1243) =12.850, p=<0.001, adj. R^2=0.201). The variables BDD status, REI weight control, mood, attractiveness, enjoyment, and tone, fitness instructor status, and exercise levels added significantly to the prediction (p=<0.05). Full coefficient results and changes in R^2 are shown in Table 3.6.

Table 3.6: Hierarchical regression in the participants with no indicated eating disorders (exercise addiction inventory scores as the dependent variable)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2	R^2	ΔR^2
	0.015	NA	0.040	0.026	0.155	0.115	0.157	0.002	0.162	0.004	0.163	0.001	0.218	0.055	0.2184	0.000
Variable	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*	β (95%CI)	*p*
Age	-0.087 (-0.053; -0.012)	0.001	-0.058 (-0.042; -0.001)	0.039	-0.038 (-0.034; 0.005)	0.159	-0.040 (-0.035; 0.005)	0.146	-0.029 (-0.031; 0.009)	0.285	-0.030 (-0.031; 0.009)	0.281	-0.045 (-0.036; 0.002)	0.093	-0.043 (-0.039; 0.006)	0.163
Sex	-0.039 (-1.042; 0.177)	0.164	-0.017 (-0.798; 0.417)	0.538	0.008 (-0.506; 0.695)	0.757	0.007 (-0.524; 0.678)	0.801	0.009 (-0.497; 0.704)	0.734	0.010 (-0.526; 0.766)	0.715	-0.011 (-0.749; 0.504)	0.701	-0.011 (-0.749; 0.508)	0.707
BMI	-0.014 (-0.077; 0.046)	0.616	-0.028 (-0.093; 0.029)	0.304	-0.035 (-0.097; 0.018)	0.181	-0.035 (-0.097; 0.018)	0.183	-0.036 (-0.098; 0.017)	0.174	-0.037 (-0.099; 0.016)	0.164	-0.013 (-0.071; 0.041)	0.605	-0.013 (-0.071; 0.042)	0.616
Ethnicity: White vs Hispanic	0.006 (-1.534; 1.918)	0.827	0.002 (-1.634; 1.776)	0.935	0.000 (-1.634; 1.576)	0.972	-0.003 (-1.716; 1.498)	0.894	0.000 (-1.638; 1.582)	0.972	-0.002 (-1.708; 1.525)	0.911	0.003 (-1.443; 1.684)	0.879	0.003 (-1.444; 1.688)	0.878
Ethnicity: White vs black[b]	-0.045 (-5.994; 0.562)	0.104	-0.038 (-5.555; 0.923)	0.160	-0.010 (-3.706; 2.443)	0.687	-0.010 (-3.689; 2.456)	0.694	-0.009 (-3.609; 2.526)	0.729	-0.007 (-3.550; 2.597)	0.761	-0.005 (-3.294; 2.650)	0.831	-0.005 (-3.303; 2.656)	0.831
Ethnicity: White vs Asian	0.000 (-1.171; 1.148)	0.984	0.000 (-1.151; 1.139)	0.991	-0.008 (-1.263; 0.903)	0.744	-0.006 (-1.216; 0.953)	0.811	-0.007 (-1.244; 0.923)	0.771	-0.009 (-1.295; 0.893)	0.718	-0.022 (-1.527; 0.592)	0.387	-0.023 (-1.578; 0.572)	0.358
Ethnicity: White vs 'other'	0.010 (-1.150; 1.724)	0.695	0.016 (-0.999; 1.840)	0.561	0.004 (-1.216; 1.474)	0.850	0.004 (-1.215; 1.474)	0.850	0.005 (-1.209; 1.476)	0.844	0.004 (-1.239; 1.449)	0.878	0.001 (-1.269; 1.330)	0.963	0.001 (-1.277; 1.338)	0.963

Life limiting illness	-0.042 (-3.85; 0.480)	0.127	-0.037 (-3.620; 0.658)	0.174	-0.037 (-3.486; 0.558)	0.155	-0.037 (-3.484; 0.557)	0.155	-0.036 (-3.451; 0.584)	0.163	-0.038 (-3.520; 0.524)	0.146	-0.041 (-3.593; 0.317)	0.100	-0.041 (-3.589; 0.329)	0.102
BDD status			0.165 (1.105; 2.232)	<0.001	0.114 (0.604; 1.705)	<0.001	0.114 (0.601; 1.701)	<0.001	0.108 (0.544; 1.646)	<0.001	0.110 (0.563; 1.668)	<0.001	0.103 (0.505; 1.574)	<0.001	0.103 (0.506; 1.578)	<0.001
REI weight control					0.070 (0.035; 0.432)	0.020	0.069 (0.035 ;0.432)	0.020	0.065 (0.021; 0.418)	0.029	0.065 (0.020; 0.417)	0.030	0.064 (0.023; 0.407)	0.027	0.064 (0.024; 0.409)	0.027
REI fitness					0.057 (-0.030; 0.548)	0.079	0.054 (-0.047; 0.532)	0.100	0.052 (-0.054; 0.524)	0.110	0.052 (-0.055; 0.525)	0.112	0.022 (-0.181; 0.383)	0.481	0.023 (-0.176; 0.390)	0.458
REI mood					0.238 (0.532; 0.890)	<0.001	0.238 (0.533; 0.891)	<0.001	0.236 (0.527; 0.885)	<0.001	0.238 (0.533; 0.892)	<0.001	0.244 (0.557; 0.904)	<0.001	0.243 (0.554; 0.902)	<0.001
REI health					-0.047 (-0.492; 0.089)	0.174	-0.046 (-0.491; 0.090)	0.177	-0.033 (-0.438; 0.149)	0.334	-0.036 (-0.450; 0.140)	0.302	-0.014 (-0.347; 0.224)	0.673	-0.015 (-0.351; 0.223)	0.661
REI attractiveness					0.075 (0.036; 0.364)	0.016	0.078 (0.044; 0.373)	0.012	0.066 (0.010; 0.342)	0.037	0.067 (0.012; 0.346)	0.035	0.078 (0.045; 0.369)	0.011	0.077 (0.044; 0.369)	0.012
REI enjoyment					0.123 (0.190; 0.505)	<0.001	0.116 (0.167; 0.486)	<0.001	0.107 (0.142; 0.463)	<0.001	0.107 (0.142; 0.463)	<0.001	0.075 (0.056; 0.369)	0.007	0.075 (0.054; 0.370)	0.008
REI tone					-0.067 (-0.338; -0.039)	0.013	-0.070 (-0.345; -0.047)	0.009	-0.073 (-0.353; -0.055)	0.007	-0.075 (-0.359; -0.060)	0.006	-0.078 (-0.362; -0.073)	0.003	-0.078 (-0.362; -0.072)	0.003

Fitness instructor status				0.042 (-0.078; 0.785)	0.108	0.038 (-0.112; 0.752)	0.146	0.037 (-0.130; 0.742)	0.169	0.092 (0.335; 1.200)	<0.001	0.093 (0.336; 1.205)	<0.001
SMUIS social integration and emotional connection						0.070 (0.002; 0.535)	0.047	0.071 (0.004; 0.539)	0.046	0.067 (-0.001; 0.515)	0.051	0.066 (-0.004; 0.513)	0.054
SMUIS integration into social routines						0.002 (-0.226; 0.246)	0.936	0.001 (-0.233;0.241)	0.973	0.021 (-0.155; 0.304)	0.523	0.022 (-0.153; 0.308)	0.508
Sexuality: Heterosexual vs homosexual								0.004 (-0.993 1.110)	0.912	-0.025 (-1.355; 0.686)	0.520	-0.024 (-1.353; 0.710)	0.541
Sexuality: Heterosexual vs bisexual								-0.009 (-1.626; 1.225)	0.782	-0.029 (-1.984; 0.778)	0.391	-0.029 (-1.974; 0.803)	0.408
Sexuality: Heterosexual vs ‘prefer not the say’								0.033 (-0.835; 3.003)	0.267	0.015 (-1.371; 2.348)	0.606	0.015 (-1.364; 2.374)	0.596
Exercise hours for leisure (h/wk)										0.246 (0.207; 0.316)	<0.001	0.246 (0.205; 0.316)	<0.001
Relationship status: Single vs ‘in a relationship’												-0.003 (-0.571; 0.501)	0.898

Relationship status: Single vs married								-0.010 (-0.653; 0.475)	0.757
Relationship status: Single vs widowed								0.014 (-2.627; 4.779)	0.568
Relationship status: Single vs 'other'								-0.005 (-3.087; 2.467)	0.826

Data is presented as mean (standard deviation), unless otherwise stated. EAI=Exercise Addiction Inventory; EAT-26=Eating Attitude Test; BDD=Body dysmorphic disorder; REI=Reasons for Exercise Inventory; SMUIS=Social Media Use Integration Scale

3a.4.2.5 Eating disorder interaction effects

There were significant interactions between eating disorder status and BMI, exercising for mood, exercising for attractiveness, and ethnicity (black vs white as the reference value). Full interaction data are shown in Table 3.7.

Table 3.7: Interaction effects between independent variables and eating disorder status (dependent variable = exercise addiction inventory total score)

Independent variable by eating disorder status (indicated/not indicated)	Beta coefficients (95%CI)	*p*-value
Age	0.001 (-0.051; 0.052)	0.993
Sex[1]	0.017 (-0.030; 0.064)	0.480
BMI	-0.260 (-0.497; -0.023)	0.032
Life limiting illness[2]	-0.025 (-0.076; 0.025)	0.331
Fitness instructor status[3]	-0.053 (-0.112; 0.006)	0.081
Exercise hours for leisure	-0.069 (-0.162; 0.023)	0.140
Homeowner status[4]	-0.022 (-0.885; 0.045)	0.516
REI weight control	-0.185 (-0.403; 0.034)	0.097
REI fitness	-0.057 (-0.293; 0.179)	0.637
REI mood	-0.314 (-0.510; -0.119)	0.002**
REI health	-0.148 (-0.369; 0.073)	0.190
REI attractiveness	-0.196 (-0.365; -0.027)	0.023*
REI enjoyment	-0.089 (-0.217; 0.039)	0.172
REI Tone	0.094 (-0.055; 0.243)	0.217
SMUIS social integration and emotional connection	-0.007 (-0.128; 0.114)	0.911
SMUIS integration into social routines	-0.113 (-0.281; 0.055)	0.187
BDD status[5]	-0.032 (-0.130; 0.066)	0.521
Sexuality: Heterosexual vs homosexual[6]	-0.099 (-0.246; 0.048)	0.187
Sexuality: Heterosexual vs bisexual[7]	0.041 (-0.010; 0.092)	0.112
Sexuality: Heterosexual vs 'prefer not the say'[8]	0.021 (-0.029; 0.071)	0.413
Relationship status: Single vs 'in a relationship'[9]	0.004 (-0.060; 0.068)	0.902
Relationship status: Single vs married[10]	-0.013 (-0.068; 0.042)	0.645
Relationship status: Single vs widowed[11]	NA (not enough data)	-
Relationship status: Single vs 'other'[12]	-0.002 (-0.068; 0.064)	0.953
Ethnicity: White vs Hispanic[13]	-0.043 (-0.091; 0.005)	0.077
Ethnicity: White vs black[14]	-0.104 (-0.159; -0.049)	<0.001**
Ethnicity: White vs Asian[15]	-0.048 (-0.098; 0.002)	0.059
Ethnicity: White vs 'other'[16]	-0.019 (-0.067; 0.029)	0.442

*P<0.05; **P<0.01; Dichotomous variable coding: 1: Female=0, Male=1; 2: Life limiting illness: No=0, Yes =1; 3: Fitness instructor: No=0, Yes =1; 4: Homeowner status: No=0, Yes =1; 5: BDD status: No=0, Yes=1; 6: Sexuality: Heterosexual=0, Homosexual=1; 7: Sexuality: Heterosexual=0, Bisexual=1; 8: Sexuality: Heterosexual=0, 'prefer not to say'=1; 9: Relationship status: Single=0, in a relationship=1; Relationship status: Single=0, married=1; 11: Relationship status: Single=0, widowed=1; 12: Relationship status: Single=0, other=1; 13: Ethnicity: White=0, Hispanic=1; 14: Ethnicity: White=0, black=1; 15: Ethnicity: White=0, Asian=1; 16: Ethnicity: White=0, other=1;

3a.5 Discussion

The present study explored the prevalence of exercise addiction among health club users, the extent to which age, BMI, gender, sexuality, social media use, BDD, fitness instructor status, eating disorder status and reasons for exercise were associated with exercise addiction scores, and whether these correlates differed according to eating disorder status. The prevalence of exercise addiction in the total sample was 30.7%, with prevalence rates differing largely according to eating disorder status (indicated eating disorders 60.2%; no indicated eating disorders 24.7%). This exercise addition prevalence is high when compared to similar studies. For example, the meta-analysis in Chapter 2 yielded prevalence rates of 8.4% in the non-indicated eating disorder group (compared to 24.7% in the current study), and 24.7% (compared to 60.2% in the current study) in groups with indicated eating disorders. It is possible that this inflated prevalence could be due to the sampling methods, in particular the use of social media as a recruitment method. For example, Instagram users have been reported to show significantly higher body dissatisfaction rates than other social media users (Brown and Tiggermann, 2016; Modica, 2020). Indeed, exercise addiction has been associated with body image issues (Corazza et al. 2019), therefore it could be possible that because a large percentage of the sample was recruited from Instagram, this could have meant a higher percentage of the sample also exhibited exercise addiction. Characteristics associated with higher exercise addiction scores in multivariable models included: having an indicated eating disorder; being a fitness instructor; leisure-time physical activity; exercising to improve mood, enjoyment, and for weight control; indicated BDD; and using social media for social integration and emotional connection. Characteristics associated with lower exercise addiction scores included: a higher BMI, reporting a life-limiting illness and ethnicity (black, and Asian, with white as the reference). There were significant interactions between eating disorder status and BMI; exercising for mood and attractiveness; and ethnicity (black with white as the reference). This results of this study, therefore, can reject the all of the null-hypotheses.

3a.5.1 Total sample

The hierarchical regression showed that the addition of all variables into the model significantly increased the R^2, apart from the addition of fitness instructor status, sexuality and relationship status, indicating their limited significance in explaining the total variance in EAI scores.

As hypothesised, the strength of associations of the two variables that could be interpreted as ‘sudden or progressively intolerable life-stress’ (eating disorder status and BDD status) in the Interactional Model of exercise addiction were among the strongest. This concurs with the results from Chapter 2 and primary studies that have shown that people with eating disorders suffer more from exercise addiction (Fietz, Touyz and Hay, 2014), and also agrees with several studies that have shown that negative self-body image is positively correlated with exercise addiction (Ertl et al., 2018; Klein et al., 2004). Moreover, this provides initial evidence that these two conditions could be listed in the Interactional Model as possible intolerable life-events.

Another variable that had one of the strongest associations with exercise addiction score was exercising to modify mood. Although this could be interpreted as ‘psychological health’ on the Interactional Model, it could be possible that this equates to a response to a sudden or progressively intolerable life stress, such as depression or anxiety, which would place this variable into this part of the model. Furthermore, this association broadly concurs with previous studies that have found that exercising for mood, is positively correlated with exercise addiction (Serier et al., 2018). Due to this, it is possible that there is a link between ‘exercise motivation’ (in particular the health (psychological) component), and ‘sudden or progressive intolerable life-stress’ (see Figure 3.1). Further analysis is required to test this model for structural reliability. It is recommended that future studies either structural equation modelling or mediation analyses to confirm or refute this novel hypothesis.

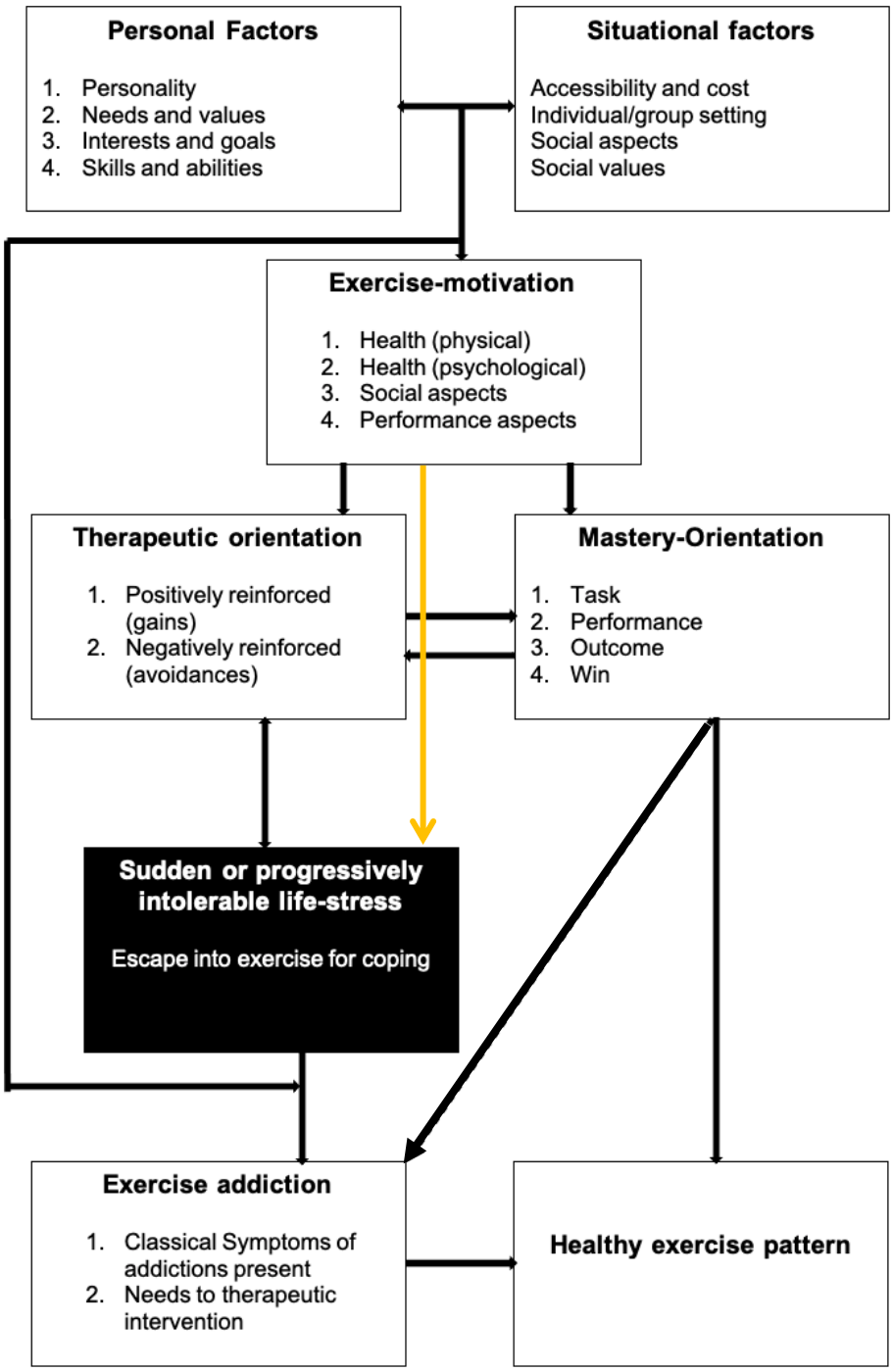

Figure 3.1: Proposed update to the Interactional Model of Exercise Addiction (Ergorov and Szabo, 2013) - the yellow line indicates the proposed addition to the Model

Unsurprisingly, leisure-time exercise was a significant correlate of higher scores of exercise addiction, which concurs with the literature (Allegre, Therme and Griffiths, 2007; Adams, Miller and Kraus, 2003; Hausenblas and Symons Downs, 2002b; Costa et al., 2013). One possible mechanism of this relationship could be the desire to increase concentrations of β-endorphins through increasing amounts of exercise, leading to a relative feeling of euphoria post-exercise (Leuenberger, 2006). Studies in other addictions have suggested that the endogenous opioid system is a key factor in generating addictions (O'Brien, 2004).

3a.5.2 Stratified by eating disorder status sub-samples

In the sub-sample of participants who had no indicated eating disorders, the hierarchical regression showed that addition of all variables into the model significantly increased the R^2, except from the addition of fitness instructor status, social media use, sexuality, and relationship status, indicating their limited significance in explaining the total variance in EAI scores. In contrast, the sample without indicated eating disorders showed that the addition of all variables into the model did not significantly increase the R^2, except from the addition of social media use, and leisure-time exercise level, indicting the limited predictive effect of the other variables on EAI scores.

Lower BMI, using social media for social integration and emotional connection and ethnicity (black, Hispanic and Asian vs white as the reference value) were only positively associated with higher exercise addiction scores among health club users with indicated eating disorders. Fitness instructor status; exercising to improve mood, attractiveness, and enjoyment; and BDD status were only associated with higher exercise addiction scores among health club users without an indicated eating disorders.

Lower BMI was a correlate of higher exercise addiction scores only in health club users who had an indicated eating disorders. This is consistent with the eating disorder literature which states that striving for a lower body weight (and therefore a lower BMI) via excessive exercise is a common symptom of both anorexia and bulimia nervosa (Abraham, 2016), adding to the evidence that exercise levels should be closely monitored in subjects with indicated eating disorders.

Participants who identified as fitness instructors without indicated eating disorders had a slightly higher risk of higher EA scores than health club users who did not identify as fitness instructors. This association did not exist for fitness instructors with indicated eating disorders. One possible reason is because of the expectation of fitness instructors to

exercise as part of their role, and the expectation of superior fitness to regular health club users (Thompson, Case and Sargent, 2001). More research is needed to test this hypothesis. A recent study reported that fitness instructors are frequently worried about members in their centres who exhibit exercise addiction tendencies, however are unsure on how to deal with these people (Colledge et al., 2020). These results are suggestive that fitness instructors should also monitor their peers, as well as their club members.

In participants with no indicated eating disorders, there were significant positive associations between exercise addiction and exercise motivations, including mood improvement, attractiveness, weight control, tone, and enjoyment. This is consistent with previous studies that have found that exercising for mood, appearance, and enjoyment is positively correlated with exercise addiction (Serier et al., 2018). Interestingly, these findings were in contrast to those for participants with indicated eating disorders, who showed no associations. This is in contrast to previous studies that have suggested that people who exercise for mood and appearance reasons are more likely to demonstrate eating pathology (Macfarlane, Owens and Cruz, 2016). One possible reason for this contrast could be the selective population of health club users. Overall, this study adds evidence that the links between exercise motivation and exercise addiction are different according to eating disorder status, and therefore indicates differing aetiology for exercise addiction for the two sub-populations. This is important as if this is correct, then therapeutic interventions for each group may need to be different. Further research exploring potential mediating relationships between reasons for exercise, eating disorders, and exercise addiction would greatly add to the knowledge in this area.

Participants with indicated BDD and without indicated eating disorders were significantly more likely to demonstrate higher exercise addiction scores. In the population with indicated eating disorders, BDD was not associated with exercise addiction scores. Although this concurs with several studies that have shown that negative self-body image is positively correlated with exercise addiction (Ertl et al., 2018; Klein et al., 2004), this is the first study to show that this is not the case in populations with indicated eating disorders. This suggests that BDD could be a primary condition in which exercise addition is a symptom, but only in the absence of an eating disorder. This is important, as if BDD were a primary condition where exercise addiction is a symptom, then the treatment of BDD should result in reduced incidence of exercise addiction. It is therefore recommended that patients presenting with exercise addiction symptoms, who do not show evidence of eating disorders, should be screened for BDD before any treatments can be considered.

In the group with indicated eating disorders, participants from ethnic minorities (black, Hispanic and Asian vs white as the reference value) yielded a higher exercise addiction scores. This is the first time such a finding has been reported, and could be because of the long-recognised limited treatment barriers to eating disorders that subjects from ethnic minorities face (Cachelin et al., 2001; Becker et al., 2003; Coffino, Udo and Grilo, 2019). The sample size for black participants, however, was small. Confirmatory and causal exploration is needed to confirm this relationship and explore interventions to address this.

3a.5.3 Exercise addiction prevalence

The prevalence of exercise addiction was high when compared to previous studies (including studies in Chapter 2), with 30.7% being classified as at risk of exercise addiction. Prevalence rates differed largely according to eating disorder status, with participants with indicated eating disorders yielding more than double the prevalence rates than those with no indicated eating disorders. These results support the results of Chapter 2. The overall exercise addiction prevalence rate is also higher than in several reviews that have estimated prevalence between 3% -14% (Di Lodovico, Poulnais and Gorwood, 2019; Marques et al., 2019). One potential reason could be because of the recruitment strategy and specific population group: this study used social media as a means of recruitment and was restricted to health club users, which is unique in this area of research. This is supported by the finding that using social media for social integration and emotional connection was a significant predictor for higher exercise addiction scores. Social media use has been shown to elicit feelings of negative body image (Fardouly and Vartanian, 2016; Perloff, 2014), which has been shown to be associated with exercise addiction. Social media is an appropriate platform to recruit from, however, primarily due to the number of people who routinely engage in social media. Recent data suggests that 2.2 billion people use social media on a daily basis (Facebook, 2019). The role of social media's influence in the aetiology of exercise addiction warrants further exploration.

3a.6 Limitations and strengths

Although this study had a large sample size, measured several novel correlates of exercise addiction, and found that correlates of exercise addiction vary significantly according to eating disorder status, the study should be considered within its limitations. Firstly, due to the cross-sectional nature of the study design, the direction of correlation (and therefore causality) is impossible to determine. Further longitudinal analysis is required to determine the direction of the observed correlations. Secondly, it has been reported that the EAI can yield false-positive results in elite athletes (Szabo et al., 2015), and it is unknown whether the EAI over-estimates exercise addiction prevalence in other highly active populations, such as health club users, or people who exercise as part of their job, such as fitness instructors. Further validation of this questionnaire in this sub-population is warranted. Thirdly, the variables accounted for a low percentage of the total variation (with the highest being 22%), meaning that other correlates could be significant and further study to examine these is needed. Furthermore, this low R^2 value, despite the findings being novel, should be considered when interpreting the magnitude of the results. Fourthly, a general limitation of this study was the method of determining populations with and without indicated eating disorders. Although the use of the EAT-26 was justified in that it is the only tool that has been validated in athletic populations, the tool was developed in 1982, meaning that the interpretation of the questions in 2020 may be different to what the authors originally intended. For example, one question in the EAT-26 states '[I am] aware of the calorie content of foods that I eat'. When the EAT-26 was developed, nutritional information (such as calories vs total energy expenditure) was less accessible than today, with current nutritional labelling making calorific values of food clearer as per guidance from the Committee on Medical Aspects of Food Policy (COMA) and the Scientific Advisory Committee on Nutrition (SACN) (Department of Health (DoH), 1991; Scientific Advisory Committee on Nutrition, 2011). This potentially means that, although the knowledge of the calorific values of food may have indicated pathological eating behaviours in the 1980s, positive answers to this question now may reflect an increase in the visibility and accessibility of calorific values rather than an increase in pathological eating behaviours. Ideally, a clinical diagnosis of an eating disorder should have been used as a measure of indicated and non-indicated eating disorders. A further limitation includes the restriction and definition of the inclusion of only health club users in the sample. Although the inclusion criteria was intended to make the population homogeneous, the question 'are you a health club user' is ambiguous and could have indeed made the sample more heterogeneous. Furthermore, this statement precluded other exercising populations (for example, cyclists, runners, and home gym users). Another limitation involves the recruitment process: the use

of female social media influencers potentially added a female skew in to the population, and introduces potential selection bias, which makes the generalisation of findings difficult. Finally, the statistical analysis could have included advanced statistics, such as structural equation modelling (SEM). Indeed, because of the large sample size it can be argued that SEM was a more appropriate method for confirming the Interactional Model of Exercise Addiction. Further study should attempt to use these advanced methods to provide further evidence of the Interactional Model's structural validity, and testing the data against other models of exercise addiction would be highly valuable.

3a.7 Conclusion

The key findings from this study suggest a direct link between exercise motivations and EA, especially if the reason for exercising is to modify mood state. It is suggested that exercising to modify mood state, eating disorder, and BDD status be included in the intolerable life-stress section of the Interactional Model of Exercise Addiction (Egorov and Szabo, 2013).

Furthermore, this study provides further evidence that the aetiology of exercise addiction differs according to eating disorder status, with variables including social media use, exercise motivation and ethnicity being uniquely correlated with exercise addiction only in populations with indicated eating disorders. Furthermore, BDD was also highly prevalent in participants without indicated eating disorders, and could be a primary condition in which exercise addiction is a symptom. It is recommended that clinicians and practitioners working with patients who present with symptoms of exercise addiction should be screened for eating disorders and BDD before treatments are considered, as both eating disorders and BDD have considerably higher co-morbid outcomes than exercise addiction, and therefore need to be treated as a primary condition. Furthermore, treatment programmes already exist for these two primary conditions and therefore can be implemented more easily. The development of screening tools that are able to stratify these populations would be beneficial to both researchers and practitioners.

3b. Study 2: Differences between the prevalence of exercise addiction in populations with and without indicated eating disorders during the COVID-19 pandemic

3b.1 Introduction

In March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic, and as of 26 April 2021, over 148,000,000 confirmed cases had been diagnosed in more than 130 countries and areas, resulting in approximately 3,000,000 deaths (World Health Organization, 2021). The COVID-19 outbreak undoubtedly affected people's lives, including work, education, travel and recreation, including exercise and eating habits (Hossain, Sultana and Purohit, 2020). For example, a recent systematic review (Stockwell et al., 2021) examined physical activity and sedentary behaviour trends over the COVID-19 pandemic and concluded that most populations significantly decreased their physical activity levels as a result of quarantine or lockdown regulations, except for one sub-population: people with eating disorders. It was reported that populations with eating disorders increased their physical activity levels, which is concerning because of the several morbid outcomes of physical activity in this population, such as stress-fractures, organ damage, and even mortality (Abraham, 2016). This has been echoed by several authors who have expressed concerns regarding the COVID-19 lockdowns' effects on people with eating disorders. In particular, eating disorder symptoms have been shown to be worsened (Fernández-Aranda et al., 2020; Touyz, Lacey and Hay, 2020), with evidence from a Spanish hospital reporting that in the first two weeks of lockdown 38% of patients reported unfavourable eating disorder symptomology (Fernández-Aranda et al., 2020). Furthermore, a representative cross-sectional study reporting that participants with indicated eating disorders increased restricting, binge eating, purging and exercise behaviours amidst the COVID-19 outbreak (Phillipou et al., 2020).

Similar concerns have been expressed regarding body dysmorphic disorder (BDD), with the Anxiety and Depression Association of America suggesting that lockdown restrictions may cause people to have increased feelings of social isolation, increased anxiety about their appearance and an inability to control comorbid disorders, such as eating disorders (Anxiety and Depression Association of America, 2020). Conversely, it has been theorised that symptoms of exercise addiction may be reduced as a result of lockdowns, mainly because of the limiting amount of exercise a person is able to do (Lim, 2020). This theory, however, assumes that problematic exercise is limited to gyms or outdoor areas (i.e., areas which have been closed or limited access imposed), which there is limited evidence to support.

Both Chapter 2 and Study 1 from this Chapter reported links between eating disorders and exercise addiction, and reported links between BDD and exercise addiction, however the effect that the COVID-19 lockdown(s) have had on BDD and exercise addiction are unknown.

The aim of this study, therefore, is to assess differences in exercise addiction, eating disorder symptomology and BDD pre vs post COVID-19 lockdowns. To address these aims, this study will answer the following questions:

1. Was there a change in exercise addiction symptomology (measured as a continuous variable) pre versus post COVID-19 lockdown?

2. Was there a change in eating disorder symptomology (measured as a continuous variable) pre versus post COVID-19 lockdown?

3. Were there changes in BDD, eating disorder, and exercise addiction status (when respectively measured as a dichotomous variable) pre versus post COVID-19 lockdown?

Furthermore, the study aimed to test the following hypotheses:

1. H_0: Exercise addiction symptomology (measured as a continuous variable) does not significantly change pre versus post COVID-19 lockdown.
   H_1: Exercise addiction symptomology (measured as a continuous variable) does significantly change pre versus post COVID-19 lockdown.

2. H_0: Eating disorder symptomology (measured as a continuous variable) does not significantly change pre versus post COVID-19 lockdown.
   H_1: Eating disorder symptomology (measured as a continuous variable) does significantly change pre versus post COVID-19 lockdown.

3. H_0: BDD, eating disorder status and exercise addiction status (measured as dichotomous variables) do not significantly change pre versus post COVID-19 lockdown.
   H_1: BDD, eating disorder status and exercise addiction status (measured as dichotomous variables) do significantly change pre versus post COVID-19 lockdown.

Understanding the impact of the COVID-19 pandemic of exercise addiction, eating disorders, and body dysmorphic disorder is an integral part of this thesis regarding its aims. For example, if results show that either primary or secondary exercise addiction and/or eating disorder symptoms increase during the pandemic, this potentially strengthens to argument that a new screening tool able to stratify between primary and secondary exercise addiction is necessary and can be used should future lockdowns occur. If, however, no changes or decreases in symptoms are found, this adds a unique contribution to the literature base regarding exercise addiction, eating disorders, and body dysmorphic disorder.

3b.2 Methods

Participants were initially recruited pre-COVID-19 pandemic via social media channels including Facebook, Instagram and Twitter from 8/4/2019 to 31/7/2019 (see Chapter 3: Study 1: Section 3a) for the pre-COVID-19 sample. Participants based in the UK who indicated in Chapter 3 study 1 consent to be contacted for a follow-up (and subsequently provided their email address) study were recruited via email invite from 26/8/2020 to 11/9/2020 to complete the post-COVID-19 lockdown survey. At the time there were relatively few COVID-19 related restrictions in place, with pubs, restaurants, hairdressers, indoor theatres, bowling alleys and soft play all being re-opened (Institute for Government, 2021). Social distancing measures were still in place. To be eligible for the study participants had to be adults above the age of 18. Emails with the link to the survey were sent out to 869 participants, with 319 (36%) respondents. The mean age of participants was 36.77 (SD=11.75), and 84% (270/319) were female. The majority (84%) of participants indicated that they were not currently under lockdown (267/319), with 16% indicating that they were still in lockdown (52/319). Full descriptive statistics are shown in Table 3.8. In both the pre and post COVID surveys, participants were taken through online survey questions including measures of age, sex, exercise addiction, BDD, eating disorder symptomology, body mass index (BMI) and current COVID-19 related lockdown status (in the post-COVID survey only). Ethical approval was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-03). All participants provided informed consent before completing both surveys and were given links to further information if any of the topics covered in the survey were distressing.

3b.2.1 Measures

Exercise addiction

Exercise addiction was measured via the Exercise Addiction Inventory (EAI) (Terry, Szabo and Griffiths, 2004), a six-item questionnaire that was developed to measure Griffith's (Terry, Szabo and Griffiths, 2004) interpretation of Brown's components of general addiction (Brown, 1993). Each question is scored on a Likert scale of 1-5, with a higher score indicating higher risk of exercise addiction. Participants whose total score is $\geq$24 are classified as 'at risk' of exercise addiction (Terry, Szabo and Griffiths, 2004). The EAI has been shown to have good reliability and validity across physically active populations (Griffiths et al., 2015; Lichtenstein and Jensen, 2016) and shows good internal reliability (pre and post COVID samples were α=0.72 and α=0.74 respectively).

Exercise hours for leisure

Participants were asked how many hours per week they exercised for leisure.

Eating disorder symptomology

Eating disorder symptomology was measured using the Eating Attitudes Test 26 (EAT-26) (Garner et al., 1982), a 26-item questionnaire scored on a Likert scale of 1-6. A score of $\geq$20 is sufficient to be classified as having possible pathological eating behaviours. The EAT-26 has shown excellent internal consistency (pre and post COVID samples were α=0.92 and α=0.87 respectively) and is validated in athletic populations (Pope et al., 2015; Doninger, Enders and Burnett, 2005).

Body dysmorphic disorder

BDD was measured using the Body Dysmorphic Disorder Questionnaire (BDDQ) (Phillips, 2005), a questionnaire based on the Diagnostic Statistical Manual for Mental Disorders-IV (American Psychiatric Association, 2000) diagnostic criteria for BDD. Classification of BDD is made based on answering positively to questions one and two, at least one part of question 3 and indicating spending one or more hours each day thinking about their appearance. The questionnaire has excellent reported sensitivity (94%) and specificity (90%) in non-clinical community populations (Brohede et al., 2013).

Lockdown status

Participants were asked if they were currently in some form of lockdown (yes or no: defined as being 'under restrictions that limit your ability to leave the house').

Note that all survey questions are available in Appendix G.

3b.3.2 Data analysis

All data were analysed using STATA Version 16 (Stata Corp, 2019). The use of a difference statistical package (Study 3a used SPSS) was a result of self-directed training in the use of the STATA software package. The differences between all continuous variables were calculated using the paired samples t-test, and differences between dichotomous variables were calculated via McNemar's test in three groups:

1. Total sample
2. Currently in lockdown
3. Not currently in lockdown

Note that the EAI and EAT-26 were treated as both dichotomous (using cut-off scores described by the original authors) and continuous variables (as a total score). Furthermore, a paired samples t-test was conducted on the respective individual questions on the EAI and EAT-26. Because several t-tests were being calculated on the same dataset, the incidence of potential type I error is increased (Haynes, 2013), and therefore a Bonferroni correction was applied using the following equation:

$$\alpha = \frac{0.05}{n\ tests\ performed}$$

For each dataset, we performed 34 t-tests, therefore statistical significance was set at 0.002.

3b.3 Results

3b.3.1 Total sample

As shown in Table 3.8, in the total sample (*n*=319), more participants had indicated BDD pre vs post-COVID-19 lockdown ($\chi2(1) =0.00$, $p=1.00$), and fewer participants were classified at risk of exercise addiction ($\chi2(1) =0.85$, $p=0.36$) and eating disorder symptomology ($\chi2(1) =0.10$, $p=0.76$). Furthermore, fewer participants had primary exercise addiction ($\chi2(1) =11.8$, $p=1.00$), and secondary exercise addiction ($\chi2(1) =41.1$, $p=0.35$). None of these dichotomous variables were statistically significant. Furthermore, participants' BMI was higher post COVID-19 compared to pre COVID, however this failed to reach significance ($t(307) = 1.57$, $p=0.117$, $d=0.09$); total EAT-26 scores were significantly higher post-COVID-19 lockdown ($t(318) = 4.02$, $p=<0.001$, $d=0.23$); EAI scores were lower post-lockdown ($t(318) = -2.13$, $p=0.034$, $d=0.12$), however this failed to reach statistical significance (as per the corrected $\alpha=0.002$); and leisure-time exercise significantly increased post-COVID-19 lockdown ($t(312) = -4.101$, $p=<0.001$, $d=0.23$).

Of the individual questions in the EAI, no scores were significantly lower post-COVID-19 vs pre-COVID-19, see Table 3.9 for full details.

Of the individual questions in the EAT-26, scorers were significantly lower post-COVID-19 in Question 8: 'I feel that others would prefer if I ate more' ($t(318) = 3.15$, $p=0.002$, $d=0.18$), and Question 17: 'I eat diet foods'' ($t(318) = 2.37$, $p=0.018$, $d=0.13$). Furthermore, scores were significantly higher in Question 25: 'I have the impulse to vomit after meals' ($t(318) = -39.11$, $p=<0.001$, $d=2.19$). See Table 3.10 for full details.

3b.3.2 Participants currently in lockdown

In the sub-sample of participants who indicated they were still in lockdown (*n*=52), more participants had indicated BDD pre vs post-COVID-19 lockdown ($\chi2(1) = 2.29$, $p=0.125$), and fewer participants were classified at risk of exercise addiction ($\chi2(1) = 1.46$, $p=0.227$) and eating disorder symptomology ($\chi2(1) = 0.00$ $p=1.00$). Furthermore, fewer participants had primary exercise addiction ($\chi2(1) = 0.77$, $p=0.73$), and secondary exercise addiction ($\chi2(1) = 11.6$, $p=0.51$). None of these dichotomous differences were statistically significant. Furthermore, BMI was higher post COVID-19, however this failed to reach significance ($t(47) = -0.22$, $p=0.830$, $d=0.03$); total EAT scores were higher post-COVID-19 lockdown, but failed to reach significance ($t(51) = -1.42$, $p=0.161$, $d=0.20$); EAI scores were lower post-lockdown ($t(51) = 2.65$, $p=0.011$, $d=0.37$), however this failed to reach statistical significance (as per the corrected $\alpha=0.002$); and leisure-time exercise increased post-COVID-19 lockdown, yet this failed to reach statistical significance ($t(50) = -1.24$, $p=0.222$, $d=0.17$).

Of the individual questions in the EAI, no scores were significantly lower post-COVID-19 vs pre-COVID-19, see Table 3.9 for full details.

Of the individual questions in the EAT-26, scores were significantly higher in Question 25: 'I have the impulse to vomit after meals' ($t(51) = -10.39$, $p=<0.001$, $d=1.44$), see Table 3.10 for full details.

3b.3.3 Participants not currently in lockdown

In the sub-sample of participants who indicated they were not still in lockdown (*n*=267), more participants had indicated BDD ($\chi2(1) = 2.29$, $p=0.125$) and eating disorder symptomology ($\chi2(1) = 0.20$, $p=0.658$) pre vs post-COVID-19 lockdown, and fewer participants were classified at risk of exercise addiction ($\chi2(1) = 1.41$, $p=0.708$). Furthermore, fewer participants had primary exercise addiction ($\chi2(1) = 10.61$, $p=1.00$), and secondary exercise addiction ($\chi2(1) = 29.2$, $p=0.56$). None of these dichotomous differences were statistically significant. Furthermore, BMI was higher post COVID-19, however this failed to reach significance ($t(259) = -1.57$, $p=0.118$, $d=0.10$); total EAT scores were significantly higher post-COVID-19 lockdown, ($t(266) = -3.78$, $p=<0.001$, $d=0.23$); EAI scores were lower post-lockdown, however this was not significant ($t(266) = 1.143$, $p=0.254$, $d=0.07$); and leisure-time exercise significantly increased post-COVID-19 lockdown ($t(261) = -3.94$, $p=<0.001$, $d=0.24$).

Of the individual questions in the EAI, no scores were significantly lower post-COVID-19 vs pre-COVID-19, see Table 3.9 for full details.

Of the individual questions in the EAT-26, scores were significantly higher in Question 25: 'I have the impulse to vomit after meals' ($t(266) = -39.96$, $p=<0.001$, $d=2.45$), see Table 3.10 for full details.

Table 3.8: Descriptive statistics

	Total sample			Currently in lockdown			Not currently in lockdown		
Variable	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p*-value	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p*-value	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p*-value
n	319		-	52		-	267		-
Sex (female)	84%		-	90.4%		-	83.5%		-
Age (years)	36.77 (11.75)		-	33.94 (11.43)		-	37.31 (11.76)		-
BMI (kg/m^2)	23.75 (8.67)	24.02 (8.61)	0.117	24.43 (6.08)	24.59 (3.85)	0.830	23.11 (3.89)	23.95 (9.25)	0.118
EAT-26 Total	13.84 (12.90)	15.76 (10.88)	<0.001*	15.67 (13.69)	17.54 (11.45)	0.161	13.48 (12.74)*	15.41 (10.75)*	<0.001*
Indicated eating disorder symptomology	30.72% (98/319)	28.84% (92/319)	0.760	38.46% (20/52)	36.54% (19/52)	1.00	25.47% (68/267)	27.34% (73/267)	0.658
EAI Total	21.49 (4.20)	21.02 (4.25)	0.034	22.21 (3.48)	20.73 (4.60)	0.011	21.35 (4.31)	21.07 (4.19)	0.254
At risk of exercise addiction	31.98% (102/319)	29.15% (93/319)	0.360	34.62% (18/52)	25.00% (13/52)	0.227	31.46% (84/267)	29.96% (80/267)	0.708
BDD status (indicated/not indicated)	33.2% (106/319)	33.5% (107/309)	1.000	38.46% (20/52)	48.08% (25/52)	0.125	30.71% (82/267)	32.21% (86/267)	0.125
Leisure-time exercise (hrs/wk)	6.47 (3.83)*	7.50 (4.26)*	<0.001*	6.71 (3.59)	7.49 (4.91)	<0.001*	6.44 (3.89)*	7.50 (4.14)*	<0.001*
Lockdown status	NA	16.3% (52/319)	-	NA					

Data is presented as mean (standard deviation), unless otherwise stated; Abbreviations: EAT-26 = Eating Attitudes Test 26; EAI=exercise addiction inventory; BDD=body dysmorphic disorder; * = statistically significant difference pre vs post COVID-19 with a Bonferroni corrected *p*=<0.002

Table 3.9: Differences between individual EAI questions pre vs post COVID-19

	Total sample			Currently in lockdown			Not currently in lockdown		
Variable	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p* value	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p* value	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p* value
n	319			52			267		
Exercise is the most important thing in my life	3.08 (1.01)	3.12 (1.00)	0.465	3.08 (0.95)	3.06 (1.02)	0.881	3.08 (1.02)	3.13 (0.99)	0.397
Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do	2.98 (1.31)	2.81 (1.26)	0.004	3.12 (1.26)	2.79 (1.38)	0.042	2.95 (1.32)	2.81 (1.24)	0.030
I use exercise as a way of changing my mood (e.g. to get a buzz, to escape, etc.)	4.24 (0.88)	4.22 (0.85)	0.690	4.42 (0.75)	4.17 (0.98)	0.074	4.21 (0.90)	4.23 (0.82)	0.707
Over time I have increased the amount of exercise I do in a day	3.71 (1.10)	3.57 (1.12)	0.033	3.87 (1.10)	3.44 (1.21)	0.023	3.69 (1.10)	3.60 (1.10)	0.213
If I have to miss an exercise session I feel moody and irritable	3.75 (1.06)	3.64 (1.06)	0.093	3.94 (0.96)	3.73 (1.09)	0.182	3.71 (1.07)	3.63 (1.06)	0.219
If I cut down the amount of exercise I do, and then start again, I always end up exercising as often as I did before	3.72 (1.05)	3.65 (1.10)	0.302	3.79 (0.96)	3.54 (1.09)	0.175	3.71 (1.07)	3.67 (1.10)	0.620

Data is presented as mean (standard deviation); Abbreviations: EAI=exercise addiction inventory; * = statistically significant difference pre vs post COVID-19 with a Bonferroni corrected *p*=<0.002

Table 3.10: Differences between individual EAT-26 questions pre vs post COVID-19

	Total sample			Currently in lockdown			Not currently in lockdown		
Variable	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p* value	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p* value	Pre COVID-19 lockdown	Post COVID-19 lockdown	*p* value
n	319			52			267		
Am terrified about being overweight.	1.30 (1.31)	1.22 (1.25)	0.148	1.60 (1.42)	1.50 (1.26)	0.489	1.25 (1.29)	1.17 (1.24)	0.203
Avoid eating when I am hungry	0.16 (0.47)	0.13 (0.52)	0.312	0.23 (0.51)	0.15 (0.41)	0.322	0.15 (0.46)	0.13 (0.42)	0.530
Find myself preoccupied with food	0.78 (1.01)	0.68 (0.94)	0.047	0.75 (0.99)	0.85 (0.94)	0.374	0.78 (1.01)	0.64 (0.94)	0.014
Have gone on eating binges where I feel that I may not be able to stop.	0.29 (0.78)	0.29 (0.75)	0.930	0.38 (0.93)	0.42 (0.87)	0.719	0.27 (0.74)	0.27 (0.73)	0.920
Cut my food into small pieces	0.15 (0.56)	0.13 (0.52)	0.464	0.29 (0.72)	0.23 (0.67)	0.444	0.12 (0.52)	0.11 (0.48)	0.647
Aware of the calorie content of foods that I eat	1.33 (1.16)	1.34 (1.12)	0.953	1.37 (1.14)	1.42 (1.23)	0.700	1.33 (1.16)	1.32 (1.10)	0.895
Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)	0.47 (0.87)	0.40 (0.79)	0.156	0.60 (0.98)	0.42 (0.87)	0.192	0.45 (0.85)	0.40 (0.78)	0.350
Feel that others would prefer if I ate more.	0.29 (0.71)	0.18 (0.58)	0.002*	0.25 (0.59)	0.06 (0.24)	0.017	0.30 (0.73)	0.21 (0.62)	0.015
Vomit after I have eaten.	0.04 (0.27)	0.04 (0.31)	0.739	0.04 (0.19)	0.00 (0.00)	0.159	0.04 (0.28)	0.05 (0.34)	0.706
Feel extremely guilty after eating.	0.35 (0.77)	0.37 (0.77)	0.458	0.50 (0.92)	0.54 (0.80)	0.749	0.32 (0.74)	0.34 (0.76)	0.498
Am preoccupied with a desire to be thinner.	0.78 (1.10)	0.78 (1.09)	1.000	0.96 (1.19)	1.17 (1.26)	0.140	0.75 (1.09)	0.71 (1.04)	0.468

Think about burning up calories when I exercise	0.89 (1.11)	0.87 (1.08)	0.591	1.10 (1.22)	1.00 (1.10)	0.527	0.85 (1.09)	0.84 (1.07)	0.787
Other people think that I am too thin	0.14 (0.48)	0.12 (0.46)	0.400	0.13 (0.44)	0.04 (0.19)	0.133	0.14 (0.49)	0.13 (0.49)	0.793
Am preoccupied with the thought of having fat on my body	0.66 (1.01)	0.69 (1.03)	0.628	0.71 (1.02)	0.94 (1.18)	0.122	0.65 (1.01)	0.64 (1.00)	0.784
Take longer than others to eat my meals	0.29 (0.75)	0.27 (0.74)	0.559	0.31 (0.78)	0.37 (0.84)	0.444	0.29 (0.74)	0.25 (0.72)	0.378
Avoid foods with sugar in them	0.53 (0.93)	0.43 (0.80)	0.019	0.52 (1.00)	0.23 (0.65)	0.021	0.54 (0.91)	0.46 (0.83)	0.144
Eat diet foods	0.31 (0.68)	0.23 (0.61)	0.018	0.31 (0.70)	0.25 (0.56)	0.497	0.31 (0.68)	0.23 (0.62)	0.023
Feel that food controls my life	0.47 (0.92)	0.45 (0.86)	0.509	0.52 (1.00)	0.46 (0 .92)	0.554	0.46 (0.92)	0.45 (0.85)	0.650
Display self-control around food	0.99 (1.03)	0.97 (0.99)	0.667	0.94 (1.09)	0.92 (1.04)	0.898	1.00 (1.02)	0.98 (0.98)	0.679
Feel that others pressure me to eat	0.22 (0.62)	0.16 (0.51)	0.059	0.19 (0.53)	0.08 (0.33)	0.033	0.23 (0.64)	0.18 (0.53)	0.178
Give too much time and thought to food	0.70 (1.04)	0.73 (1.07)	0.607	0.75 (1.06)	0.75 (1.06)	1.000	0.69 (1.03)	0.73 (1.07)	0.565
Feel uncomfortable after eating sweets	0.75 (1.07)	0.63 (1.02)	0.029	0.87 (1.10)	0.83 (1.13)	0.811	0.73 (1.07)	0.59 (0.99)	0.020
Engage in dieting behaviour	0.61 (0.96)	0.57 (0.92)	0.516	0.79 (1.02)	0.77 (1.02)	0.883	0.57 (0.94)	0.54 (0.89)	0.516
Like my stomach to be empty	0.39 (0.82)	0.38 (0.80)	0.761	0.58 (0.91)	0.52 (0.90)	0.644	0.36 (0.80)	0.35 (0.77)	0.931
Have the impulse to vomit after meals	0.13 (0.50)	2.68 (0.76)	<0.001*	0.25 (0.65)	2.44 (1.02)	<0.001*	0.10 (0.46)	2.73 (0.69)	<0.001*
I enjoy trying rich new foods	0.78 (0.94)	1.01 (1.14)	0.020	0.75 (1.01)	1.17 (1.18)	0.111	0.79 (0.93)	0.98 (1.14)	0.071

Data is presented as mean (standard deviation); Abbreviations: EAT-26 = Eating Attitudes Test 26; * = statistically significant difference pre vs post COVID-19 with a Bonferroni corrected *p*=<0.002

3b.4 Discussion

This study of 319 participants measured the profiles of indicated BDD, eating disorder symptomology and exercise addiction in a sample of health club users pre-COVID-19 vs post-COVID-19 lockdown, both as a total sample and stratified according to current lockdown status. The results of this study refutes null hypotheses 1 and 2, and confirms null hypothesis 3.

The results show that the incidence of BDD did not change in either the total sample or according to current lockdown status. Although this is the first empirical study to explore the effects of COVID-19 on BDD, hypotheses have suggested that COVID-19 could make BDD symptoms worse, due to increases in social isolation and depressive feelings (Anxiety and Depression Association of America, 2020). Increases in social isolation and lower mental health have been shown to be a consequence of COVID-19 (Banerjee and Rai, 2020), however this study suggests that this may not translate into increases in BDD in this population.

In all groups, there were decreases in total EAI score, however they did not reach statistical significance (as per the corrected significance of p=<0.002) and did not translate to significantly fewer participants who were categorised as 'at risk' from exercise addiction (as per the authors' cut-off of ≥24). Furthermore, when exploring the individual EAI questions, no questions yielded significant differences. Although these results broadly agree with Lim (Lim, 2020), who suggested that COVID-19 related lockdowns could reduce exercise addiction symptomology, the conservative value for statistical significance suggests that no changes were apparent.

In both the total sample and the participants who indicated they were not currently in lockdown, total EAT-26 scores significantly increased, suggesting higher levels of morbid eating behaviours. These increases, however, did not translate to significantly more participants scoring above the original authors' cut offs (≥20) and having eating disorder symptomology. Interestingly, when looking at changes in individual questions within the EAT-26, one question yielded a large significant increase: having the impulse to vomit after meals. Although this indicates possible bulimic behaviour, all of the other questions pertaining to bulimia yielded no changes. This could indicate that participants are simply feeling sick after they eat, possibly due to other stresses that COVID-19 has caused. It is, however, a finding that warrants further exploration and practitioners should be aware of this when working with health club users.

A further novel finding of this study was that leisure time exercise significantly increased both in the total sample and in the participates who were not currently in lockdown. Although the lack of statistical increase in the group who were currently in lockdown was unsurprising, increases in exercise levels post-COVID-19 are encouraging, due to the several health benefits of exercise. To date, several authors have reported decreases in exercise *during* the COVID-19 lockdown (Stockwell et al., 2021), which our study did not find, however to date, no studies have reported exercise levels pre versus post lockdown. One possible reason for this finding is because health club users were eager to restart their exercise routine post-lockdown, and 'make up' for time lost by exercising more. Furthermore, people who have been unable to work may have more time to exercise.

Based on these findings, it is recommended that practitioners closely monitor the behaviours of people with potential morbid eating patterns during times of lockdown, as these behaviours could worsen during these periods. Furthermore, governments and public health officials should note these findings when considering interventions during any future lockdowns. Information on healthy eating behaviours could be beneficial should future lockdowns occur. Future research should focus on the effects of interventions in any future lockdowns and further longitudinal studies to confirm our results in a representative sample of the population.

3b.5. Limitations and Strengths

Although this study has several strengths, including the longitudinal study design and a large sample size, this study should be considered within its limitations. Firstly, the use of a self-report tools carry inherent limitations (Demetriou, Ozer and Essau, 2015), including the contextual limitations regarding the EAI and EAT-26 (see Chapter 3: Study 1: Section 3a.6). Secondly, the use of a conservative *p*-value increased the likelihood of type II errors. Further, regardless of the conservative *p*-values, the observed effect sizes were small, thus making the application of results to inform policy difficult. Lastly, the sample was restricted to health club users who were recruited via social media, and the sample had a high proportion of females (possibly due to the recruitment process). The high proportion of females is not representative of the UK gym users – with the gender balance being reported at approximately 50% (Lake, 2020). This gender skew and recruitment methodology therefore makes the generalisation of the findings challenging.

3b.6 Conclusion

In conclusion, eating disorder symptomology (measured as a continuous variable) significantly increased pre vs post COVID-19 lockdown, however this did not translate to significant increases in the number of participants with possible eating disorders (as measured as a dichotomous variable). Exercise addiction symptomology, measured as a continuous and dichotomous variable, did not change pre vs post COVID-19 lockdown. Furthermore, incidences of BDD, primary, and secondary exercise addiction appears to have been unchanged following COVID-19 lockdown.

If future lockdowns or periods of enforced quarantines are required, practitioners working with people with suspected morbid eating habits should monitor this closely. This includes populations who have conditions that have been shown to be comorbid to eating disorders, including body image disorders and obsessive compulsive disorders (Hollander and Wong, 1995). Furthermore, interventions promoting healthy eating behaviours during times of lockdown are warranted and should be explored by public health practitioners.

This Chapter consisted of two studies: one large study comparing exercise addiction correlates in populations with and without indicated eating disorders, and the other study examining differences in exercise addition, eating disorder symptomology, and BDD pre vs post COVID-19 lockdown. The first part of this Chapter provides further evidence that exercise addiction has differing aetiologies in participants with vs without indicated eating disorders, and provides further justification for the need of a new screening tool that is able to stratify between possible primary and secondary exercise addition. Chapter 4 describes the development and validation of this new tool.

3.3 Chapter 3: novel contributions and take-home messages

- Correlates of exercise addiction are significantly different in populations with vs without indicated eating disorders

- Body dysmorphic disorder could be a primary disorder in which exercise addiction is a symptom

- Eating disorder symptoms significantly increased pre-vs post COVID-19 lockdown

Chapter 4: The creation and validation of the Secondary Exercise Addiction Scale (SEAS)

4.1 Publication details

The contents of this Chapter have been published in one peer-reviewed journal articles:

a. Trott, M., Johnstone, J., McDermott, D.T., Mistry, A. and Smith, L., 2021. The development and validation of the secondary exercise addiction scale. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*, pp.1-10.

4.2 Chapter 4 abbreviations

Table 4.1: Chapter 4 abbreviations

AUC	Area under the curve
BMI	Body mass index
CFA	Maximum likelihood confirmatory factor analysis
CFI	Comparative fit index
ICC	Intra-class coefficient
DSM-5	Diagnostic and Statistical Manual for Mental Disorders 5
EAI	Exercise addiction inventory
EAT-26	Eating attitude test 26
EDS	Exercise dependence scale
EDS-R	Revised exercise dependence scale
EFA	Exploratory factor analysis
KMO	Kaiser-Meyer-Olkin
PCA	Principal Component Analysis
ROC	Radio operator characteristic
RMSEA	Root mean square error of approximation
SEAS	Secondary exercise addiction scale
SD	Standard deviation
TLI	Tucker-Lewis index

This Chapter examines the address the following aim in Chapter 1:

1. It is then the aim of the thesis to create and validate a screening tool that is able to determine possible primary or secondary exercise addiction using one, short-form questionnaire.

4.3 Introduction

Chapters 2 and 3a both reported evidence that exercise addiction has potential differing aetiologies in populations with vs without indicated eating disorders, with exercise addiction possibly being secondary to eating disorders. This introduction examines tools used to assess both exercise addiction and eating disorders.

Currently there are several tools available to screen for exercise addiction (discussed in detail in Chapter 1: Section 1.5), with the Exercise Dependence Scale (EDS; Hausenblas and Symons Downs, 2002) and the Exercise Addiction Inventory (EAI; Terry, Szabo and Griffiths, 2004) being described in the literature as 'broadly comparable' (Szabo et al., 2015; Berczik et al., 2012), and consistently yielding lower exercise addiction prevalence rates than other measurement tools (see Chapter 2).

One of the key differences between the EDS and the EAI is their length. The original EDS had 30 items, with its revised version, the EDS-R (Symons Downs, Hausenblas and Nigg, 2004) having 21 items. The EAI has six items. Although the number of questions is likely to affect their respective specificity and sensitivity, it may also affect how the two questionnaires are used in practice. It has been reported that shorter-form questionnaires provide less of a burden on participants than longer form questionnaires (DeVellis, 2016), and shorter questionnaires are more useful when time is a limiting factor, such as in an applied exercise setting. For example, sessions with gym users and exercise professionals are typically limited in the amount of time scheduled for each appointment. Another notable difference between the two tools is the way in that they are scored: the EDS-R classifies a person as one of three categories:

1. Exercise dependent
2. Symptomatic non-dependent, and
3. Asymptomatic non-dependent

whereas the EAI creates a dichotomy of 'at risk' or 'not at risk' of exercise addiction based on an absolute cut off point.

The EDS-R concurs with Freimuth and colleagues (2011), claiming that exercise addiction (or 'dependence': the term used by Hausenblas and Symons Downs 2002) exists on a spectrum, rather than a dichotomy (see Chapter 1: Section 1.4.4, for full information).

The EDS-R, requires substantially more effort to score than the EAI, due to its length, and its method of scoring: it takes a complex flow diagram to determine whether or not a person is 'exercise dependent' 'symptomatic non-dependent', or 'asymptomatic'. Furthermore, the EAI can be used as a dichotomous or continuous variable, meaning that data collected using the EAI can be analysed using more statistical methods than the EDS-R.

There are several tools available to screen for eating disorders, such as the Eating Attitudes Test (EAT; Garner et al., 1982) and the SCOFF questionnaire (Morgan, Reid and Lacey, 1999). Like the exercise addiction screening tools, consideration needs to be taken as to the practicality of using eating disorder screening tools when being used in applied settings. For example, some tools like the Eating Disorder Examination Questionnaire (Mond et al., 2004) require ED specialists to conduct the scoring, which may be problematic in applied settings. Others, such as the EAT-26, are significantly longer (26 questions) than shorter form screening tools like the SCOFF (five questions). As with the exercise addiction screening tools, shorter form questionnaires have advantages when used in time-sensitive applied settings.

Currently two screening tools need to be administered to determine participants at risk of exercise addiction and indicated eating disorders, which provides both the researcher and practitioner with a wealth of choices as to which tool to use. As Chapters 2 and 3 have suggested, the creation of one tool that is able to measure for both is warranted. The aim of this study, therefore, was to create and validate a new short-form screening tool able to stratify exercise addiction status in line with Freimuth and colleagues' (2011) theory that exercise addiction exists on a spectrum and eating disorder status. To achieve this, four mini studies were conducted, with the following aims:

- Study 1: To create an initial pool of questions and reduce these to a short form questionnaire with two distinct sections - eating disorder pathology and exercise addiction.

- Study 2: To confirm the underlying latent structure of the newly reduced questions.

- Study 3: To determine sensitivity and specificity of the questions against currently available eating disorder and exercise addiction questionnaires and to determine suitable scoring cut offs.

- Study 4: To determine test-retest reliability of the final questionnaire and further concurrent validity with other eating disorder and exercise addiction measurement tools.

Given the evidence provided in Chapters 2 and 3, the creation of an exercise addiction screening tool that is also able to stratify between potential indicated eating disorders (and in so doing stratify between potential primary and secondary exercise addiction) would be beneficial for several reasons, including the ability to quickly and easily determine potential secondary exercise addiction, and refer the individual to treatment/support for pathological eating behaviours, which carry with them significant morbid characteristics (see Chapter 3: Section 3a.5). Furthermore, considering that it has been reported that maladaptive exercise could manifest before the development of a diagnosable eating disorder (Fietz, Touyz and Hay, 2014; Meyer et al., 2011), such a tool could be used to identify people who are at risk of an eating disorder and be referred to treatment before the potential eating disorder becomes clinically significant. A further benefit of such a tool is that it will be able to indicate whether an individual potentially has primary exercise addiction independent of maladaptive eating behaviours and be referred to relevant health professionals for evaluation and monitoring.

4.4 Study 1

The aim of Study 1 was to create and reduce an initial pool of questions to a short form questionnaire (the Secondary Exercise Addiction Scale; SEAS) with two distinct sections - eating disorder pathology and exercise addiction. The initial question pool was developed to measure two things:

1. Symptoms of exercise addiction based on Brown's (1993) six components of general addiction (salience, mood modification, tolerance, withdrawal symptoms, conflict, and relapse - see Chapter 1: Section 1.5.6), and
2. Symptoms of eating disorders, based on the DSM-5 criteria for anorexia and bulimia nervosa (restriction of intake, fear of gaining weight, body image disturbances, recurring episodes of binge-eating, and the use of vomiting, laxatives, medications, and/or fasting to control weight gain; American Psychiatric Association, 2013).

An initial pool of 22 items was developed using these theoretical components of exercise addiction and eating disorders as underlying factors with two questions related to each factor. The items were developed independently from any existing measures. Initial content validity was established by consulting two experts in the field (an eating disorder expert, a sports psychiatrist who specialises in eating disorders and exercise, and a psychologist who specialises in scale development). Both experts were sent copies of the 22 items and the components that they theoretically loaded against and asked if any changes to the pool should be made. Both experts fully agreed with the 22 items and suggested no changes. Each item on the initial pool of 22 items was scored on a Likert scale of 1-6, with higher scores indicating more positive responses to the questions. The Likert scale of 1-6 was chosen so that participants could not score exactly in the middle of the scale (e.g. if the Likert scale were 1-7, participants who were ambivalent could score every question as 4), which has been reported to prevent ambiguous results (Szabo et al., 2019). Table 4.2 shows all of the questions and their respective theoretical components.

Table 4.2: Initial pool of questions and corresponding factors

Construct		Question
Eating disorders		
Restriction of intake	1	I often restrict my intake of food
	2	I limit the number of calories I eat
Fear of gaining weight	3	I'm afraid of putting on weight
	4	I feel that I look fat
Body image disturbance	5	I hate the way my body looks
	6	People often say I look too thin
Recurring episodes of binge-eating	7	I often binge-eat on foods and feel that I cannot stop
	8	I often eat lots of food in a short space of time
Use of vomiting, laxatives, diuretics, medications, fasting to control weight gain	9	I have used medication, (e.g. laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months
	10	Medication, fasting, and/or vomiting after meals helps me to lose weight
Exercise addiction		
Salience	11	Exercise is my number 1 priority
	12	I don't think I would manage very well without exercise
Mood modification	13	I find I need to exercise to improve my mood
	14	Exercise is the only way I can deal with stress
Tolerance	15	I feel I need to do more exercise to get the same buzz
	16	The more exercise I do, the more I need to keep doing to get the same feelings
Withdrawal	17	When I take a break from exercise, I feel irritable and moody
	18	I dread having to take a break from exercise (e.g. due to injury/illness/social commitments)
Conflict	19	I often find my exercise habits affect my relationships (e.g. family/friends/partners)
	20	I neglect friends/family/relationships because I want to exercise
Relapse	21	The urge to exercise is stronger than my want to do less exercise.

	22	If I were to stop exercising, I would start again at the same level as before.

Furthermore, the general readability of each item was assessed by plotting the number of proportionate syllables onto Fry's readability graph (Fry, 1977; see appendix H). The average number of syllables per 100 words was calculated with the following equation (note that s= number of syllables in the question, and w=number of words in the question):

$$\left(\frac{s}{w}\right) \times 100$$

Average number of sentences per 100 words was calculated with the following equation:

$$w/100$$

The mean readability of the initial 22 items according to Fry's (1977) readability scale was 6th grade, which is the equivalent of ages 11-12, which has been reported as suitable for questionnaires (DeVellis, 2017).

4.4.1 Methodology

There is an ongoing debate about which statistical tool is the most appropriate for the reduction of survey questions, with the debate surrounding two types of analysis: Principal Component Analysis (PCA), and Exploratory Factor Analysis (EFA). Both are multivariable techniques that inform a researcher as to which data to retain within a dataset (Cramer and Howitt, 2021), and several authors argue that both methods yield very similar results, especially if communalities are large (Alavi et al., 2020). The key differences is what each method aims to achieve. The EFA is primarily a technique that discovers latent variables and uses this as a way of reducing data based on this newly discovered underlying latent structure. Conversely, the PCA is primarily a data-reduction method based on capturing the maximum variance of the data, and may not output as strong a model as the EFA (Cramer and Howitt, 2021).

The EFA, therefore, may be more appropriate where there is a paucity of literature confirming an underlying the structure in the initial item-development, if the underlying structure is unknown, or if the primary aim is the development of an underlying structural model. The PCA, however, is more suited when the primary aim is not to identify a new, unknown structure (Abdi and Williams, 2010). Because the items in the initial pools of questions in this study were based on already existing theory, and already existing theoretical models (exercise addiction based on Brown's components of addiction and eating disorders based on the diagnostic criteria of eating disorders), it was decided that a PCA would be more appropriate in this instance.

4.4.2 Methods

For Study 1, participants were recruited via social media (Facebook and Twitter) from 1/3/2020 to 15/6/2020 through social media accounts. Participants were asked to share on their social media accounts once they had completed the survey as a way of encouraging their networks to participate. Participants provided informed consent to prior to taking part in the survey, including the right to withdraw and access to further support if any of the topics were distressing. To be eligible for the studies participants were required to be adults (>18 years) undertaking >150 minutes of physical activity per week, as per the UK Department of Health guidelines (Department of Health, 2019). This broad inclusion criteria was selected because it is desirable for the participants to be as heterogeneous as possible to make the generalisation of results as wide as possible. For Studies 1 and 2, participants were randomised into two groups so that two different pools of participants were used for each study. Ethical approval was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-13).

Note that all survey questions for Studies 1, 2 and 3 are available in Appendix I.

4.4.2.1 Sample size calculation

There is extensive debate in the literature about what constitutes an appropriate sample size for a PCA analysis. Some authors argue that the sample size should be relative to the number of measured items with others suggest absolute numbers of participants (Abdi and Williams, 2010). Given the debate, the decision was taken that the sample size would be adequate if the data was statistically factorizable - namely by using Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measures. Bartlett's test of sphericity tests the null hypothesis that the included variables are not correlated by comparing the observed correlation matrix to the identity matrix, and indicates that a sample is factorizable with a significant result (Cramer and Howitt, 2021). The KMO is a measure of proportion of variance among the variables that might be common variance - with lower proportions indicating a higher likelihood of the data being factorizable, and a result of >0.5 being adequate for analysis (Kaiser, 1974). If the data was not factorizable, more participants would be recruited until the data was of factorizable quality.

4.4.2.2 Data analysis

All analyses were conducted using Stata 16 (Stata Corp, 2019).

To reduce the initial 22 questions to an 11-item short-form scale, a PCA was conducted on a randomised sample of the total participants. To aid interoperability of the resulting factor loadings, an orthogonal rotation (direct oblimin with a delta=0) was employed. The initial suitability of the PCA was assessed prior to analysis by (a) correlations of >0.3, (b) a Kaiser-Meyer-Olkin (KMO) measure of >0.7, and (c) a statistically significant Bartlett's test of sphericity. Components were identified by assessing a scree plot for an inflection point: because the initial pool of questions were based on two theoretical models, a two-factor solution was hypothesised. Questions that loaded the highest on their respective factors were retained in the final scale. To determine readability age, the final items were then plotted against Fry's (1977) readability scale.

4.4.3 Results

A total of 721 participants completed the survey, with 82.4% (n=594) female, a mean age of 35.60 years (SD=11.93) and a mean BMI of 23.74 (SD=4.10). Following randomisation into two groups, there was a total of 339 participants, with a mean age of 35.89 years (SD=11.55), mean BMI of 23.50 (SD=4.18), and 82.0% of participants were female. Full demographic information for Study 1 is shown in Table 4.3.

Table 4.3: Descriptive statistics for Study 1

	Study 1 sample
N	339
Gender (female)	82.0% (*n*=278)
Age (years)	35.89 (11.55)
BMI	23.50 (4.18)
EAI total score	21.43 (4.43)
Exercise addiction prevalence	36% (*n*=122)
SCOFF total score	1.35 (1.29)
Main exercise location	
Gym	60.2% (*n*=204)
Sports club	17.4% (*n*=59)
Running outside	9.4% (*n*=32)
University gym	2.4% (*n*=8)
University sports club	0.3% (*n*=1)
At home	4.1% (*n*=14)
Other	6.2% (*n*=21)

All statistics are reported as mean (SD) unless otherwise stated; BMI=Body Mass Index; EAI=exercise addiction inventory.

The PCA correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3 The KMO measure was 0.868, which is classified as 'meritorious' according to Kaiser (Kaiser, 1974), and Bartlett's test of sphericity was statistically significant ($X^2(231)=4170.831$; $p < 0.001$), indicating that the included data was indeed factorisable.

Although six components had an Eigenvalue of >1, the scree plot indicated that there was an inflection point after two components, and a two-component solution met the interpretability criteria, therefore two components were extracted (see Figure 4.1 and Table 4.3), one for exercise addiction and one for disordered eating. The fully rotated component matrix with which items were retained for the final version of the SEAS can be found in Table 4.4. Furthermore, the mean readability of the retained 11 items according to the Fry's (1977) readability scale was 7th grade, which is the equivalent of ages 12-13, which has been reported as suitable for questionnaires (DeVellis, 2017: see Appendix H for full chart).

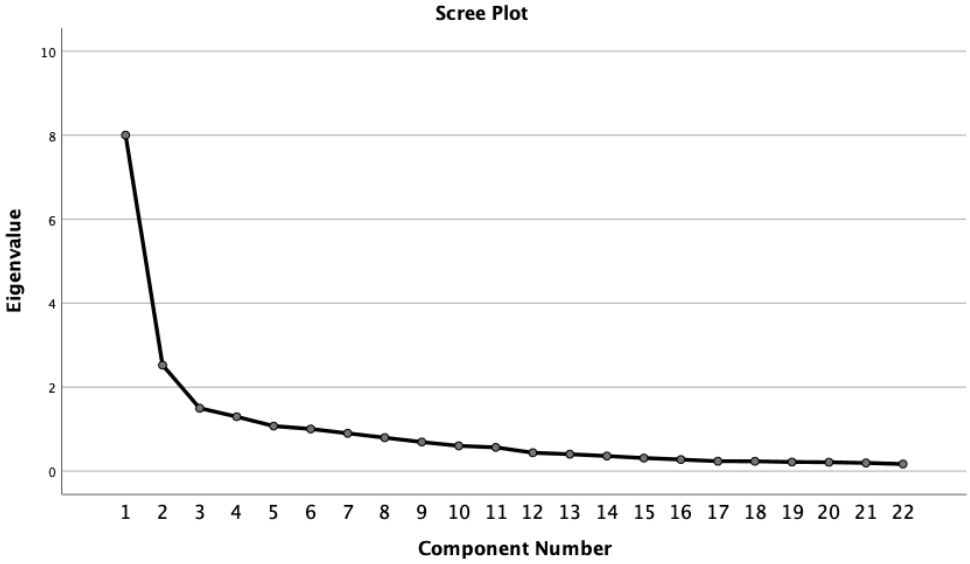

Figure 4.1: Scree plot for principal component analysis for the initial pool of 22 items.

Table 4.4: Rotated structure matrix with direct oblimin rotation for the two-factor model (items in bold were retained)

Construct		Exercise addiction	Disordered eating
Restriction of intake	***'I often restrict my intake of food'***	-	**0.61**
	'I limit the number of calories I eat'	-	0.53
Fear of gaining weight	*'I'm afraid of putting on weight'*	-	0.59
	'I feel that I look fat'	-	**0.80**
Body image disturbance	***'I hate the way my body looks'***	-	**0.66**
	'People often say I look too thin'	-	-0.12
Recurring episodes of binge-eating	***'I often binge-eat on foods and feel that I cannot stop'***	-	**0.71**
	'I often eat lots of food in a short space of time'	-	0.69
Use of vomiting, laxatives, diuretics, medications, fasting to control weight gain	***'I have used medication, (e.g. laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months'***	-	**0.61**
	'Medication, fasting, and/or vomiting after meals helps me to lose weight'	-	0.62
Salience	***'Exercise is my number 1 priority'***	**0.73**	-
	'I don't think I would manage very well without exercise'	0.69	-
Mood modification	***'I find I need to exercise to improve my mood'***	**0.72**	-
	'Exercise is the only way I can deal with stress'	0.72	-
Tolerance	***'I feel I need to do more exercise to get the same buzz'***	**0.71**	-
	'The more exercise I do, the more I need to keep doing to get the same feelings'	0.67	-
Withdrawal	*'When I take a break from exercise, I feel irritable and moody'*	0.72	-
	'I dread having to take a break from exercise (e.g. due to injury/illness/social commitments)'	**0.76**	-
Conflict	*'I often find my exercise habits affect my relationships (e.g. family/friends/partners)'*	0.64	-
	'I neglect friends/family/relationships because I want to exercise'	**0.65**	-
Relapse	***'The urge to exercise is stronger than my want to do less exercise.'***	**0.76**	-
	'If I were to stop exercising, I would start again at the same level as before.'	0.62	-

4.4.4 Discussion

The aim of Study 1 was to report how questions for the SEAS were conceptualised and describes how the 22 items were reduced to an 11-item, short-form scale. The initial items were developed in consultation with a psychologist with expertise in scale development, and a sports psychiatrist with a speciality in eating disorders, with the initial set of questions being based on the DSM-5 (American Psychiatric Association, 2013) criteria for anorexia and bulimia nervosa, and symptoms of exercise addiction based on Brown (1993), with two questions per theorical item in the first instance. After the PCA was conducted, two emerging constructs were extracted: namely exercise addiction and disordered eating. From here, the scale was reduced to 11 items (one item per theoretical construct), retaining the respective construct item that had the highest factor loading. Furthermore, the retained items were highly loaded against each respective factor, with every factor's loading at >0.6, which has been indicated as a strong correlation in this context, and merits inclusion (Spicer, 2005). Moreover, as well as strong statistical support, the extracted two-component model also has strong conceptual support considering that these matched the two components that the SEAS was based on. The readability of the retained items was ages 12-13, which has been reported as acceptable for questionnaires (DeVellis, 2016), and ensures that the high proportion of the population would be able to understand the survey.

In conclusion, the newly reduced, 11-item scale loads strongly on its respective constructs and could be a valid tool for measuring both exercise addiction and disordered eating behaviours. Study 2 aims to extend these findings by assessing the robustness of the SEAS factor structure using confirmatory factor analysis (CFA).

4.5 Study 2

The aim of Study 2 was to confirm the latent structure of the reduced SEAS items as stated in Chapter 4 Study 1, based on the factors that were extracted. In brief, the proposed model contains two latent factors: exercise addiction and disordered eating, with (assumed) causal links between exercise addiction and each of Brown's (1993) general components of addiction (salience, mood modification, tolerance, withdrawal, conflict, and relapse) (Brown, 1993), and (assumed) causal links between disordered eating and each component of eating disorders, based on the DSM-5 diagnostic criteria for anorexia and bulimia nervosa (restriction of intake, fear of gaining weight, body image disturbances, recurring episodes of binge-eating, and use of vomiting, laxatives, diuretics, medications, or fasting to control weight gain) (American Psychiatric Association, 2013). The full proposed model structure is shown in Figure 4.2.

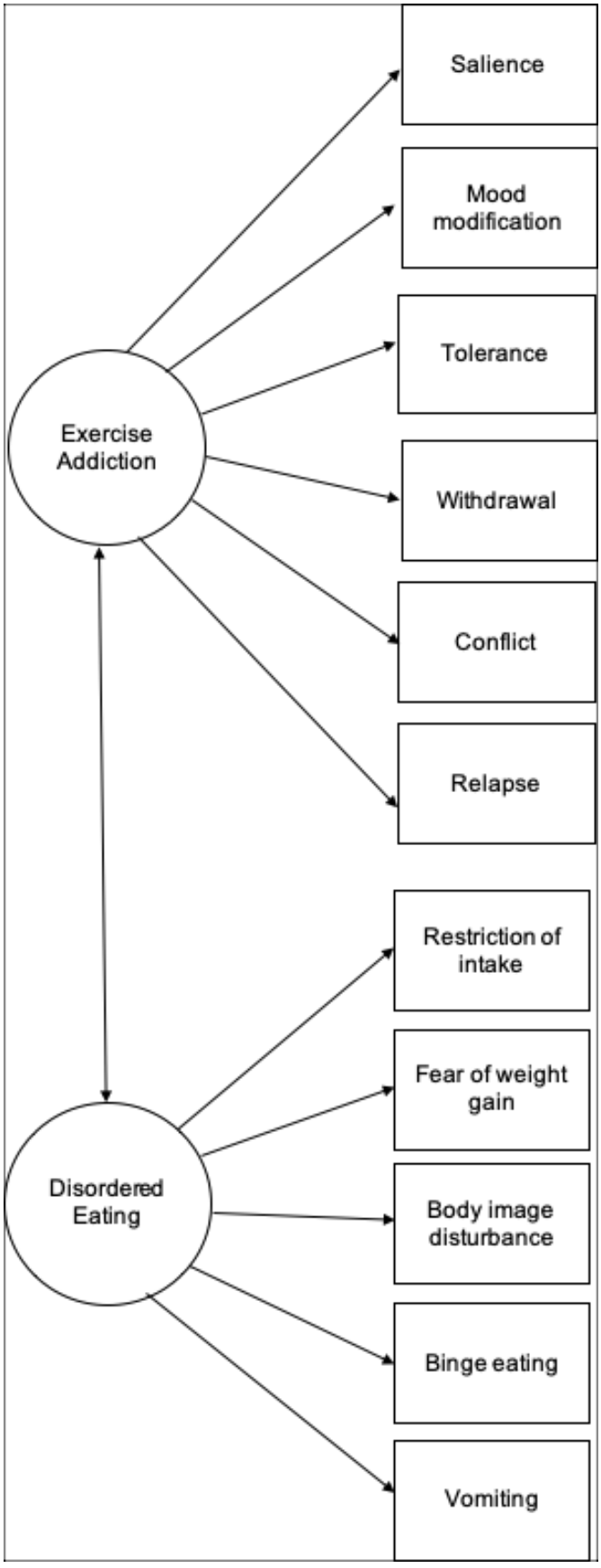

Figure 4.2: Proposed structure of the Secondary Exercise Addiction Scale

4.5.1 Methods

Participant recruitment has been described in detail in Chapter 4: Study 1: Section 4.2.2. For this study, the other randomised group (that was not used in Study 1) was used. Ethical approval was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-13).

Note that all survey questions for Studies 1, 2 and 3 are available in Appendix H.

4.5.2 Data analysis

To confirm the proposed structure of the newly reduced 11-item SEAS, a maximum likelihood confirmatory factor analyses (CFA) was conducted on the other randomised sample of participants, using Stata 16 (Stata Corp, 2019), against the structural model shown in Figure 4.2. The CFA is a type of structural equation modelling, and is a multivariate statistical technique which assesses how well a proposed model fits the available data, thus providing a means of assessing construct validity, and has been deemed an essential next step in scale development (DeVellis, 2016; Cramer and Howitt, 2021). The CFA yields several fit indexes that allow the assessment of fit against proposed models in order to assess which latent variables best explain the observed variables (Cramer and Howitt, 2021). Of these fit indices, several were used to deemed if the data were an acceptable fit in the current study, using the guideless suggested by Hu and Bentler (1999), including:

1. Comparative fit index (CFI) > 0.90
2. Tucker-Lewis index (TLI) >0.90, and
3. Root mean square error of approximation (RMSEA) <0.08

Note that although Chi-square has been reported as being a useful tool in determining a good model fit (Cramer and Howitt, 2021), it is also highly sensitive to larger sample sizes, and has thus been suggested as being an unreliable measure of fitness (Hu and Bentler, 1999), and was not used as a fit-index parameter in this study.

4.5.3 Results

A total of 721 participants completed the survey, with 82.4% (n=594) female, a mean age of 35.60 years (SD=11.93) and a mean BMI of 23.74 (SD=4.10). Following randomisation, the mean age for Study 2 was 35.35 years (SD=12.27), mean BMI was 23.95 (SD=4.02), and 82.7% of participants were female. Full demographic information is shown in Table 4.5.

Table 4.5: Study 2 descriptive statistics

	Study 2 sample
N	382
Gender (female)	82.7% (*n*=316)
Age (years)	35.35 (12.27)
BMI	23.95 (4.02)
EAI total score	21.37 (4.36)
Exercise addiction	33% (*n*=126)
SCOFF total score	1.25 (1.33)
Main exercise location	
Gym	63.4% (*n*=242)
Sports club	13.6% (*n*=52)
Running outside	7.1% (*n*=27)
University gym	3.7% (*n*=14)
University sports club	0.0% (*n*=0)
At home	6.3% (*n*=24)
Other	6.0% (*n*=23)

All statistics are reported as mean (SD) unless otherwise stated; BMI=Body Mass Index; EAI=Exercise Addiction Inventory

The CFA (X^2=147.896) of the proposed model yielded a CFI of 0.933, TLI of 0.914, and a RMSEA of 0.08, indicating an acceptable fit to the model. Standardised factor loadings are shown in Table 4.6 and Figure 4.3.

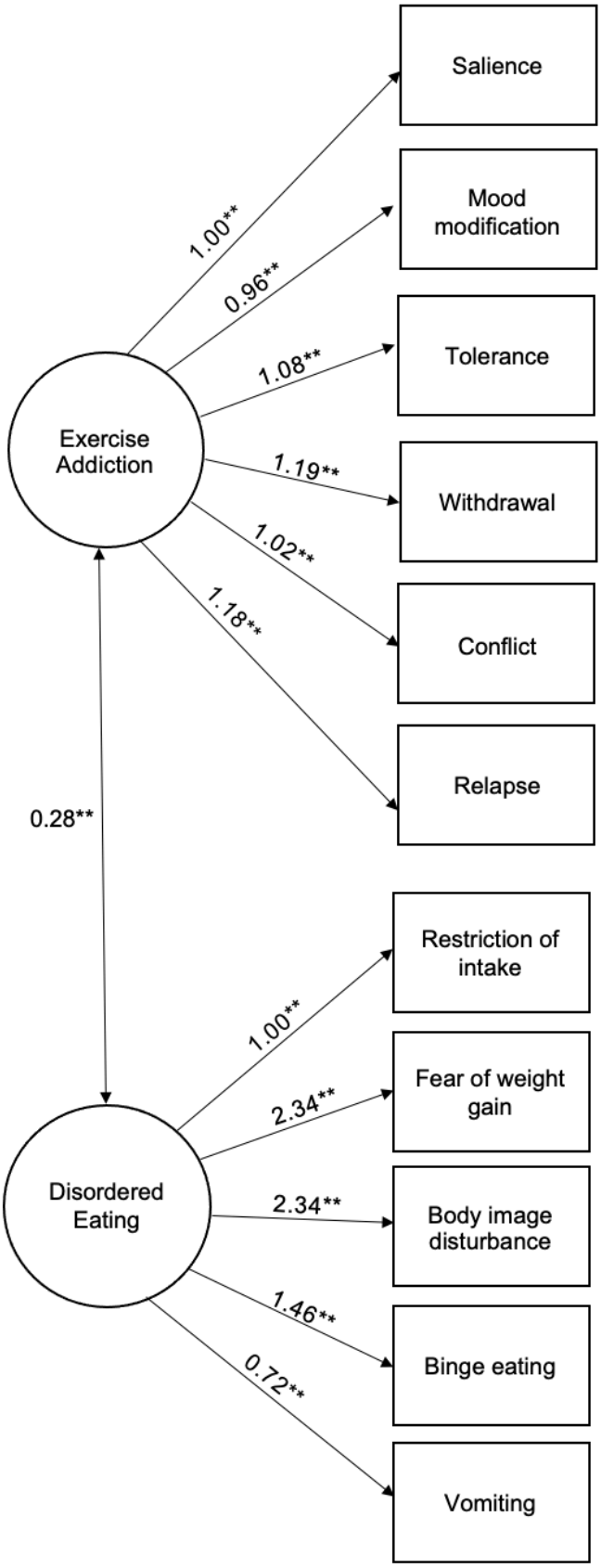

Figure 4.3: Confirmatory factor analysis of the proposed Secondary Exercise Addiction Scale constructs before modification (p=<0.001)**

Table 4.6: Standardised factor loadings of the Secondary Exercise Addiction Scale

Construct	Items	Factor loadings (95% CI)	Standardized error
Disordered Eating			
Restriction of intake	'I often restrict my intake of food'	1 (constrained)	
Fear of gaining weight	'I feel that I look fat'	2.34 (1.71-2.97)	0.32
Body image disturbance	'I hate the way my body looks'	2.34 (1.71-2.97)	0.32
Recurring episodes of binge-eating	'I often binge-eat on foods and feel that I cannot stop'	1.46 (1.02-1.90)	0.22
Use of vomiting, laxatives, diuretics, medications, fasting to control weight gain	'I have used medication, (e.g. laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months'	0.72 (0.44-1.00)	0.14
Exercise Addiction			
Salience	'Exercise is my number 1 priority'	1 (constrained)	
Mood modification	'I find I need to exercise to improve my mood'	0.96 (0.81-1.11)	0.78
Tolerance	'I feel I need to do more exercise to get the same buzz'	1.08 (0.91-1.25)	0.87
Withdrawal	I dread having to take a break from exercise (e.g. due to injury/illness/social commitments)'	1.19 (1.01-1.37)	0.92
Conflict	'I neglect friends/family/relationships because I want to exercise'	1.02 (0.85-1.19)	0.88
Relapse	'The urge to exercise is stronger than my want to do less exercise.'	1.18 (1.00-1.36)	0.96

4.5.5 Discussion

The aim of Study 2 was to confirm the latent structure of the SEAS, based on the two-component model proposed in Study 1, with the results showing that the data, based on a different sample of participants as Study 1, acceptably fit the proposed model. Although this was unsurprising (given that the items were developed based on two respectively developed models of exercise addiction and disordered eating), the results indicate that the underlying factor structure is robust when tested under different populations and appears to be measuring the same constructs across populations.

Study 3 describes the process of determining acceptable cut-off scores for each section of the SEAS and aims to examine concurrent reliability against already existing short-form exercise addiction and disordered eating questionnaires.

4.6 Study 3

The aim of Study 3 was to determine sensitivity and specificity of the SEAS against currently available short-form exercise addiction and eating disorder questionnaires, and to determine suitable scoring cut offs based on these comparisons. A further aim was to determine concurrent validity of the SEAS against currently available short form exercise addiction and disordered eating questionnaires.

4.6.1 Method

Participant recruitment has been described in detail in Chapter 4: Study 1: Section 4.2.2. For this study, the entire sample was used. Ethical approval was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-13).

Measures

Exercise Addiction

The Exercise Addiction Inventory (EAI; Terry, Szabo and Griffiths, 2004) was used as the tool to measure against the exercise addiction section of the SEAS. The primary reason why this tool was chosen was because it is the only short-form tool available for measuring exercise addiction. The EAI is a six-item questionnaire that assesses each component of Brown's theory of addiction (Brown, 1993) in an exercise context. Each question is scored on a Likert scale of 1-5, with a higher score indicating higher risk of exercise addiction. Participants who score $\geq$24 are classified as 'at risk' of exercise addiction (Terry, Szabo and Griffiths, 2004). The EAI has been shown to have good reliability and validity across physically active populations (Griffiths et al., 2015; Lichtenstein and Jensen, 2016; Terry, Szabo and Griffiths, 2004), and has shown good internal reliability in the studies in this thesis (Chapter 3a α=0.72; Chapter 3b α=0.74; Chapter 4: Study 3 α=0.76).

Eating disorder symptomology

The SCOFF questionnaire (Morgan, Reid and Lacey, 1999) was used as the tool to measure against the disordered eating section of the SEAS. The primary reason why this tool was chosen was because it is the only short-form tool available for measuring eating disorder symptomology, and has been adopted by several UK Clinical Commissioning Groups as a

means for initial eating disorder assessment (Hill et al., 2010). The SCOFF is a five-item questionnaire that assess core features of anorexia and bulimia nervosa, with dichotomous (yes/no) answers for each question. The authors defined a total of two or more positive answers as indicative of either anorexia or bulimia nervosa. The SCOFF has shown excellent sensitivity (100%) and specificity (87.5%) against clinically diagnosed eating disorder patients (Hill et al., 2010).

Note that all survey questions for Studies 1,2 and 3 are available in Appendix I.

4.6.2 Data analysis

To determine that the final version of the SEAS gave adequate predictive values two Receiver Operator Characteristic (ROC) curves were plotted against the respective sections of the SEAS against already existing short-form screening tools for exercise addition and disordered eating. To further establish concurrent validity, total scores of the respective exercise addition and disordered eating sections of the SEAS were compared with the total scores from already existing short-form respective screening tools for exercise addition and disordered eating.

Cut off points were determined based on the sensitivity and specificity of the respective sections of the survey against the EAI or SCOFF, and were initially based on scores that would indicate maladaptive behaviours in each question. Because one of the potential uses of this tool in primary care settings, it was decided that high specificity be preferential to sensitivity, to reduce the amount of potential false-negative results. To establish concurrent validity, a Pearson's correlation was used to measure associations between the respective total scores of two sections of the SEAS and the results of the EAI and SCOFF. Internal reliability using a Cronbach's alpha was also assessed. All statistics in Study 3 were conducted using the total combined sample of Studies 1 and 2.

4.6.3 Results

A total of 721 participants completed the survey, with 82.4% (n=594) female, a mean age of 35.60 years (SD=11.93) and a mean BMI of 23.74 (SD=4.10). Full demographic information is shown in Table 4.7.

Table 4.7: Descriptive statistics of Study 3

	Total sample
n	721
Gender (female)	82.4% (*n*=594)
Age (years)	35.60 (11.93)
BMI	23.74 (4.10)
EAI total score	21.40 (4.39)
Exercise addiction prevalence	34.4% (*n*=248)
SCOFF total score	1.30 (1.31)
Main exercise location	
Gym	61.9% (*n*=446)
Sports club	15.4% (*n*=111)
Running outside	8.2% (*n*=59)
University gym	3.1% (*n*=22)
University sports club	0.1% (*n*=1)
At home	5.3% (*n*=38)
Other	6.1% (*n*=44)

All data are reported as mean (SD) unless otherwise stated; BMI=Body mass index; EAI=Exercise Addiction Inventory

The ROC curves yielded excellent areas under the curve (exercise addiction= 0.89 95% CI 0.86-0.91; disordered eating=0.87 95% CI 0.85-0.90; see Figures 4.4 and 4.5).

A preliminary cut-off score was determined, based on a score of four or more in every question in each respective section of the SEAS (≥24 for exercise addiction and ≥20 for potential eating disorders). All potential scores were then assessed for their sensitivity and specificity based on the EAI and SCOFF, respectively. A cut off score of ≥24 in the exercise addiction section yielded sensitivity of 86.69% and specificity of 74.42 against the EAI; because specificity was highly preferred over sensitivity, a cut-off score of >28 was the lowest score to yield a specificity of >90%, therefore it was determined that a cut off score of >28 be suitable to determine people at risk of exercise addiction (see Table 4.8). A cut off score of >20 in the disordered eating section yielded sensitivity of 46.23% and specificity of 96.27% against the SCOFF. Because of this high specificity, and a cut-off score of >20 was retained for this section (see Table 4.9). Although lower scores also yielded specificity of >90%, the predominant reason why a score of 20 was maintained was because it yielded

very high specificity whilst also being in a range where a scorer would have to score a mean of 4 per question.

Table 4.8: Sensitivity and specificity for potential cut off scores for the exercise addiction section of the Secondary Exercise Addiction Scale.

	Cut off score	Sensitivity	Specificity
No risk of exercise addiction	20	95.97%	49.05%
	21	94.76%	54.76%
	22	92.34%	61.31%
	23	90.73%	69.34%
	24	86.69%	74.42%
	25	83.47%	79.92%
	26	77.42%	84.99%
	27	69.76%	87.95%
At risk of exercise addiction	**28**	**62.90%**	**91.97%**
	29	54.44%	94.29%
	30	45.97%	96.19%
	31	36.29%	97.89%
	32	25.00%	98.73%

Table 4.9: Sensitivity and specificity for potential cut off scores for the disordered eating section of the Secondary Exercise Addiction Scale.

	Cut off score	Sensitivity	Specificity
No indicated eating disorder	14	88.01%	68.76%
	15	83.56%	76.92%
	16	76.37%	83.68%
	17	67.81%	87.65%
	18	61.99%	91.14%
	19	52.40%	94.64%
Indicated eating disorder	**20**	**46.23%**	**96.27%**
	21	39.38%	97.90%
	22	29.45%	99.07%
	23	23.97%	99.53%
	24	18.15%	99.53%
	25	15.75%	99.77%
	26	9.93%	99.77%

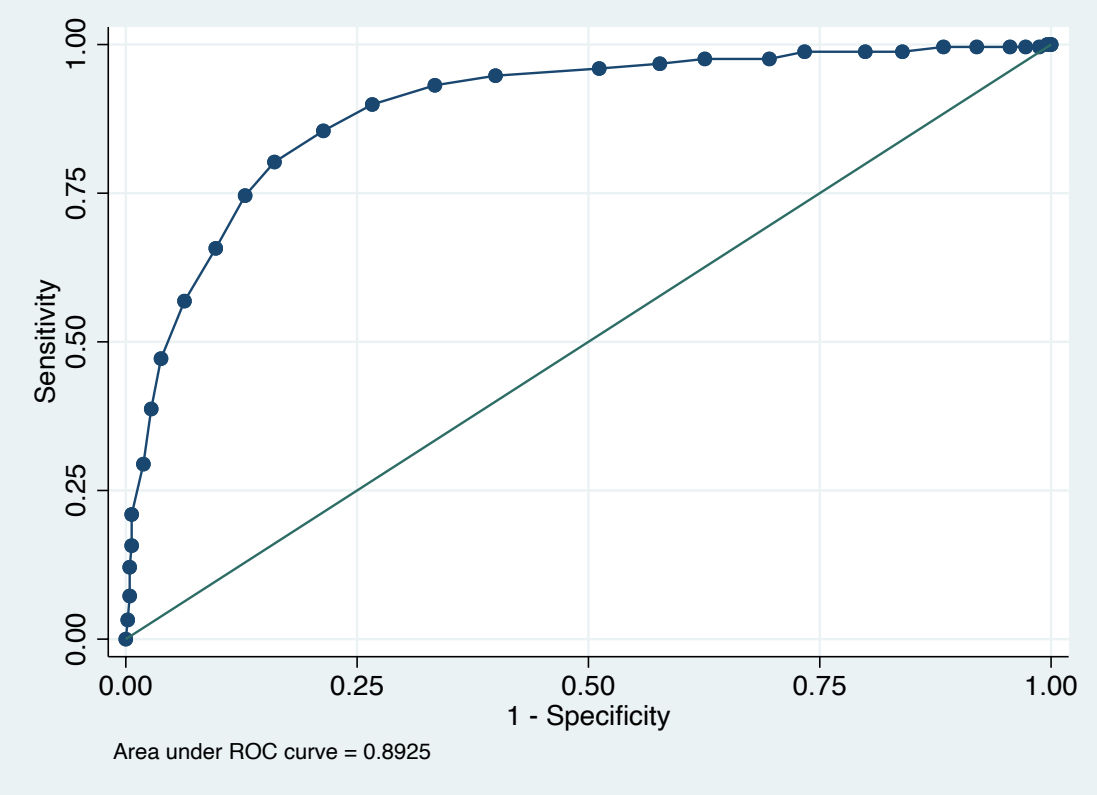

Figure 4.4: ROC curve showing sensitivity and specificity for the exercise addiction section of the Secondary Exercise Addiction Scale versus the Exercise Addiction Inventory

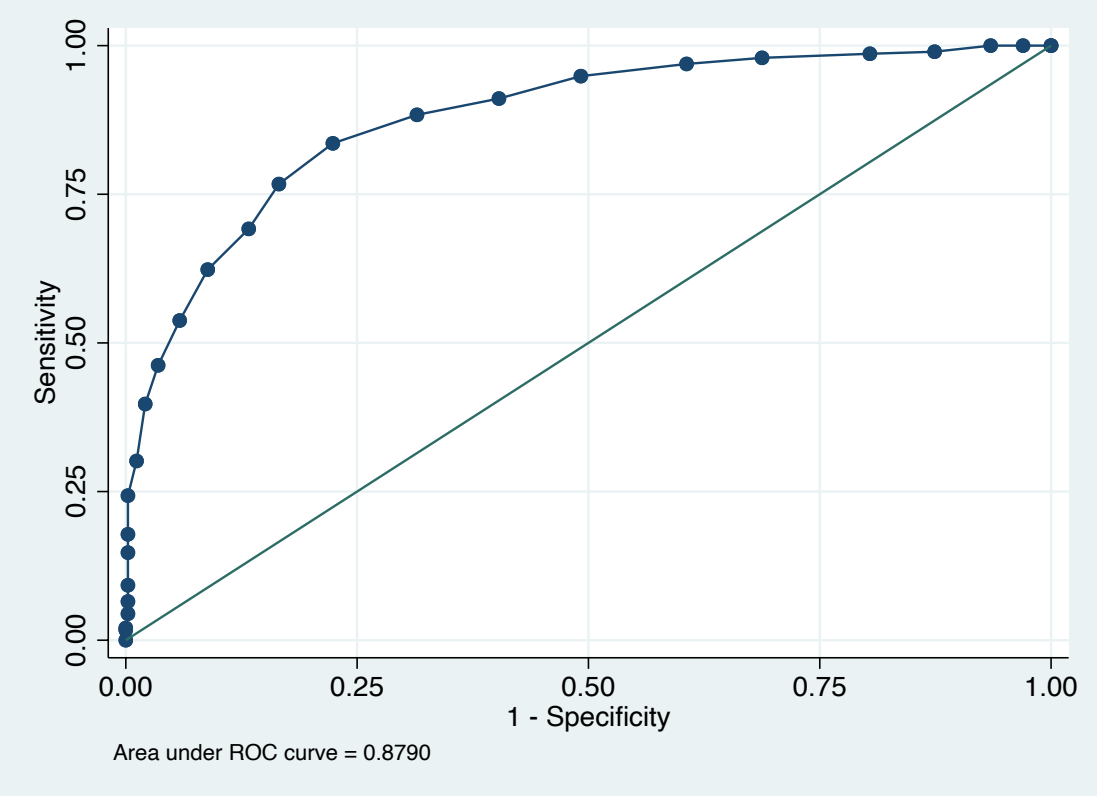

Figure 4.5: ROC curve showing sensitivity and specificity for the eating disorder section of the Secondary Exercise Addiction Scale versus the SCOFF

Using these newly determined cut-off scores, 14% of participants were determined as at risk of primary exercise addiction (scoring above the cut off for being at risk of exercise addiction but not for eating disorder symptomology), compared to 15% using the respective SCOFF and EAI cut offs; 8.5% of participants were determined as at risk of secondary exercise addiction (scoring above the cut offs for both exercise addiction and eating disorder symptomology), compared to 19.4% using the respective SCOFF and EAI cut offs; 8.7% had eating disorder symptomology in the absence of exercise addiction, compared with 21.1% using the respective SCOFF and EAI cut offs; and the remaining 68.8% of participants had no indicated exercise addiction or eating disorder symptomology, compared with 44.5% using the respective SCOFF and EAI cut offs, see Table 4.10 for more details.

Table 4.10: Comparative score for the Secondary Exercise Addiction Scale and the SCOFF and Exercise Addiction Inventory

	SEAS		SCOFF and EAI	
	n	Percentage	n	Percentage
Primary exercise addiction	101/721	14.0%	108/721	15.0%
Secondary exercise addiction	61/721	8.5%	140/721	19.4%
Eating disorder symptomology only	63/721	8.7%	152/721	21.1%
No indicated exercise addition or eating disorder symptomology	496/721	68.8%	321/721	44.5%

SEAS=Secondary Exercise Addiction Survey; EAI=Exercise Addiction Inventory

The total scores of both the exercise addiction and eating disorder sections of the SEAS yielded significant associations with the total scores of the EAI (0.701, *p*=<0.001) and SCOFF (0.717, *p*=<0.001) respectively. Cronbach's alpha was 0.85 (95%CI 0.83-0.86) for the total SEAS, 0.84 (95% CI 0.82-0.85) for the exercise addiction section and 0.75 (95% CI 0.72-0.78) for the disordered eating section. Full internal reliability statistics can be found in Table 4.11.

Table 4.11: Secondary Exercise Addiction Scale internal reliability statistics

	Cronbach's Alpha if item deleted (total SEAS)	**Cronbach's Alpha if item deleted (individual sections)**
Exercise addiction		Exercise addiction section total = 0.84
'Exercise is my number 1 priority'	0.83	0.81
'I find I need to exercise to improve my mood'	0.83	0.81
'I feel I need to do more exercise to get the same buzz'	0.82	0.80
I dread having to take a break from exercise (e.g. due to injury/illness/social commitments)'	0.83	0.80
'I often find my exercise habits affect my relationships (e.g. family/friends/partners)'	0.83	0.82
'If I were to stop exercising, I would start again at the same level as before.'	0.84	0.82
Disordered eating		Disordered eating section total = 0.75
'I often restrict my intake of food'	0.84	0.74
'I feel that I look fat'	0.83	0.65
'I hate the way my body looks'	0.83	0.66
'I often binge-eat on foods and feel that I cannot stop'	0.84	0.72
'I have used medication, (e.g. laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months'	0.84	0.75

4.6.4 Discussion

The aim of Study 3 was to establish concurrent validity and determine the cut offs for the exercise addiction and disordered eating sections of the SEAS, using already existing short-form exercise addiction and eating disorder screening tools. Each respective ROC analysis confirmed that the sections predict exercise addiction and disordered eating well. It has been well reported that areas under the curve (AUC) need to be >0.5 for the respective diagnostic tools to be valid, with higher values indicting better predictive values. Both of Study 3's reported AUC were excellent, indicating that the SEAS has excellent predictive value.

The initial cut-off scores for the two sections of the SEAS were based on mean values of ≥4 for every question (≥24 and ≥20 for the exercise addiction and disordered eating sections, respectively). When referencing the exercise addiction initial cut off scores against sensitivity and specificity with the EAI, it was found that the specificity was lower than sensitivity. Because of this, the cut-off score for the exercise addiction section of the was increased to >28, which increased the specificity by to 91%. The specificity of the disordered eating section of the SEAS with a cut off score of ≥20 was 96%, so this cut off score was retained. The full SEAS with scoring information can be found in Tables 4.12 and 4.13.

Table 4.12: The Secondary Exercise Addiction Scale

	Over the previous three months, how much do you agree or disagree over the following statements?	1 (completely disagree)	2	3	4	5	6 (completely agree)
Section A	1 'Exercise is my number 1 priority'						
	2. 'I find I need to exercise to improve my mood'						
	3. 'I feel I need to do more exercise to get the same buzz'						
	4. 'I dread having to take a break from exercise (e.g., due to injury/illness/social commitments)'						
	5. 'I often find my exercise habits affect my relationships (e.g., family/friends/partners)'						
	6. 'If I were to stop exercising, I would start again at the same level as before.'						
Section B	7. 'I often restrict my intake of food'						
	8. 'I feel that I look fat'						
	9. 'I hate the way my body looks'						
	10. 'I often binge-eat on foods and feel that I cannot stop'						
	11. 'I have used medication, (e.g., laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months'						
Total score for Section A.....							
Total score for Section B.....							

Table 4.13: Scoring for the Secondary Exercise Addiction Scale

		Section A	
		Total score between 6-28	Total score between 29-36
Section B	Total score between 5-20	No exercise addiction or eating disorder risk	Risk of primary exercise addiction
	Total score between 21-30	Risk of eating disorder	Risk of secondary exercise addiction

4.7 Study 4

The aim of Study 4 was to determine test-retest reliability of the SEAS and to confirm further concurrent validity with longer-form exercise addiction and eating disorder measurement tools.

4.7.1 Methods

For Study 4, a convenience sample was invited to take part in the study via email. To be eligible for Study 4 participants were required to be adults (>18 years of age) undertaking >150 minutes of physical activity per week, as per the UK Department of Health guidelines (Department of Health, 2019). Participants who took part in this study were then invited to take part in re-test of the SEAS two weeks after completion of the first questionnaire.

Participants were oriented to an online battery of questions hosted through an academic survey website (Jisc Online Surveys, 2020), including measures of age, sex, exercise addiction, eating disorder symptomology, and the SEAS. Ethical approval for all studies was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-20).

4.7.1.1 Measures

Exercise addiction

The Revised Exercise Dependence Scale (EDS-R; Symons Downs, Hausenblas and Nigg, 2004) was used as the longer-form tool to measure exercise addiction. The EDS-R is a 21-item questionnaire, derived from the original 30-item Exercise Dependence Scale (Hausenblas and Symons Downs, 2002b). Each question is scored on a Likert scale of 1-6, with three questions addressing each of the DSM-IV (American Psychiatric Association, 2000) respective criteria for substance abuse (tolerance, withdrawal, continuance, lack of control, reduction in other activities, time, and intention effects). The EDS-R yields three different results: (1) nondependent asymptomatic; (2) nondependent symptomatic; and (3) at risk. The EDS-R has been well validated in active populations and has shown excellent internal reliability in previous studies (α=0.92; Symons Downs, Hausenblas and Nigg, 2004) and in the current study (α=0.94).

Eating disorder symptomology

The Eating Attitudes Test 26 (EAT-26) (Garner et al., 1982) was used as the longer-form tool to measure eating disorder symptomology. The EAT-26 is a 26-item questionnaire scored on a Likert scale of 1-6. A score of ≥20 is sufficient to be classified as having possible pathological eating behaviours. The EAT-26 has been well validated in athletic populations (Doninger, Enders and Burnett, 2005; Pope et al., 2015), and has shown excellent internal consistency in the studies in this thesis (Chapter 3: Study α=0.91; Chapter 3: Study 2 α=0.87; current study α=0.90).

Each participant provided informed consent prior to taking part in the survey, including the right to withdraw and access to further support if any of the topics were distressing. To determine test-retest reliability of the SEAS, two weeks after the completion of the first questionnaire, participants were invited to take part in a second online questionnaire consisting of the SEAS only.

All survey questions for Study 4 are available in Appendix J.

4.7.1.2 Data analysis

To compare the results of the first and second SEAS answers, an intra-class coefficient (ICC) was conducted, with an *r*=>0.7 being deemed as acceptable (Nunnally and Bernstein, 1994). The sample size required for estimating an ICC *r* of 0.7 with 95% confidence interval (CI) and a standard deviation (SD) of 0.2, with estimated 25% dropout rate between the two weeks' questionnaires, for two repeated measures was 35 participants (Bonett, 2002), therefore the study aimed to recruit 40 participants.

To determine concurrent reliability with the respective sections of the SEAS and the EAT-26 and EDS-R, a Pearson's correlation was conducted. Moreover, confirmatory ROC analyses were conducted to confirm the Study 3 cut off points against the dichotomised EAT-26 scores (with EAT-26 total scores ≥20 classifying participants as having possible eating disorder symptomology) and EDS-R (classified as 'at risk') results, respectively.

4.7.3 Results

A total of 45 participants completed the first survey, with 62.2% (n=28) female, a mean age of 32.87 years (SD=7.80), and a mean BMI of 23.96 years (SD =3.49). The second survey yielded a 31 (68%) completion rate. Full demographic information is shown in Table 4.14.

Table 4.14: Descriptive statistics for Study 4

n	45		
Gender (female)	62.2% (n=28)		
Age (years)	32.87 (7.80)		
BMI	23.96 (3.49)		
EDS-R total score	64.60 (20.57)		
EDS-R at risk of exercise addiction (yes)	8.9% (4/45)		
EDS-R symptomatic non-dependent (yes)	80% (36/45)		
EDS-R asymptomatic non-dependent (yes)	13.3% (6/45)		
EAT-26 total score	11.02 (11.47)		
EAT-26 indicated eating disorder (yes)	22.2% (n=10)		
	First administration (*n*=45)	**Second administration (*n*=31)**	**Intra-class correlation (95% CI; p-value)**
Total SEAS exercise addiction score	21.93 (5.98)	20.68 (6.91)	0.933 (0.860-0.968; *p*=<0.001)
Total SEAS eating disorder score	13.53 (6.41)	12.61 (5.48)	0.949 (0.893-0.975; *p*=<0.001)

All data are reported as mean (SD) unless otherwise stated; BMI=Body mass index; EDS-R=Exercise Dependence Scale - revised; EAT-26=Eating Attitudes Test

Based on the SEAS cut-off scores described in Study 3, 32 (71.1%) participants were classified as having no risk of exercise addiction or eating disorders, 4 (8.9%) participants were classified as being at risk of primary exercise addiction, 3 (6.7%) participants were classified as being at risk of secondary exercise addiction, and 6 (13.3%) participants were classified as being at risk of an eating disorder.

The intra-class-correlation between the first and second administrations of the eating disorder section of the SEAS was 0.95 (95% CI 0.89-0.98; *p*=<0.001), and the exercise addiction section of the SEAS 0.93 (95% CI 0.86-0.97; *p*=<0.001). The association between the total score of the exercise addiction section and the total score of the EDS-R was 0.718 (*p*=<0.001). The association between the total score of the disordered eating section of the SEAS and the total score of the EAT-26 was 0.721 (*p*=<0.001).

The confirmatory ROC curves yielded excellent areas under the curve (exercise addiction= 0.97 95% CI 0.92-1.00); eating disorders=0.864 95% CI 0.74-0.99; see Figures 4.6 and 4.7). Using the cut-off score determined in Study 3, the exercise addiction section of the SEAS yielded sensitivity of 100% and specificity of 92.68% against the EDS-R classification of 'at risk' (see Table 4.15). The eating disorder section of the SEAS yielded sensitivity of 70.00% and specificity of 91.43% against the EAT-26's established cut off (see Table 4.16).

Table 4.15: Sensitivity and specificity for cut off scores for the exercise addiction section of the Secondary Exercise Addiction Scale vs the Revised Exercise Dependence Scale.

Cut off score	Sensitivity	Specificity
>26	100%	85.37%
>27	100%	90.24%
>28	100%	**92.68%**
>29	50.00%	95.12%
>30	50.00%	97.56%

Table 4.16: Sensitivity and specificity for cut off scores for the disordered eating section of the Secondary Exercise Addiction Scale against the Eating Attitudes Test 26.

Cut off score	Sensitivity	Specificity
>18	80.00%	80.00%
>19	70.00%	88.57%
>20	**70.00%**	**91.43%**
>21	60.00%	91.43%
>22	50.00%	91.43%

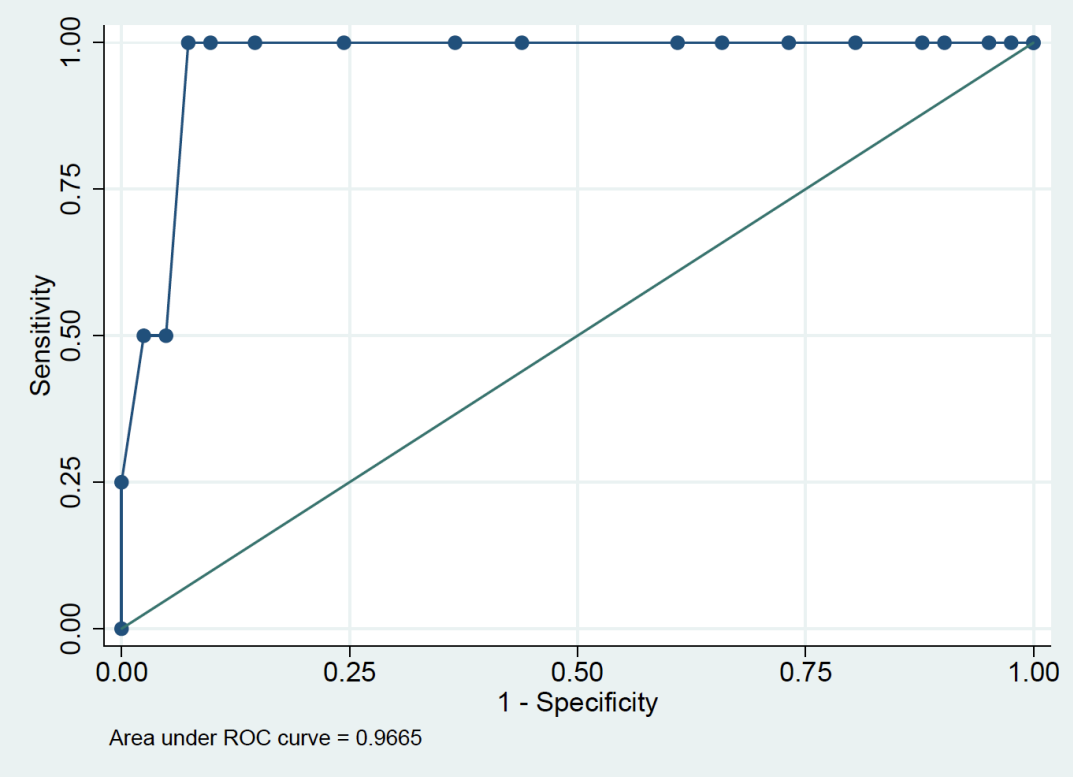

Figure 4.6: ROC curve showing sensitivity and specificity for the exercise addiction section of the Secondary Exercise Addiction Scale versus the Revised Exercise Dependence Scale.

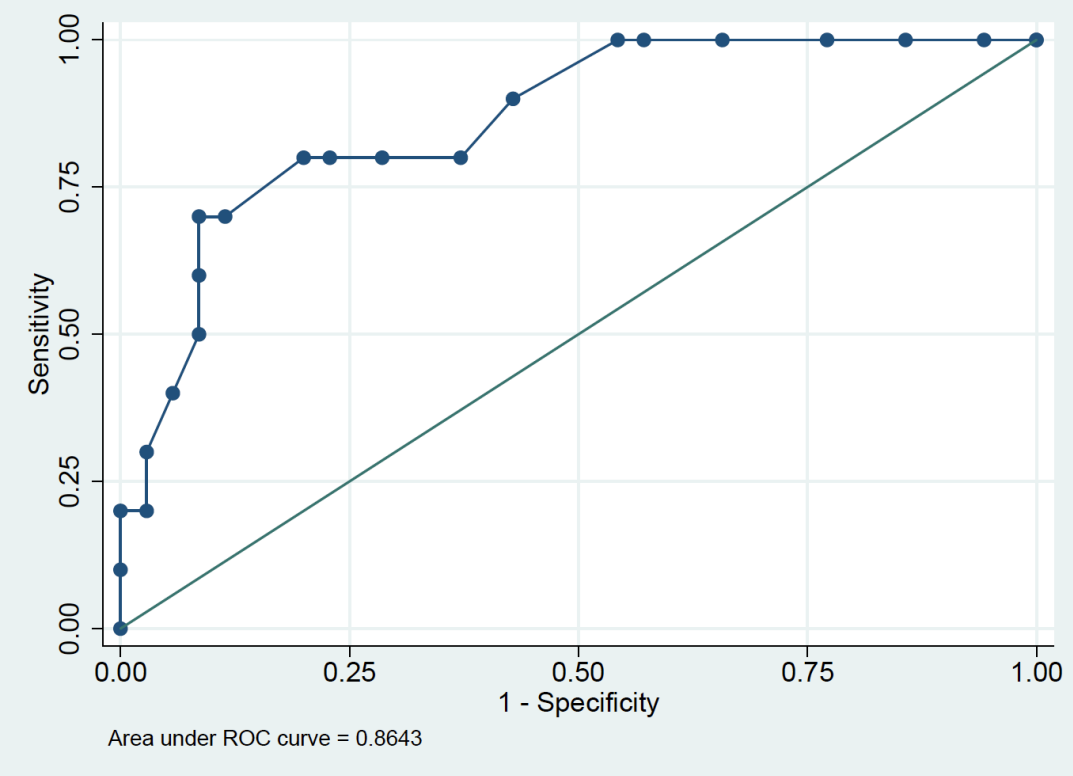

Figure 4.7: ROC curve showing sensitivity and specificity for the eating disorder section of the Secondary Exercise Addiction Scale versus the Eating Attitudes Test 26.

4.7.4 Study 4 Discussion

The primary aim of Study 4 was to confirm the test-retest reliability of the SEAS. A secondary aim of Study 4 was to further confirm the concurrent validity of the SEAS against longer-form exercise addiction and eating disorder screening questionnaires.

The results of the test-retest reliability were 0.95 and 0.93 for the respective eating disorder and exercise addiction sections, indicating excellent reliability (DeVellis, 2016; Everitt, 2002). Furthermore, when comparing the scores of the respective sections of the SEAS against longer form exercise addiction and eating disorder questionnaires, the SEAS yielded excellent concurrent validity (DeVellis, 2016), adding evidence that the results from the SEAS are robust when measured against respective longer-form questionnaires. Regarding the cut-off scores, each of the cut off scores determined in Study 3 yielded good specificity and sensitivity.

4.8 Chapter 4: General Discussion

This Chapter describes the creation and validation of a novel screening tool for exercise addiction, that can stratify between potential primary and secondary exercise addiction. When compared to other short-form exercise addiction and eating disorder screening tools, the development of the SEAS has arguably been more rigorous at every stage. For example, both the EAI (Terry, Szabo and Griffiths, 2004) and SCOFF questionaries do not appear to have item-reduction as a method of determining which questions were to be included, and also does not appear to have a confirmatory factor analysis, bringing into question their respective latent structure. Furthermore, the cut off scores that were suggested by the authors of the EAI do not appear to have any statistical support, despite the authors comparing the results of their tool to other existing 'gold standard' tools.

The SEAS has potential for several different areas of practice, including in exercise addiction and eating disorder related research: this thesis has shown that exercise addiction appears to have different aetiology in indicated vs no-indicated eating disorder populations, and the application of the SEAS could help researchers determine these groups quickly and easily. Furthermore, there is potential for the SEAS to be used in clinical practice, as a tool to identify people with suspected eating disorders - while the SCOFF already exists for this purpose, the SEAS can also identify whether or not people are at risk of morbid exercise behaviours, potentially informing potential treatments quicker.

4.9 Limitations

The studies in this Chapter should be considered within its limitations. Firstly, the eating disorders section of the SEAS was validated against non-clinical populations, therefore its use as a clinical tool is limited. Further study should focus on validation against clinical populations. Secondly, because there are no diagnostic criteria for exercise addiction, the results from the exercise addiction section of the SEAS should be used as a continuous variable wherever possible. Further study is required to validate the exercise addiction section of the SEAS in a clinical setting. Thirdly, at no point during the development process, people with lived experience of exercise addiction were not consulted, which potentially limits the content validity. Furthermore, although the exercise addiction prevalence rates yielded from the EAI were similar to Study 3a and 3b, these prevalence rates were higher than reported in other studies using the EAI as a measurement tool. Like studies 3a and 3b, this is likely because of the recruitment method. These elevated prevalence rates, however, are not representative of the general population and therefore are challenging to generalise.

Further studies should aim to validate the SEAS in a representative population. Lastly, the validation of the SEAS was conducted in English only, limiting its use in other languages.

4.10 Conclusion

This Chapter explains the creation and validation of a novel screening tool, the Secondary Exercise Addiction Scale, or SEAS. This tool is 11 questions long and has been developed to assess symptoms of exercise addiction and eating disorders, respectively using Brown's theory of general addiction and the DSM-5 criteria for eating disorders.

Study 1 explains how the initial pool of items was developed, and then describes how the initial pool was reduced to for a short-form tool using a PCA. The results of the PCA showed two latent factors - exercise addiction and eating disorders, suggesting that the questions being asked in the SEAS are well suited to the initial aims of their creation. Furthermore, the majority of questions in the SEAS load highly onto their respective domains. Study 2 describes the robustness of the underlying latent structure of the newly reduced SEAS, and found that the underlying structure yielded an acceptable fit indicating that the underlying structure was robust. Study 3 described how the cut-off scores were determined for each section of the SEAS, and also determined concurrent reliability against short form exercise addiction and eating disorder questionnaires. Concurrent reliability was further strengthened in Study 4, finding strong associations between the exercise addiction and eating disorders sections of the SEAS against respective longer-form questionnaires. Furthermore, test-retest reliability was established.

Chapter 5 examines this thesis holistically identifying novel contributions to the literature, directions for future research, and also discusses the limitations of this thesis.

Chapter 5: General discussion

5.1 Rationale for thesis

Exercise addiction has been researched for decades yet is still a poorly understood phenomenon. The criteria to classify someone as being 'exercise addicted' have historically ranged from simply the presence of withdrawal symptoms upon exercise cessation (Morgan, 1979), to the presence of several behavioural concepts based on current clinical diagnostic criteria for substance abuse (Hausenblas and Symons Downs, 2002). One of the first published conceptualisations of exercise addiction stated that exercise addiction may be a primary condition, where the presence of exercise addiction cannot be accounted for by any other disorder (such as eating disorders), or a secondary condition where the exercise addiction is secondary to a primary condition (such as an eating disorder) (de Coverley Veale, 1987). Given that one of the symptoms of eating disorders (particularly anorexia and bulimia nervosa) is 'excessive exercise' (American Psychiatric Association, 2013), it is logical that studies aiming to explore exercise addiction preclude potential primary conditions such as eating disorders, or at least stratify between indicated and non-indicated eating disorders.

This, however, has not been standard practice in exercise addiction research to date - the majority of studies that explore exercise addiction (in any context) fail to screen for potential eating disorders (Symons Downs, MacIntyre and Heron, 2019) - making the interpretation of findings especially difficult. Indeed, in both studies in Chapter 2 almost 100 studies were excluded because they did not include an eating disorder screening. This, however, is based on the underlying assumption that de Coverley Veale (1987) was correct: that there are significant aetiological differences in exercise addiction between people with eating disorders and those with no indicated eating disorders. To date, there is a paucity in the literature providing evidence to confirm or refute this assumption, therefore this thesis was conducted to address this, and to provide evidence on exercise addiction in the context of eating disorder stratification. This thesis examined, and provided evidence for this, in two ways:

1. Provision of evidence (in the form of a systematic literature review and meta-analysis) that the prevalence of exercise addiction was vastly different in populations with vs without eating disorders (Chapter 2)

and

2. Provision of evidence, in the form of a large primary study, that several correlates of exercise addiction were significantly different in populations with versus without indicated eating disorders (Chapter 3)

The evidence in Chapters 2 and 3 provided novel evidence that there are aetiological differences in exercise addiction, indicating a clear benefit to stratifying populations according to eating disorder symptomology to determine people with possible primary and possible secondary exercise addition. It was therefore the aim of Chapter 4 to develop a new screening tool for exercise addition that could stratify people at risk of primary and secondary exercise addiction. The following Chapter discuss these Chapters in more detail.

5.2 Existing aetiological differences between exercise addiction in indicated and no-indicated eating disorders.

Prior to the data published from this thesis, the studies that provided the most evidence to support the hypothesis that exercise addiction is different in eating disorder vs non-eating disorder populations were those that measured exercise addiction prevalence. It had been previously reported in a systematic review that exercise addition prevalence differed according to the type of exercise a population engages in, ranging from 1.9% in the general population to 15.3% in 'mixed disciplines/ball games' (Di Lodovico, Poulnais and Gorwood, 2019). Despite the aforementioned review not stratifying between people with or without eating disorders, studies that had exclusively examined exercise addiction in eating disorder patients yielded much higher prevalence rates, ranging from 29%-80% (Dalle Grave, Calugi and Marchesini, 2008; Bratland-Sanda et al., 2011), however directly comparing these prevalence rates introduces population bias, and therefore more evidence was needed. Before this thesis, a systematic review examining the differences in prevalence between indicated and non-indicated eating disorder populations had not been conducted. Furthermore, because some authors have hypothesised that exercise addition does not exist in the absence of eating disorders (Bamber et al., 2003), it was important to examine this claim, by systematically reviewing the current literature base to determine if exercise addiction had been reported in the exclusive absence of eating disorders, and statistically pool prevalence rates thereof if these studies had been published.

The primary results of Chapter 2 provide novel, original evidence of three things:

1. That exercise addiction (using currently known diagnostic criteria and tools) appears to exist in the absence of eating disorders, refuting Bamber and colleagues' (2003) claim that exercise addiction only exists in the presence of an eating disorder.

2. That exercise addiction prevalence rates are significantly higher in populations with indicated eating disorders vs populations without indicated eating disorders, providing evidence of differing aetiologies between the two.

3. That different exercise addiction screening tools yield a wide range of prevalence rates, even in similar athletic populations.

This discussion will examine these in turn.

5.2.1. Exercise addiction appears to exist in the absence of indicated eating disorders.

To the author's knowledge, Bamber et al. (2003) is the only author to explicitly suggest that exercise addiction may not exist in the absence of eating disorders. The results from this thesis provide substantial evidence to the contrary: that exercise addiction appears to exist in the absence of an eating disorder, and therefore Bamber's (2003) hypothesis should be refuted. Furthermore, although they found that all 10 participants who were at risk of exercise addiction also showed signs of a clinical eating disorder, their sample size was very small. Although there are clear limitations to this study that make it challenging for the authors to generalise their claims (e.g., very limited sample size and the population being women-only), the study does provide some strengths that need to be addressed when comparing the results of this thesis. The most important strength of this study is their methodical screening of eating disorders and mixed methods approach. Several authors have claimed that eating disorder screening tools have limited diagnostic validity (Berg et al., 2011, 2012; Garner, 1991; Garner et al., 1982), and therefore any results yielded from these questionnaires need to be treated with caution. Bamber and colleagues went a step further and confirmed (or refuted) these questionnaire findings with in-depth qualitative interviews and found that all 10 of their exercise addicted participants had indicated eating disorders, despite some of them not indicating an eating disorder in the questionnaire. This strength highlights the key limitation of Chapter 2: Study 1: that all the participants in the included studies were exclusively screened for indicated eating disorders using an eating disorder questionnaire, rather than clinical interviews, meaning that it is possible (albeit very unlikely with a pooled sample size of 3,635) that every participant indeed had a false-negative result in their respective eating disorder screen. It is recommended that future studies employ qualitative methodologies to:

1. Confirm or refute the presence of eating disorders in participants.
2. Examine in more detail what participants with indicated eating disorders and exercise addiction are experiencing, and subsequent thematic analysis.

To the author's knowledge, Chapter 2: Study 1 was the first study to systematically review and examine exercise addiction in participants in the absence of indicated eating disorders. All previous reviews in this area (whether narrative, systematic, or meta-analytic) fail to examine the paradigm of exercise addiction in the exclusive absence of eating disorders at all (Cockerill and Riddington, 1996; Leuenberger, 2006; Hausenblas and Symons Downs, 2002a; Di Lodovico, Poulnais and Gorwood, 2019; Marques et al., 2019), and therefore this

study provides a novel contribution to the literature. Furthermore, the subsequent published version of this study has been cited in literature (see Chapter 8), indicating that **this study has already informed future research**.

5.2.2. Exercise addiction prevalence rates in populations with indicated vs without indicated eating disorders.

Because Chapter 2: Study 1 established that exercise addiction appears to exist in the absence of indicated eating disorders, the logical next step was to examine if exercise addiction was prevalent in populations with indicated eating disorders, and systematically compare these two populations, which Chapter 2: Study 2 attempted to address. The results of Chapter 2: Study 2 showed that populations with indicated eating disorders yielded large, significantly higher exercise addiction prevalence rates than participants with no indicated eating disorders, with an odds ratio of 3.7. Although this difference was stark, it was not altogether unsurprising. Indeed, both the World Health Organisation (2018) and the American Psychiatric Association (2013) explicitly state that 'excessive exercise' is part of the diagnostic criteria for both anorexia nervosa and bulimia nervosa, mainly due to the effect of exercise at burning energy - people with eating disorders see exercise as a means to burn calories, in turn making them thinner (Abraham, 2016). Of the existing literature reviews that had explored exercise addiction prior to the study being conducted (and subsequently published), only two have reported exercise addiction in the context of an eating disorder, with both (narrative) reviews briefly describing the studies conducted in the early 1980s that compared eating disorder patients and obligatory runners (see Chapter 1: Section 1.3) (Cockerill and Riddington, 1996; Allegre et al., 2006). Both of these reviews are purely descriptive, and do not provide any critique or discussion of exercise addiction in the context of eating disorders apart from describing previous studies.

To date, two systematic reviews have examined exercise addiction and eating behaviours after Study 2 was conducted and subsequently published (see Chapter 8). Indeed, the published version of Study 2 is cited in both studies. In the first, Alcaraz-Ibane et al (2020) examine eating disorders in the domain of morbid exercise behaviour - essentially expanding the inclusion criteria from Study 2 to include a more broad range of morbid exercise behaviours - rather than just exercise addiction as a dichotomy. Although the results from the Chapter 2: Study 2 are not directly comparable due to differing methodologies and effect size reporting, their results are broadly in agreement with the results from Chapter 2: Study 2 - they found negative associations between several types of eating disorder behaviours and morbid exercise behaviours. Furthermore, when discussing their results, the proposed reasons and mechanisms were very similar to Chapter 2: Study 2. In the other systematic review conducted after the publication of Chapter 2: Study 2, Strahler and colleagues (2021) found that exercise addiction was positively correlated with orthorexia nervosa - a condition which can be defined as the obsession with the

consumption of healthy foods (Simpson and Mazzeo, 2017). Although orthorexia nervosa is not a recognised eating disorder by either the American Psychiatric Association (2013) or the WHO (2018) (this is the primary reason why it was not considered or included in this thesis thus-far), all of these studies suggest similar things: that exercise addiction is correlated with potentially morbid eating behvaiours.

To the author's knowledge, **Chapter 2: Study 2 was the first study to systematically review and examine exercise addiction prevalence in populations with vs without indicated eating disorders**, and thus providing a novel contribution to the literature. Furthermore, the subsequent published version of this paper has been cited several times (see Chapter 8), including in two subsequent systematic reviews and meta-analyses, indicating that **this body of research has already been used to further discussion in the field**.

5.3 Aetiological differences in exercise addiction, eating disorders and body dysmorphic disorder.

Chapter 3: Study 1 aimed to examine if there were aetiological differences in exercise addiction according to eating disorder status. This was examined in the form of a large, cross-sectional survey on health club users. The correlates that were measured across eating disorder groups were exercise addiction, reasons for exercise, social media use, body dysmorphic disorder (BDD), as well as several pieces of demographic information. The key findings were that there were indeed significant differences between several correlates when stratified by eating disorder status, including large differences in exercise addiction prevalence (indicated eating disorders 60.2%; no indicated eating disorders 24.7%). Furthermore, BMI, the use of social media for social integration and emotional connection and ethnicity (white vs black, Hispanic and Asian) were only positively associated with higher exercise addiction scores in people with indicated eating disorders. Fitness instructor status, exercising to improve mood, attractiveness, exercising for enjoyment, and BDD status were only associated with higher exercise addiction scores among health club users without an indicated eating disorder. Moreover, this study found significant interaction effects between eating disorder status and exercising to improve mood; exercising for attractiveness; BMI; and ethnicity. To date, this is the **only study to explore differences in correlates stratified between eating disorder status, and provides direct evidence of significant differences between the two populations, indicating that exercise addiction shares different characteristics across different eating disorder populations**, indicating a novel contribution to the literature. Furthermore, it recommends stratifying between eating disorder populations in future research, so that

a. Future research can understand in more detail the differences between the two populations.
b. People with indicated eating disorders can be referred to the relevant clinical practitioner for treatment.

Chapter 3: Study 2 explored exercise addiction, BDD, and eating disorder symptoms in a unique situation: lockdowns arising as a result of the COVID-19 pandemic, using a longitudinal study design using participants from Chapter 3: Study 1 who indicated consent to be contacted for a possible follow-up study. After a post-hoc Bonferroni correction, both exercise addiction and BDD status were unchanged following the first COVID-19 lockdown. Eating disorder symptoms (as measured on a continuous scale), significantly increased, indicating more pathological eating behaviours as a result of an enforced period of

confinement. This was the **first (and to date, the only) study to measure exercise addiction and BDD changes during the COVID-19 pandemic**, and although these results contradict others who had hypothesised decreases in exercise addiction symptoms (Lim, 2020), and increases in BDD (Anxiety and Depression Association of America, 2020), **these were the first reported empirical data on these topics**. Regarding eating disorder symptoms, the results from Chapter 3: Study 2 were in agreement with other studies that had measured changed in eating disorder symptoms in clinical populations (Fernández-Aranda et al., 2020).

The results from this study not only **provide a unique contribution to the literature** (both in terms of exercise addiction and the mental health consequences of the COVID-19 pandemic in general), but also provides evidence of possible targeted interventions should another lockdown (or another pandemic) require enforced quarantines.

5.4 The Secondary Exercise Addiction Scale

5.4.1 Scale development best practice

Chapters 2 and 3 of this thesis provide evidence that exercise addiction is different in populations with vs without eating disorders, suggesting differing aetiologies for primary and secondary exercise addiction. This evidence also provides some justification for the development and validation of a new screening tool that is able to differentiate between potential primary and secondary exercise addiction: The Secondary Exercise Addiction Scale (SEAS). Chapter 4 described the development and validation of the SEAS in several stages:

a. Initial question development and subsequent item reduction
b. Confirmatory factor analysis
c. Internal reliability
d. Concurrent reliability against existing short and long form questionnaires
e. Test-retest reliability

When comparing these stages to the two most frequently used exercise addiction questionnaires (the Exercise Addiction Inventory and the Exercise Dependence Scale) - **the development of the SEAS has arguably been more rigorous at every stage** and conforms with reported scale development best practice (DeVellis, 2016). For example, the Exercise Addiction Inventory (EAI: Terry, Szabo and Griffiths, 2004) does not appear to have item-reduction as a method of determining which questions were to be included, and also does not appear to have a confirmatory factor analysis either, bringing into question it's latent structure reliability. Furthermore, the cut off scores that were suggested by the authors do not appear to have any statistical support, despite the authors comparing the results of their tool to other existing tools. Regarding the Exercise Dependence Scale (EDS: Hausenblas and Symons Downs, 2002b), the development was similar to the development of the SEAS, apart from the confirmatory factor analysis, which was not conducted in the development of the EDS, which, like the EAI, questions the robustness of the underlying latent structure.

5.4.2 Practical applications of the SEAS

The SEAS's most novel property is its ability to stratify between potential primary and secondary exercise addiction in only 11 questions, and its simple scoring system. Unlike other existing tools, **this is the first exercise addiction measurement tool to be able to stratify between these populations,** and has several potential applications, including:

a. To enable researchers to consistently screen for potential eating disorders in exercise addiction research.
b. To enable practitioners to screen for exercise addiction and eating disorders.

This thesis has provided evidence that exercise addiction is different depending on whether participants have indicated or no indicated eating disorders and should be considered as two separate populations when assessing correlates or aetiology. The creation of the SEAS allows researchers to quickly and easily screen participants and sub-group them accordingly. It is worth noting that because there is no direct evidence (and no clinical diagnostic criteria) of exercise addiction existing as a dichotomy, this author believes that it is prudent to consider exercise addiction as part of a continuum, as per the recommendations from Freimuth and colleagues (2011). The SEAS, therefore, is recommended to be used as a sub-grouping tool, and in any resulting correlational analyses exercise addiction should be considered as a continuous variable.

c. In practice as a tool to identify people with potential eating disorders

The SEAS has the potential to be used in practice for the identification of people with potential eating disorders. Because evidence has shown that exercise is a key component in the diagnoses and development of eating disorders (Abraham, 2016; World Health Organization, 2018; American Psychiatric Association, 2013), and the eating disorders section of the SEAS is based on clinical diagnostic criteria for eating disorders, the SEAS could be used in a variety of settings. For example, if a patient was presenting in a clinical setting with overuse injuries (such as stress fractures), the SEAS could be quickly administered to determine if the patient were demonstrating pathological eating behaviours and be referred for treatment before the pathological eating behaviours manifest into a diagnosable eating disorder. Another example of a practical use for the SEAS could be in fitness centres: it has been reported that the majority fitness instructors are unsure what to do or say if their clients demonstrate potential disturbed eating behaviours (Colledge et al., 2020). In this situation the SEAS could be administered as part of a routine meeting with a

client, with a referral to a doctor recommended if the client showed potential secondary exercise addiction.

5.5 Limitations and recommendations for future directions of research

This thesis has provided novel contributions to the literature regarding exercise addiction and its relationship to eating disorders. While the limitations have been discussed in each chapter, there are several common limitations to be discussed. Furthermore, this thesis raises several questions which have led to several recommendations for future research, which are discussed in this section.

5.5.1 The exercise addiction dichotomy problem

One of the key limitations of exercise addiction research in general (and by extension this thesis) is the assumption that exercise addiction is a diagnosable problem at all. Currently, all attempts as exercise addiction classification are based on the assumption that exercise addiction leads to significant decreases in quality of life and thus, is a problem. Although this assumption is supported by a handful of case-studies (Griffiths, 1997; Warner and Griffiths, 2006), more are needed to conclusively refute or support the hypothesis that exercise addiction is a real problem that requires attention. Furthermore, because there are no clinical diagnostic criteria for exercise addiction, the majority of tools that have been developed to classify people as ‘at risk’ of exercise addiction are based on educated guesses. The author has tried to address this with the SEAS by suggesting that the exercise addiction section of the tool be used as a continuous variable in research, and used as a tool to indicate suspected secondary exercise addiction where the eating disorder is the primary cause for concern.

To provide more evidence that exercise addiction does indeed cause a large reduction in quality of life, and to provide more evidence on the potentially dichotomous nature of exercise addiction, qualitative investigation is warranted to explore to what extent scoring above a quantitative threshold on an exercise addiction measurement tool decreases quality of life, and what symptoms participants are experiencing and to what extent - something that is difficult to do with purely quantitative methods.

5.5.2 Limitations of addiction theory

One key limitation of the components of general addiction as proposed by Brown (1993) and modified by Griffiths (1995) is the high level of subjectivity in one of the criteria: the presence of conflict as a result of the addiction. Conflicts that arise as a result of excessive exercise require two parties, meaning that the temperament of the other party needs to be considered as a moderating factor. For example, an avid exerciser may go the gym five times a week with no conflicts arising from this behaviour, and thus score low on this part the SEAS questionnaire. However, the same person may then develop a relationship with a new partner who dislikes the exerciser's exercise pattern, thus potentially creating several conflicts with the exerciser. In this scenario the exerciser would score highly on the conflict section of the SEAS, yet in both of these scenarios the only variable to change is the inclusion of a new partner, meaning that the results of this part components of general addiction could be highly sensitive to external moderators. Indeed, in this scenario conflict may be more of a correlate of exercise addiction than a domain of the condition itself. There is the possibility that internal conflict is a more appropriate domain of exercise addiction. Further research into this is highly recommended to determine the (a) extent of external moderating factors (such as external conflict) correlate with exercise addition, and (b) to examine whether internal conflict should replace 'conflict' in the general model of behavioural addictions, and in the aetiological conceptualisations of exercise addiction.

5.5.3 Device-based versus subjective measures of physical activity and exercise

Another limitation of many correlates measured across the studies in this thesis was that they were subjectively measured via questionnaire. It has been widely reported that subjective measures are less accurate than device-based measurements. For example, several studies have shown that people over-estimate physical activity and sedentary behaviour when compared to device-based measured physical activity and sedentary behaviour via an accelerometer (Hangstromer et al., 2010; Vanhees et al. 2005). Future studies should aim to use device-based measures where possible to confirm for refute the results presented in this thesis.

5.5.4 Exercise addiction treatment

Limited research has been conducted exploring possible treatments for exercise addiction. One notable addition is the recommendations of Adams, Miller and Kraus (2003), who suggested that treatment for exercise addiction should incorporate the following:

a. ‘Accepting the role and responsibility of primary support for the person and participant in the management process’.
b. ‘Recognize that the addiction is likely to cause a breakdown in communication with significant others.’
c. ‘Recognize that the likely response is intense fear of losing control, helplessness, and that this may show itself through disorganized behaviour through compulsions.’
d. ‘Psychotherapeutic intervention utilized individualized approaches depending on the psychopathology noted in the patient.’

(Adams, Miller and Kraus, 2003, p 103)

Adams and colleagues also suggested that behavioural therapy should be a mode of treatment. Although these guidelines have been criticised as being ‘sparse’ and void of detail (Lichtenstein et al., 2017) - they are the only published guidance available for the treatment of exercise addiction. One alternative treatment has been piloted in a case study, with the patient showing lower EAI scores post-4 weeks of taking an anti-psychotic drug (Quetiapine)(Di Nicola et al., 2010). The effectiveness of cognitive behavioural treatments, however, have been shown to be limited (Weinstein and Weinstein, 2014), suggesting that more research into potential treatments for exercise addiction should be considered. It is worth noting that due to the higher rates of serious injury and mortality amongst eating disorder patients, treatment for any potential eating disorders should be prioritised over treatment specifically for exercise addiction, although further research is required to explore the relationships between the two so that effective treatments can be refined and/or developed.

5.5.5 Qualitative research

The aims of this thesis were to examine differences between the prevalence of exercise addiction across different tools, prevalence across primary and secondary exercise addiction, and compare differences in correlates in primary and secondary exercise addiction. Furthermore, this thesis described the creation and validation of a new tool, the SEAS. In all these aims, a quantitative approach was the most appropriate to answer the research questions, however future research should aim to utilise either a qualitative or mixed methods approach. Currently there are relatively few studies that aim to explore people's subjective experiences of experiencing exercise addiction symptoms; indeed the majority of studies utilise a quantitative approach. The addition of qualitative research has the potential to add a richness to the literature and inform (for example, via thematic analyses) practitioners, and inform future research. Furthermore, the use of quantitative research methods could be applied when assessing the usefulness of the newly created SEAS. For example, the use of semi-structured interviews with practitioners could give useful insights into the applicability and practicality of the SEAS in practice.

5.6 Conclusion

This thesis has presented a novel contribution to the literature in several areas relating to exercise addiction and its relationship with eating disorders (see Table 5.1 for key take-home messages). Firstly, it was shown that exercise addiction exists in the absence of eating disorders, and that exercise addiction prevalence differs according to the tool used to measure exercise addiction risk. This finding was confirmed in a second review, which also showed that exercise addiction prevalence is significantly higher in people with indicated eating disorders vs people with no evidence of an eating disorder, yielding an odds ratio of 3.7. Thirdly, this thesis showed, through a large primary study of health club users, that correlates of exercise addiction, including exercise motivations and body dysmorphic disorder, are significantly different in populations with vs without indicated eating disorders. Lastly, this thesis described the creation and validation of a novel screening tool that is able to stratify between potential primary and secondary exercise addiction.

Table 5.1: Key implications of this thesis

1	Exercise addiction prevalence significantly differs according to eating disorder status
2	Correlates of exercise addiction differ according to eating disorder status
3	Exercise addiction status did not appear to change during the COVID-19 lockdown
4	The Secondary Exercise Addiction Scale appears to be a valid tool for determining possible primary and secondary exercise addiction

Chapter 6: Reflection

6.1 Introduction

Reflective practice is one of the key ways in which a researcher can improve research practice (Jasper, 2005). Including the mini studies in Chapter 4, there were eight studies included in this thesis, spanning 3.5 years of research. This Chapter will describe a reflective account of some key events that occurred during this PhD, using the components of reflection proposed by Gibbs (1988). Although these events do not convey the entire number of potentially reflective moments during the PhD process, they have been selected because I feel they are the events that taught me the most as an early career researcher.

6.2 Chapter 2

6.2.1 Description

Chapter 2 of this thesis involved two systematic reviews and meta-analyses, which took approximately one year. There are two things I remember vividly about the process of these two reviews which will be reflected on: the process of literature searching and the meta-analytic process. The process of literature searching, and data extraction was a start-stop process, and I had to re-do the searches several times until everything was reproducible. The meta-analytic process involved me having to re-run the meta-analysis in the second review as I had incorrectly started to compare people with versus without exercise addiction in different populations, which would have introduced major population bias.

6.2.2 Feelings

This was a strange time in my PhD as I was just starting and remembering feeling anxious that I did not know (a) what to do, and (b) how to do it. As I was working full time and studying part time, I was also worried about time management, as at the time my wife was pregnant, and I had to also support her. Regarding having to re-run the literature search, this was initially frustrating, as at the time I thought that I had done everything correctly. Regarding having to re0run the meta-analysis, the initial feelings were that of imposter syndrome – that I should have already known about population bias and that I was not ‘up for’ the task of completing a PhD – either from a work ethic and an intellectual point of view. As time went on, however, all of these feelings subsided, and a feeling of relief was more prominent – relief that I had gone through these events so early in my research career and that I had learnt from them.

6.2.3 Evaluation and analysis

The process of having to restart the literature review was because I was not thorough enough in the original searches and was not meticulous enough in recording every detail about every step of the process. The process of having to repeat the meta-analysis was because I simply did not know enough at the time. This evaluation of the experience, however, was not all negative. Indeed, I was still able to complete two major pieces of work in a year, despite the setbacks and other challenges, which I take as a positive. Further, both projects were eventually published in the peer reviewed literature, with the latter study gaining media exposure.

6.2.4 Conclusion and action plan

It is likely that I would have been quicker in my work had these events not occurred, although I also believe that it was (at least partly) necessary to go through these experiences so that I could learn from them. In future projects I plan to be (and have been) much more meticulous in my planning and documentation of systematic reviews. Furthermore, because the feedback regarding the re-running of the second meta-analysis was because of a colleague's suggestion, I now actively try and get as much peer feedback as possible before completing a project and sending it off for peer review.

6.3 Chapter 3

6.3.1 Description

Chapter 3 of this thesis involved two primary studies and lasted for approximately 1.5 years. The reflection component will consist of one key event, which at the time I did not consider to be a key event, but as time as gone on, I now consider it vital. During the data collection stage of the first study in Chapter 3, I asked social media influencers to help me with my data collection, predominately because they had both approached me because they were interested in the study and wanted to help. They were both females who had previously suffered from eating disorders. The help of these two influencers helped me get several more participants than was expected. When analysing and reflecting on the data, however, I realised that this method of recruiting participants was likely to introduce several sample biases, which I had not considered at the time.

6.3.2 Feelings

Before the events of Chapter 3, I felt a sense that I 'needed' to recruit as many participants as possible, which I think contributed to me not considering the large sampling bias I was introducing into my dataset when accepting the help of these social media influencers. This feeling of 'needing' to recruit as many participants as possible likely came from a sense that good research studies always have lots of participants, and the (incorrect) assumption that there is a linear relationship between sample size and quality of research. This is likely due to seminal studies that have population level data being regularly cited. Furthermore, there was an element of lack of experience as well – that I did not know to what magnitude these social media influencers could attract participants. During the event the feelings were of elation – hundreds of participants were completing the survey which to me (at the time) was a fantastic result. It was only after months of making sense of the data I started to feel that the data might not be representative. This never made me worried per se, however, because even though the dataset influenced by sampling bias is a valuable, just less generalisable.

6.3.3 Evaluation and analysis

I feel that the events in Chapter 3 were quite simple – I did not understand the impact (and the magnitude of that impact) that accepting these offers of help would yield. Further, on reflection, there is another reason why this event happened. Because of my history as an international fitness presenter, the only way I knew how to recruit participants was to use my immediate network, which at the time coincidently included several social media influencers. It was also 'the easier way' because I had an expansive network as part of my role. Previously, I had noticed that lots of my network had posted surveys through their social

media channels, which normalised this method of recruitment for me. What I was unaware of, however, was the bias that this would automatically introduce.

6.3.4 Conclusion and action plan

I now have a much better understanding of the potential influence of certain methods of recruitment on the generalisability of the results. This has led me to be much more specific when writing research protocols and much more mindful about how data is collected. On a wider level, I also have a deeper appreciation that there is no one perfect way to collect data – every dataset is going to be subject to bias of some sort. The key thing is how I deal with the data and what inferences are made as a result of discussing said data. I also realise how difficult it is to get a truly representative sample!

6.4 Chapter 4

6.4.1 Description

Chapter 4 of this thesis comprised of four mini studies that validated the SEAS, which lasted for approximately one year. The key event was at the beginning of the process when developing the initial set of questions. Although the process was robust, there was a stage that could have been added to make this stage of the process even more thorough – the addition of more questions in the initial pool of items, and the addition of insights from people with lived experience of exercise addiction and eating disorders. This would have added more data on people's lived experience of exercise addiction (which is lacking in the literature generally and would have informed the way in which some of the initial pool of questions could have been phrased. Further, because the team that I consulted as part of the initial scale development and I had not had a history of exercise addiction and/or eating disorders, it was difficult to imagine what it must feel like, and therefore how to phrase the questions to yield the best result.

6.4.2 Feelings

The process of planning for Chapter 4 I felt was the most meticulous of the entire thesis, so at this point I was feeling confident of how a new scale should be created and validated. Like in Chapter 3, it was not until after all four mini studies of Chapter 4 had been completed that I considered a qualitative approach might be appropriate (asking people with exercise addiction and eating disorders about their experiences). There was a feeling of regret that I hadn't considered this at an earlier stage. It is likely that my previous experiences of being a quantitative researcher was one of the key reasons why a qualitative approach had not been considered. Indeed, in my BSc and MSc courses I had never conducted any qualitative research and had only studied it briefly in my previous education. Therefore, with a very large skew in my training and experience towards quantitative research, I leaned towards a quantitative approach.

6.4.3 Evaluation and analysis

The events in Chapter 4 were due to ignorance – which is something that is quite hard to write down! The problem was being not well-read per se, it was not being expansively read. I had extensively researched the methods that previous exercise addition scales had been subjected to, and only one had included qualitative data collection of people with lived experiences of exercise addiction. Because my reading was limited to exercise addiction scale development, I had not considered what best practice looked like on a wider scale.

6.4.4 Conclusion and action plan

I now have a much more thorough understanding of scale development, which will help me in future studies. The next scale development study I am part of will be informed by this and using qualitative work to inform scale development is certainly something that will be considered at an early stage. Like Chapter 3, I also now a deeper appreciation that there is no perfect way to approach and conduct a scale development project. My project was not a bad project, and the methods used were not wrong. The appreciation is that there are other methods that could have been used, and these need to be fully considered in the process of project planning.

6.5 Overall conclusion

There are several ways in which I have changed as a researcher during the process of this thesis. I feel that the most profound change is the way in which I consider the value of qualitative research. Historically I always had an indifference to qualitative research, but now I appreciate more how valuable and rich a dataset gathered through qualitative methods can be. I now appreciate that this is especially true in a phenomena like exercise addiction, that has a paucity of qualitative studies, case studies, and no official recognition as a disorder. I now understand that to fully understand something like exercise addiction, a qualitative approach must be seriously considered. Interestingly, this has also changed the way I conduct research as part of my job at Anglia Ruskin University – I am now more open to mixed method designs and have recently submitted a small grant bid to include interviewing participants in a semi-structured interview as part of a research project. Indeed, I feel like a better rounded researcher at the end of this PhD process.

Finally, I have an understanding that this is not the end of my learning – indeed this is the very beginning. I cannot wait to see what my research future holds, and look forward to being open to new ideas, criticism, and creating lots of new knowledge.

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8. Outputs

8.1 Published articles resulting from this thesis

a) **Trott, M.,** Johnstone, J., Firth, J., Grabovac, I., Smith, L. 2020 Prevalence and correlates of body dysmorphic disorder in health club users in the presence vs absence of eating disorder symptomology. *Eating and Weight Disorders.* https://doi.org/10.1007/s40519-020-01018-y

b) **Trott M;** Yang, L; Jackson, S; Firth, J; Gillvray, C; Stubbs, B; Smith, L. 2020. Prevalence and correlates of exercise addiction in the presence vs absence of indicated eating disorders. *Frontiers in Sport and Active Living*. https://doi.org/10.3389/fspor.2020.00084

c) **Trott, M**; Jackson, S; Firth, J; Fisher, A; Johnstone, J; Mistry, A; Stubbs, Smith, L. 2020. Exercise addiction prevalence and correlates in the absence of eating disorder symptomology. A systematic review and meta-analysis. *Journal of Addiction Medicine.* DOI: 10.1097/ADM.0000000000000664

d) **Trott M**., Jackson, S., Firth, J., Jacob, L., Grabovac, I., Mistry, A., Stubbs, B., Smith, L., 2020. A comparative meta-analysis of the prevalence of exercise addiction in adults with and without disordered eating. *Eating and Weight Disorders.* DOI: https://doi.org/10.1007/s40519-019-00842-1

e) **Trott M**., Johnstone, J., Pardhan, S., Barnett, Y., Smith, L. 2021. Changes in body dysmorphic disorder, eating disorder, and exercise addiction symptomology during the COVID-19 pandemic: A longitudinal study of 319 health club users. *Psychiatry Research*. DOI: https://doi.org/10.1016/j.psychres.2021.113831

f) **Trott, M**., Johnstone, J., McDermott, D.T., Mistry, A. and Smith, L., 2021. The development and validation of the secondary exercise addiction scale. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*. https://doi.org/10.1007/s40519-021-01284-4

Article c) has been cited in (*excluding self-citations*):

- Colledge, F., Sattler, I., Schilling, H., Gerber, M., Pühse, U. and Walter, M., 2020. Mental disorders in individuals at risk for exercise addiction–a systematic review. *Addictive Behaviors Reports*, p.100314.

Article d) has been cited in (*excluding self-citations*):

- Alcaraz-Ibáñez, M., Paterna, A., Sicilia, Á. and Griffiths, M.D., 2020. Morbid exercise behaviour and eating disorders: A meta-analysis. Journal of Behavioral Addictions, 9(2), pp.206-224.

- Colledge F, Walter M (2020). Bewegungssucht – aktuelle Studien und neue Forschungsrichtungen. *Suchtmedizin* 22(3): 99-104

- de la Vega, R., Almendros, L.J., Barquín, R.R., Boros, S., Demetrovics, Z. and Szabo, A., 2020. Exercise Addiction During the COVID-19 Pandemic: an International Study Confirming the Need for Considering Passion and Perfectionism. *International Journal of Mental Health and Addiction*, pp.1-12.

- Hambleton, A., Le Grange, D., Miskovic-Wheatly, J., Touyz, S., Maguire, S. Translating evidence-based treatment for digital health delivery: A protocol for family-based treatment for anorexia nervosa using telemedicine. *Journal of Eating Disorders.* 8(1)

- Godoy-Izquierdo, D., Ramírez, M.J., Díaz, I. and López-Mora, C., 2021. A systematic review on exercise addiction and the disordered eating-eating disorders continuum in the competitive sport context. *International Journal of Mental Health and Addiction*, pp.1-33.

- Godoy-Izquierdo, D., Navarrón, E., López-Mora, C. and González-Hernández, J., 2021. Exercise Addiction in the Sports Context: What Is Known and What Is Yet to Be Known. *International Journal of Mental Health and Addiction*, pp.1-18.

- Gori, A., Topino, E. and Griffiths, M.D., 2021. Protective and Risk Factors in Exercise Addiction: A Series of Moderated Mediation Analyses. *International Journal of Environmental Research and Public Health*, *18*(18), p.9706.

- Leme, A.C.B., Haines, J., Tang, L., Dunker, K.L., Philippi, S.T., Fisberg, M., Ferrari, G.L. and Fisberg, R.M., 2020. Impact of Strategies for Preventing Obesity and Risk Factors for Eating Disorders among Adolescents: A Systematic Review. *Nutrients*, 12(10), p.3134.

- Lim M. 2020 Exercise addiction and COVID-19-associated restrictions. *Journal of Mental Health*. DOI: 10.1080/09638237.2020.1803234.

- Martenstyn, J., Touyz., S., Maguire, S. 2021 Treatment of compulsive exercise in eating disorders and muscle dysmorphia: protocol for a systematic review. *Journal of Eating Disorders* 9 (1)

- Strahler, J., Wachten, H., Muller-Alcazar, A. 2021 Obsessive healthy eating and orthorexic eating tendencies in sport and exercise contexts: A systematic review and meta-analysis. *Journal of Behavioural Addictions.* DOI:10.1556/2006.2021.00004

8.2 Oral presentation resulting from this thesis

- **Trott, M**., Johnstone, J., McDermott, D.T., Mistry, A. and Smith, L.. The development and validation of the secondary exercise addiction scale. Conference presentation at: Society of the Study of Addiction (SSA) PhD Symposium. 2021. November 03; Online.

- **Trott M**., Johnstone J., Pardhan, S., Barnett, Y., Smith, L. 2021. Changes in body dysmorphic, eating disorder, and exercise addiction symptomology during the COVID-19 pandemic: a longitudinal study. Conference presentation at: Faculty of Health and Medical Sciences Annual Conference: 2021 March 03; Cambridge, UK.

- **Trott M**; Stubbs, B., Smith, L., 2019. Exercise addiction prevalence in the absence of eating disorder symptomology. A systematic review and meta-analysis. *Journal of Sports Sciences,* 37(sup1), pp1-93. Conference presentation at: The British Association of Sport and Exercise Sciences Annual Conference: 2019 Nov 08; Leicester, UK.

8.3 Poster presentations resulting from this thesis

- **Trott M**; Stubbs, B., Smith, L., 2019. Exercise addiction prevalence in the absence of eating disorder symptomology. A systematic review and meta-analysis. Poster presented at: Psychology of Wellness. British Psychological Society East of England Branch Conference: 2019 Sept 12; Cambridge, UK.

8.4 Media articles resulting from this thesis

- Trott, M; Smith, L. 2020. Exercise addiction is a real mental health condition, yet still poorly understood. *The Conversation.* [online]. Available from https://theconversation.com/exercise-addiction-is-a-real-mental-health-condition-yet-still-poorly-understood-133577 (accessed 6th March 2021; see Appendix O for full text). As of 21 March 2021, this article has been viewed 20,715 times.

- Marsh, S. 2020. People with eating disorders likelier to get hooked on exercise. *The Guardian* [online]. Available from: https://www.theguardian.com/society/2020/jan/02/people-with-eating-disorders-likelier-to-get-hooked-on-exercise (accessed 31st March 2021).

- Ives, J. 2020. Exercise addiction more common among people with eating disorder. *News Medical Life Sciences* [online]. Available from: https://www.news-medical.net/news/20200128/Exercise-addiction-more-common-among-people-with-eating-disorder.aspx (accessed 31st March 2021).

- Trott, M. Smith, L. 2020. Are you addicted to exercise? *Raidio Teilifis Eireann (RTE)* [online]. Available from: https://www.rte.ie/brainstorm/2020/0722/1154840-exercise-addiction/ (accessed 31st March 2021).

- BBC Radio Cambridgeshire has interviewed the author several times about work contained in this thesis.

- Heart FM has interviewed the author several times about work contained in this thesis.

8.5 Published articles not relating to this thesis

a) Granziol, U., Zorzi, A., Cardaioli, F., Cipriani, A., D'Ascenzi, F., Firth, J., Stubbs, B., **Trott, M**. and Solmi, M., 2021. Exercise addiction in athletes: Comparing two assessment instruments and willingness to stop exercise after medical advice. *Psychological Assessment*.

b) Smith, L., Bloska, J., Jacob, L., Barnett, Y., Butler, L., **Trott, M**., Odell-Miller, H., Veronese, N., Kostev, K., Bettac, E.L. and Godier-McBard, L., 2021. Is loneliness associated with mild cognitive impairment in low-and middle-income countries?. *International journal of geriatric psychiatry*.

c) Stockwell, S; **Trott M** (joint first author); Tully, M; Shin, J; Barnett, Y; Butler, L; McDermott, D; Schuch, F; Smith, L. 2021 Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: A Systematic Review. *BMJ Sport and Exercise Medicine Open*.

d) Horne, J., Kentzer, N., Smith, L., **Trott, M**. and Vseteckova, J., 2021. A Systematic Review on the Prevalence of Physical Activity, and Barriers and Facilitators to Physical Activity, in Informal Carers in the United Kingdom. *Journal of Physical Activity and Health*, *18*(2), pp.212-218.

e) Pizzol, D; Foresta, C; Garolla, A; Demurtas, J; **Trott, M**; Bertoldo, A; Smith, L. 2020. Pollutants and sperm quality: a systematic review and meta-analysis. *Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-020-11589-z*

f) Pizzol, D., Dermurtas, J., Celotto, S., Maggi, S., Smith, L., Angiolelli, G., **Trott, M.,** Yang, L., Veronese, N. 2020 Urinary incontinence and quality of life: a systematic review and meta-analysis. *Aging Clin Exp Res. https://doi.org/10.1007/s40520-020-01712-y*

g) Vianya-Estopa, M., Wolffsohn, J., Beukes, E., **Trott, M**., Smith, L., Allen, P. 2020. Soft contact lens wearers' compliance during the COVID-19 pandemic. *Contact lens and anterior eye*. https://doi.org/10.1016/j.clae.2020.08.003

h) Jacob., L; **Trott, M;** Yakkundi, Y.; Butler, L; Barnett, Y; Armstrong, N; McDermott, D; Schuch, F; Meyer, J; Lopez-Bueno, R; Lopez Sanchez, G; Bradley, D; Tully, M; Smith, L; 2020 The association between screen time and mental health during COVID-19: a cross sectional study. *Psychiatry Research*

i) Arik, F; Soysal, P; Capar, E; Kalan, U; Smith, L; **Trott, M**; Isik, A. 2020. The association between fear of falling and orthostatic hypotension in older adults. *Aging Clinical and Experimental Research*. DOI: https://doi.org/10.1007/s40520-020-01584-2

j) Veronese, N; Demurtas, J; Yang, L; Tonelli, R; Barbagallo, M; Lopalco, P; Lagolio, E; Celotto, S; Pizzol, D; Zou, L; Tully, M; Llie, P; **Trott, M**; Lopez Sanchez, G; Smith, L. 2020. Use of Corticosteroids in Coronavirus Disease 2019 Pneumonia: A Systematic Review of the Literature. *Frontiers in Medicine.* DOI: https://doi.org/10.3389/fmed.2020.00170

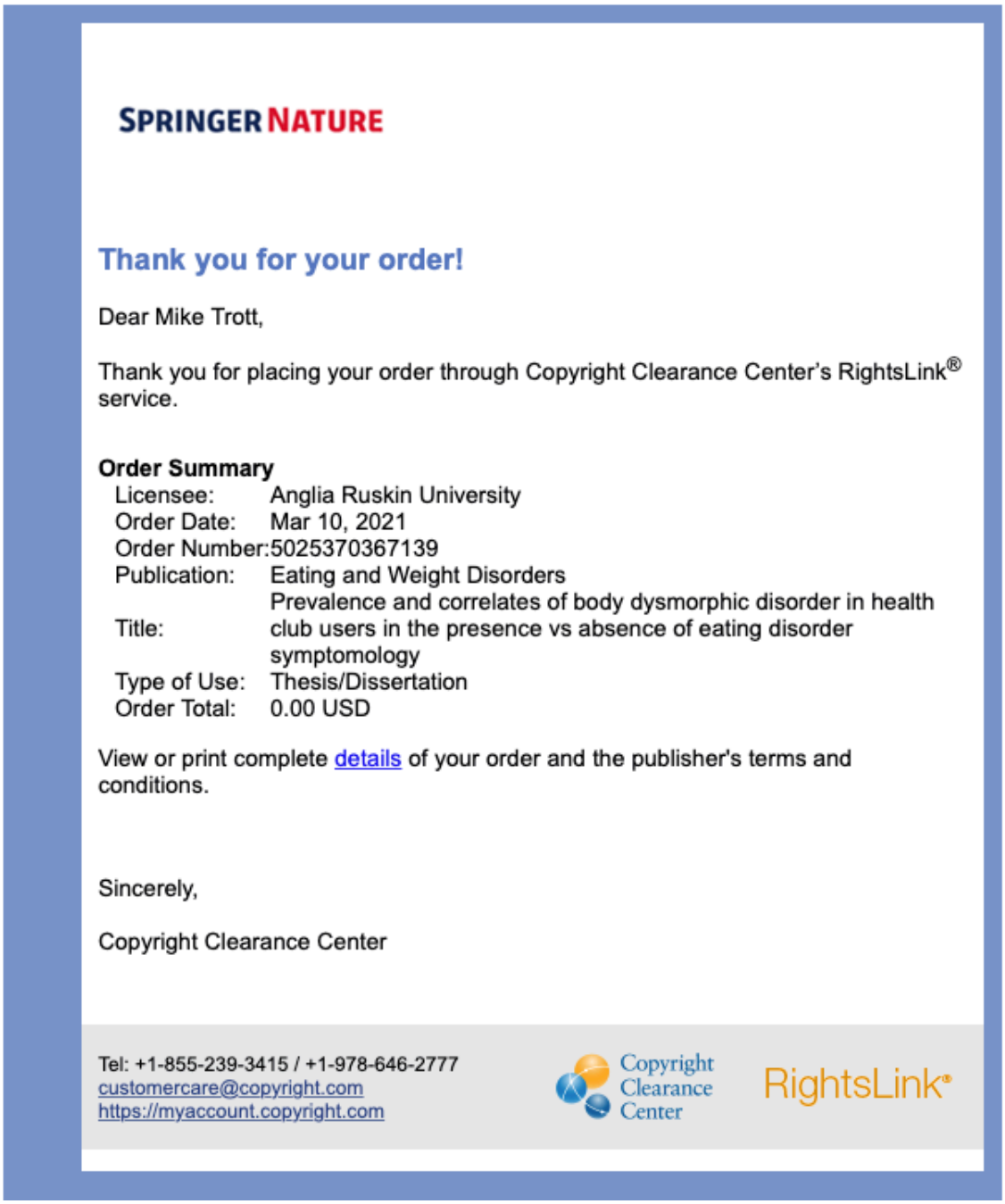
k) Lopez Sanchez, G., Pardhan, S., **Trott, M.,** Sánchez-Castillo., S; Jackson, S., Tully, M., Gorely, T., López-Bueno, R., Veronese, N., Skalska, M., Jastrzębska, J., Jastrzębski, Z., Smith, L., 2020. The association between physical activity and

cataracts among 17,777 adults residing in Spain. *Ophthalmic Epidemiology*. DOI: https://doi.org/10.1080/09286586.2020.1730911

l) Lopez Sanchez, G., **Trott, M.,** Sánchez-Castillo., S; Jackson, S., Tully, M., Gorely, T., López-Bueno, R., Veronese, N., Skalska, M., Jastrzębska, J., Jastrzębski, Z., Smith, L., 2019 The association between physical activity and cataract among 1711 older adults residing in Spain. *European Geriatric Medicine.* 10 (1) pp162.

8 Appendices

Appendix A: Copyright permission for paper entitled ‘Prevalence and correlates of body dysmorphic disorder in health club users in the presence vs absence of eating disorder symptomology’



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Title:	Prevalence and correlates of body dysmorphic disorder in health club users in the presence vs absence of eating disorder symptomology
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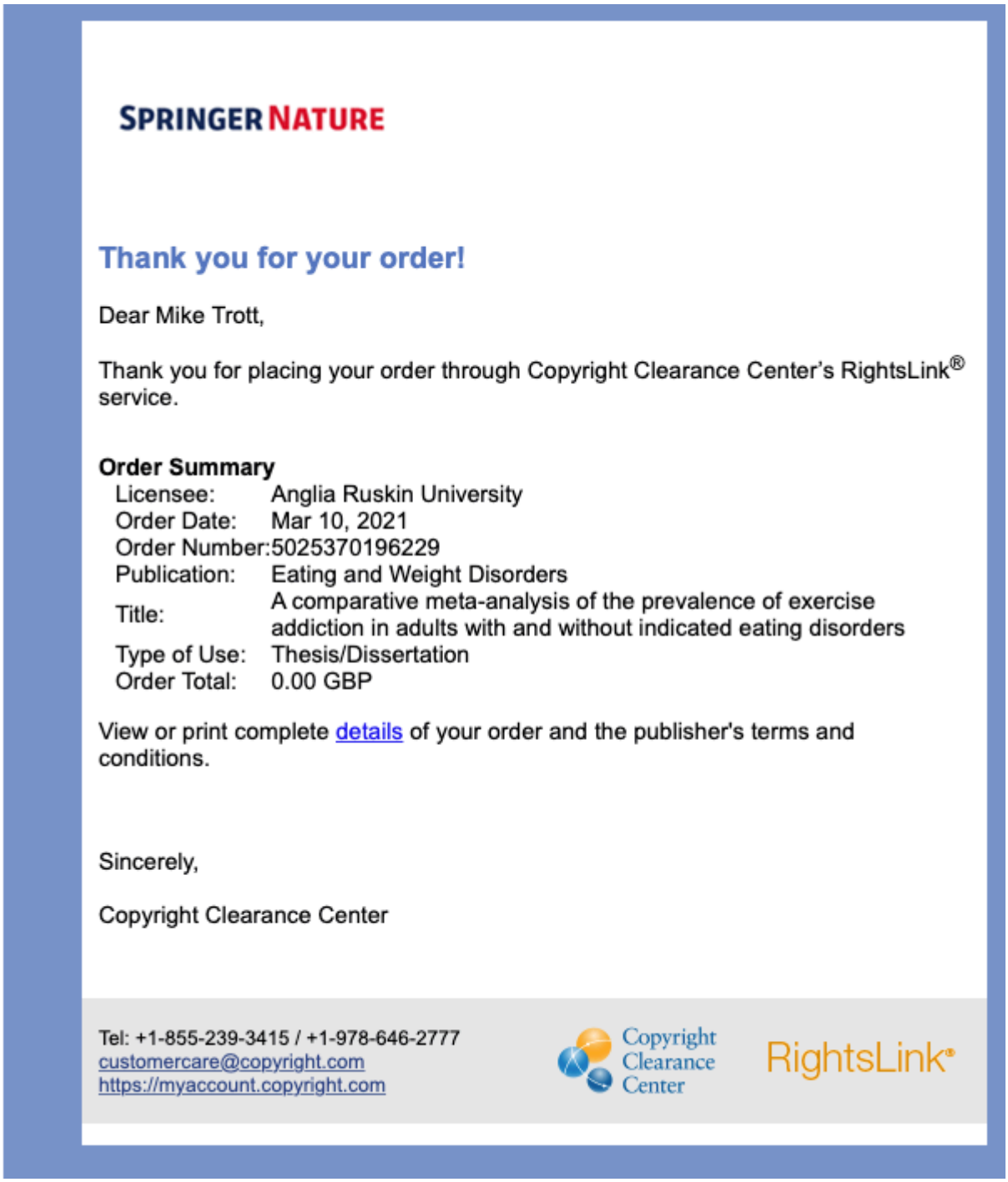

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Appendix E: The Newcastle-Ottowa Scale for cross-sectional studies

Sample selection Criteria (6 stars)																			
1) Representativeness of the sample: a) Truly representative of the average in the population** (all subjects or random sampling); b) Somewhat representative of the average in the target population* (non-random sampling); c) Selected group of subjects; d) No description of the sampling strategy																			
2) Sample size: a) Justified and satisfactory*; b) Not justified.																			
3) Non-respondents: a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory*; b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory; c) No description of the response rate or the characteristics of the responders and the non-responders.																			
4) Ascertainment of the exposure: a) Validated measurement tool **; b) Non-validated measurement tool but the tool is available or described*; c) No description of the measurement tool.																			
Comparability (4 stars)																			
1) Comparison group: a) Described by authors as separate from exposure (i.e. different community/location)*; b) Described by authors as community exposure within the same location*; c) No comparison group.																			
2) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled: a) The study controls for the most important factor (select one)*; b) The study controls for any additional factor *.																			

Outcome (1 star)																			
2) Statistical test: a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value)*; b) The statistical test is not appropriate, not described, or incomplete.																			
Total (11 stars)																			

Appendix F: Survey questions for Chapter 3: Study 1

p. 1 **Information and consent**

Add item

1 My name is Mike Trott and I am currently studying my PhD in Sports and Exercise Science at Anglia Ruskin University in Cambridge, currently performing a research project for the second year of my PhD. I am organising this research and am supervised by Dr Lee Smith, Dr Brendon Stubbs and Dr James Johnstone. My research is an assessment of exercise dependence in fitness instructors and health club users, and should take less than 10 minutes to complete. This will also add to the current body of knowledge around this topic and could also help to prove/refute a common conceptualization of exercise dependence. You have been invited to take part in this study as you meet the following criteria: - You are either a health club user or an exercise instructor. - You are over 18. Taking part is completely optional, you should only agree to take part if you are happy to do so. If you agree to take part, you must read the information carefully and answer all questions to the best of your ability. All questions must be answered in order to compete the survey. There are no risks or precautions to be taken when participating in this study. If you have any questions please feel free to contact me via email(1). All information collected from you during your participation in this research will be anonymised. The information will not be incorrectly distributed in any way. The final report will include your data – but it will not be possible to identify you from the data. (1) mike.trott@pgr.anglia.ac.uk I agree to take part in this study, I have read the information above. I understand what my role will be in this research, and all my questions have been answered to my satisfaction. I have been informed that the confidentiality of the information I provide will be safeguarded. I am free to ask any questions at any time before and during the study. By consenting to take part in this research you have not compromised your statutory legal rights. All information from your participation in this research will be collected and stored in accordance with the General Data Protection Regulation (GDPR, 2016) . Data Protection: I agree to the University (Anglia Ruskin University and its partner colleges) processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me. Once you have consented, information from completed and submitted surveys cannot be withdrawn. I give my consent to participate in this study *

Yes

No

Add item

Add item

p. 2

Add item

2 What is your age?

Add item

Add item

3 What is your sex?

Male

Female

Add item

Add item

4 How would you define your sexuality?

Heterosexual

Homosexual

Bisexual

Show all (4)

Add item

Add item

5 What is your current relationship status?

Single

In a relationship

Married

Show all (5)

Add item

Add item

6 What is your height (in cm)?

Add item

Add item

5 What is your current relationship status?

Single

In a relationship

Married

Show all (5)

Add item

Add item

6 What is your height (in cm)?

Add item

Add item

7 What is your weight (in kg)?

Add item

Add item

8 Which country do you currently reside?

Add item

Add item

9 Do you have a life-limiting illness? (illnesses where it is expected that death will be a direct consequence of the specified illness. Such illnesses may include, but are not limited to: cancer. heart disease. chronic obstructive pulmonary disease.)

Yes

No

Add item

Add item

10 Are you an exercise instructor?

Yes

No

Add item

Add item

p. 5

Add item

16 Please answer the following questions

	Strongly disagree	Disagree	Neither agree of disagree	Agree	Strongly agree
Exercise is the most important thing in my life	☐	☐	☐	☐	☐
Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do	☐	☐	☐	☐	☐
I use exercise as a way of changing my mood (e.g. to get a buzz, to escape, etc.)	☐	☐	☐	☐	☐
Over time I have increased the amount of exercise I do in a day	☐	☐	☐	☐	☐
If I have to miss an exercise session I feel moody and irritable	☐	☐	☐	☐	☐
If I cut down the amount of exercise I do, and then start again, I always end up exercising as often as I did before	☐	☐	☐	☐	☐

p. 3

Add item

11 As part of your role as an exercise instructor, on average how many hours per week do you exercise as part of your job (not including your own training)?

Add item

Add item

p. 4

Add item

12 Are you a health club user?

Yes

No

Add item

Add item

13 On average, how many hours per week do you train for leisure?

Add item

Add item

14 Do you own your own house?

Yes

No

Add item

Add item

15 What is your ethnicity?

White or caucasian

Black or african american

Hispanic or latino

Asian

Another race

Show less

Add item

p. 6

Add item

17 Please answer the following questions

	Always	Usually	Often	Sometimes	Rarely	Never
Am terrified about being overweight.	☐	☐	☐	☐	☐	☐
Avoid eating when I am hungry.	☐	☐	☐	☐	☐	☐
Find myself preoccupied with food.	☐	☐	☐	☐	☐	☐
Have gone on eating binges where I feel that I may not be able to stop.	☐	☐	☐	☐	☐	☐
Cut my food into small pieces.	☐	☐	☐	☐	☐	☐
Aware of the calorie content of foods that I eat.	☐	☐	☐	☐	☐	☐
Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)	☐	☐	☐	☐	☐	☐
Feel that others would prefer if I ate more.	☐	☐	☐	☐	☐	☐
Vomit after I have eaten.	☐	☐	☐	☐	☐	☐
Feel extremely guilty after eating.	☐	☐	☐	☐	☐	☐
Am preoccupied with a desire to be thinner.	☐	☐	☐	☐	☐	☐
Think about burning up calories when I exercise.	☐	☐	☐	☐	☐	☐
Other people think that I am too thin.	☐	☐	☐	☐	☐	☐
Am preoccupied with the thought of having fat on my body.	☐	☐	☐	☐	☐	☐
Take longer than others to eat my meals.	☐	☐	☐	☐	☐	☐
Avoid foods with sugar in them.	☐	☐	☐	☐	☐	☐
Eat diet foods.	☐	☐	☐	☐	☐	☐
Feel that food controls my life.	☐	☐	☐	☐	☐	☐
Display self-control around food.	☐	☐	☐	☐	☐	☐
Feel that others pressure me to eat.	☐	☐	☐	☐	☐	☐
Give too much time and thought to food.	☐	☐	☐	☐	☐	☐
Feel uncomfortable after eating sweets.	☐	☐	☐	☐	☐	☐
Engage in dieting behavior.	☐	☐	☐	☐	☐	☐
Like my stomach to be empty.	☐	☐	☐	☐	☐	☐
Have the impulse to vomit after meals.	☐	☐	☐	☐	☐	☐
I enjoy trying rich new foods	☐	☐	☐	☐	☐	☐

p. 7

Add item

18 People exercise for a variety of reasons. When people are asked why they exercise, their answers are sometimes based on the reasons they believe they should be exercising. What we want to know are the reasons people actually have for exercising. Please respond to the items below as honestly as possible. To what extent is each of the following an important reason you have for exercising?

	1 - not important at all	2	3	4 - moderately important	5	6	7 - extremely important
To be slim	☐	☐	☐	☐	☐	☐	☐
To lose weight	☐	☐	☐	☐	☐	☐	☐
To maintain my current weight	☐	☐	☐	☐	☐	☐	☐
To improve my muscle tone	☐	☐	☐	☐	☐	☐	☐
To improve my strength	☐	☐	☐	☐	☐	☐	☐
To improve my endurance, stamina	☐	☐	☐	☐	☐	☐	☐
To improve my flexibility, coordination	☐	☐	☐	☐	☐	☐	☐
To cope with sadness, depression	☐	☐	☐	☐	☐	☐	☐
To cope with stress, anxiety	☐	☐	☐	☐	☐	☐	☐
To increase my energy levels	☐	☐	☐	☐	☐	☐	☐
To improve my mood	☐	☐	☐	☐	☐	☐	☐
To improve my cardiovascular fitness	☐	☐	☐	☐	☐	☐	☐
To improve my overall health	☐	☐	☐	☐	☐	☐	☐
To increase my resistance to illness and disease	☐	☐	☐	☐	☐	☐	☐
To maintain my physical well-being	☐	☐	☐	☐	☐	☐	☐
To improve my appearance	☐	☐	☐	☐	☐	☐	☐
To be attractive to members of the opposite sex	☐	☐	☐	☐	☐	☐	☐
To be sexually desirable	☐	☐	☐	☐	☐	☐	☐
To meet new people	☐	☐	☐	☐	☐	☐	☐
To socialize with friends	☐	☐	☐	☐	☐	☐	☐
To have fun	☐	☐	☐	☐	☐	☐	☐
To redistribute my weight	☐	☐	☐	☐	☐	☐	☐
To improve my overall body shape	☐	☐	☐	☐	☐	☐	☐
To alter a specific area of my body	☐	☐	☐	☐	☐	☐	☐

Add item

p. 8

Add item

19 Please answer these questions regarding social media (Facebook, Instragram, Twitter, Snapchat, etc) usage

	1 (strongly disagree)	2	3	4	5	6 (strongly agree)
I feel disconnected from friends when I have not logged onto social media	☐	☐	☐	☐	☐	☐
I would like it if everyone used social media to communicate	☐	☐	☐	☐	☐	☐
I would be disappointed if I could not use social media at all	☐	☐	☐	☐	☐	☐
I get upset when I can't log into social media	☐	☐	☐	☐	☐	☐
I prefer to communicate with others mainly through social media	☐	☐	☐	☐	☐	☐
Social media plays an important role in my social relationships	☐	☐	☐	☐	☐	☐
I enjoy checking my social media account(s)	☐	☐	☐	☐	☐	☐
I don't like to use social media	☐	☐	☐	☐	☐	☐
Using social media is part of my everyday routine	☐	☐	☐	☐	☐	☐
I respond to content that others share using social media	☐	☐	☐	☐	☐	☐

Add item

Add item

p. 9

Add item

20 Are you worried about how you look? *

Yes

No

Add item

Add item

p. 10

Add item

21 Do you think about your appearance problems a lot and wish you could think about them less?

Yes

No

Add item

Add item

p. 11

Add item

22 Is your main concern with how you look that you aren't thin enough or that you might get too fat?

Yes

No

Add item

Add item

p. 11

Add item

22 Is your main concern with how you look that you aren't thin enough or that you might get too fat?

Yes

No

Add item

Add item

23 Has this problem often upset you a lot?

Yes

No

Add item

Add item

24 Has this problem often gotten in the way of doing things with friends, dating, relationships with people, or your social activities?

Yes

No

Add item

Add item

25 Has this problem caused you any problems with school, work, or other activities?

Yes

No

Add item

Add item

26 Are there things you avoid becuase of the way you look?

Yes

No

Add item

Add item

27 On an average day, how much time do you usually spend thinking about how you look?

Less than 1 hour per day

1-3 hours per day

More than 3 hours per day

Add item

Add item

p. 12

Add item

28 If you would like to have access to the results of this study, please fill in your email address below.

Add item

a If you would be happy to be contacted for a possible follow-up study please click yes. If you would prefer not to be contacted for a follow-up study, please click no.

Yes

No

Add item

Add item

Add item

p. 13 Final page

Add item

Thank you for taking part in this survey. You have helped in the advancement of knowledge in the field of exercise dependence.

If you are worried about any of the topics covered in this survey, please speak to your GP.

More information on eating disorders can be found here

More information on body dysmorphia can be found here

Add item

Appendix G: Survey questions for Chapter 3: Study 2

p. 1 Information and consent

Add item

1 My name is Mike Trott and I am currently studying my PhD in Sports and Exercise Science at Anglia Ruskin University in Cambridge, currently performing a research project for the third year of my PhD. I am organising this research and am supervised by Dr Lee Smith, Dr Brendon Stubbs and Dr James Johnstone. This research is designed to evaluate whether exercise addiction levels, body dysmorphia levels, reasons for exercise and eating disorder symtoms have changed since the COVID-19 pandemic. You have been invited to take part in this study as you meet the following criteria: - You completed the exercise addiction questionaire last year, and - You are over 18. Taking part is completely optional, you should only agree to take part if you are happy to do so. If you agree to take part, you must read the information carefully and answer all questions to the best of your ability. All questions must be answered in order to compete the survey. There are no risks or precautions to be taken when participating in this study. If you have any questions please feel free to contact me via email(1). All information collected from you during your participation in this research will be anonymised. The information will not be incorrectly distributed in any way. The final report will include your data – but it will not be possible to identify you from the data. (1) mike.trott@pgr.aru.ac.uk I agree to take part in this study, I have read the information above. I understand what my role will be in this research, and all my questions have been answered to my satisfaction. I have been informed that the confidentiality of the information I provide will be safeguarded. I am free to ask any questions at any time before and during the study. By consenting to take part in this research you have not compromised your statutory legal rights. All information from your participation in this research will be collected and stored in accordance with the General Data Protection Regulation (GDPR, 2016) . Data Protection: I agree to the University (Anglia Ruskin University and its partner colleges) processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me. Once you have consented, information from completed and submitted surveys cannot be withdrawn. I give my consent to participate in this study *

Yes

No

Add item

Add item

2 T Email address

QUESTION USES PARAMETER email QUESTION HIDDEN

Add item

Add item

p. 2

Add item

3 Are you currently in 'lockdown' (under restrictions that limit your ability to leave the house)?

Yes

No

Add item

Add item

4 T What is your height (in cm)?

Add item

Add item

5 T What is your weight (in kg)?

Add item

Add item

p. 5

Add item

10 Please answer the following questions

	Always	Usually	Often	Sometimes	Rarely	Never
Am terrified about being overweight.	☐	☐	☐	☐	☐	☐
Avoid eating when I am hungry.	☐	☐	☐	☐	☐	☐
Find myself preoccupied with food.	☐	☐	☐	☐	☐	☐
Have gone on eating binges where I feel that I may not be able to stop.	☐	☐	☐	☐	☐	☐
Cut my food into small pieces.	☐	☐	☐	☐	☐	☐
Aware of the calorie content of foods that I eat.	☐	☐	☐	☐	☐	☐
Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)	☐	☐	☐	☐	☐	☐
Feel that others would prefer if I ate more.	☐	☐	☐	☐	☐	☐
Vomit after I have eaten.	☐	☐	☐	☐	☐	☐
Feel extremely guilty after eating.	☐	☐	☐	☐	☐	☐
Am preoccupied with a desire to be thinner.	☐	☐	☐	☐	☐	☐
Think about burning up calories when I exercise.	☐	☐	☐	☐	☐	☐
Other people think that I am too thin.	☐	☐	☐	☐	☐	☐
Am preoccupied with the thought of having fat on my body.	☐	☐	☐	☐	☐	☐
Take longer than others to eat my meals.	☐	☐	☐	☐	☐	☐
Avoid foods with sugar in them.	☐	☐	☐	☐	☐	☐
Eat diet foods.	☐	☐	☐	☐	☐	☐
Feel that food controls my life.	☐	☐	☐	☐	☐	☐
Display self-control around food.	☐	☐	☐	☐	☐	☐
Feel that others pressure me to eat.	☐	☐	☐	☐	☐	☐
Give too much time and thought to food.	☐	☐	☐	☐	☐	☐
Feel uncomfortable after eating sweets.	☐	☐	☐	☐	☐	☐
Engage in dieting behavior.	☐	☐	☐	☐	☐	☐
Like my stomach to be empty.	☐	☐	☐	☐	☐	☐
Have the impulse to vomit after meals.	☐	☐	☐	☐	☐	☐
I enjoy trying rich new foods	☐	☐	☐	☐	☐	☐

Add item

Add item

p. 8

Add item

13 Are you worried about how you look? *

Yes

No

Add item

Add item

p. 9

Add item

14 Do you think about your appearance problems a lot and wish you could think about them less?

Yes

No

Add item

Add item

p. 10

Add item

15 Is your main concern with how you look that you aren't thin enough or that you might get too fat?

Yes

No

Add item

Add item

16 Has this problem often upset you a lot?

Yes

No

Add item

Add item

17 Has this problem often gotten in the way of doing things with friends, dating, relationships with people, or your social

Yes

No

p. 11

Add item

21 Please indicate whether you would like a copy of the published results of this study when avaiable.

Yes

No

Add item

Add item

p. 12 Final page

Add item

Thank you for taking part in this survey. You have helped in the advancement of knowledge in the field of exercise habit changes during COVID-19.

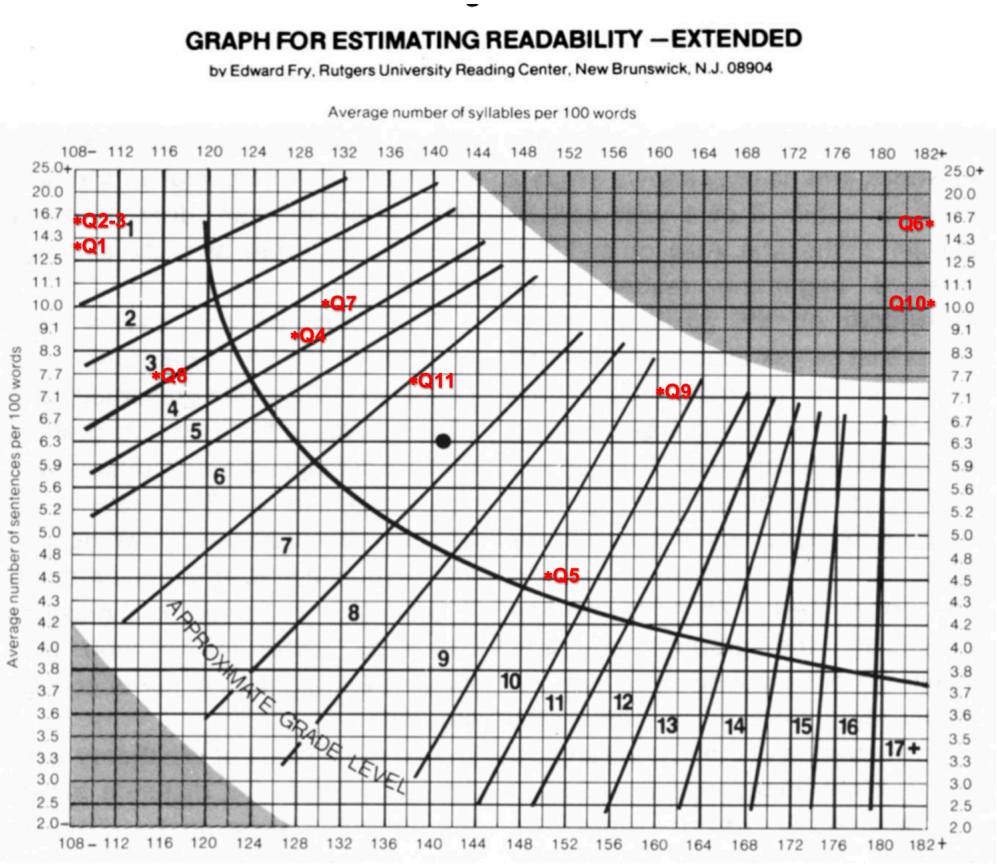
If you are worried about any of the topics covered in this survey, please speak to your GP.

More information on eating disorders can be found here

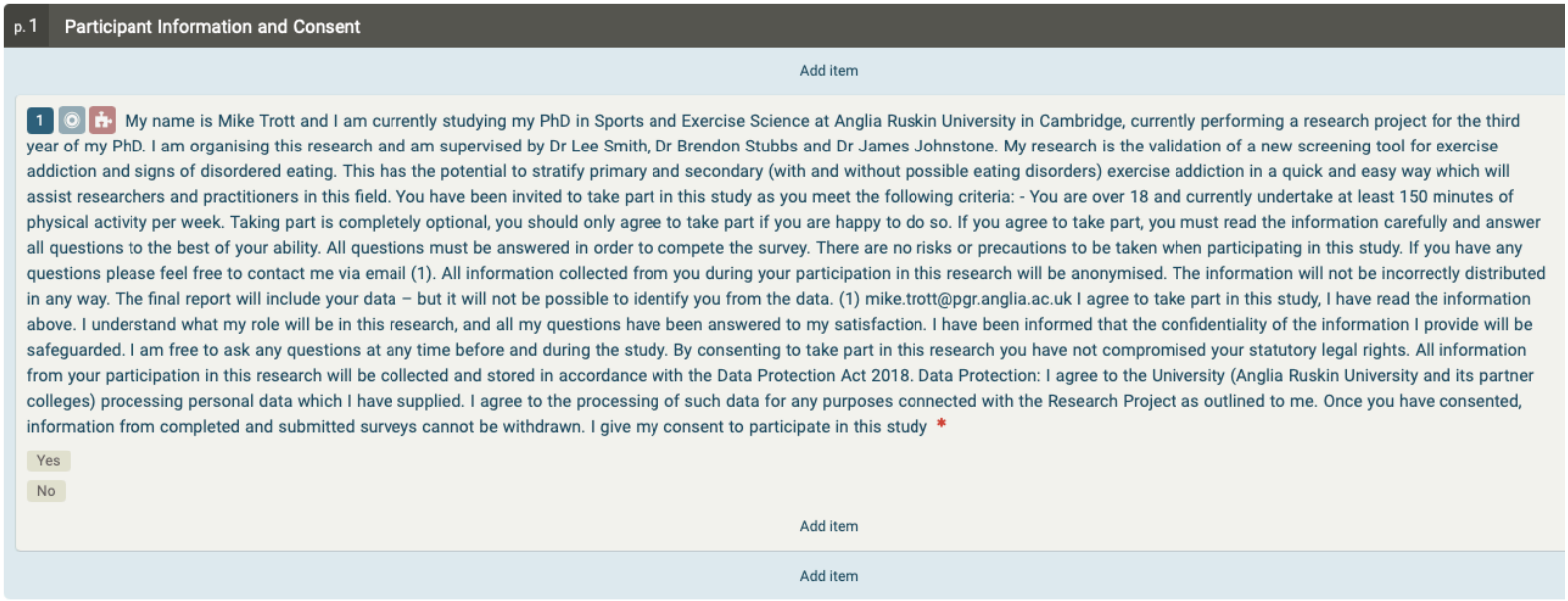
More information on body dysmorphia can be found here

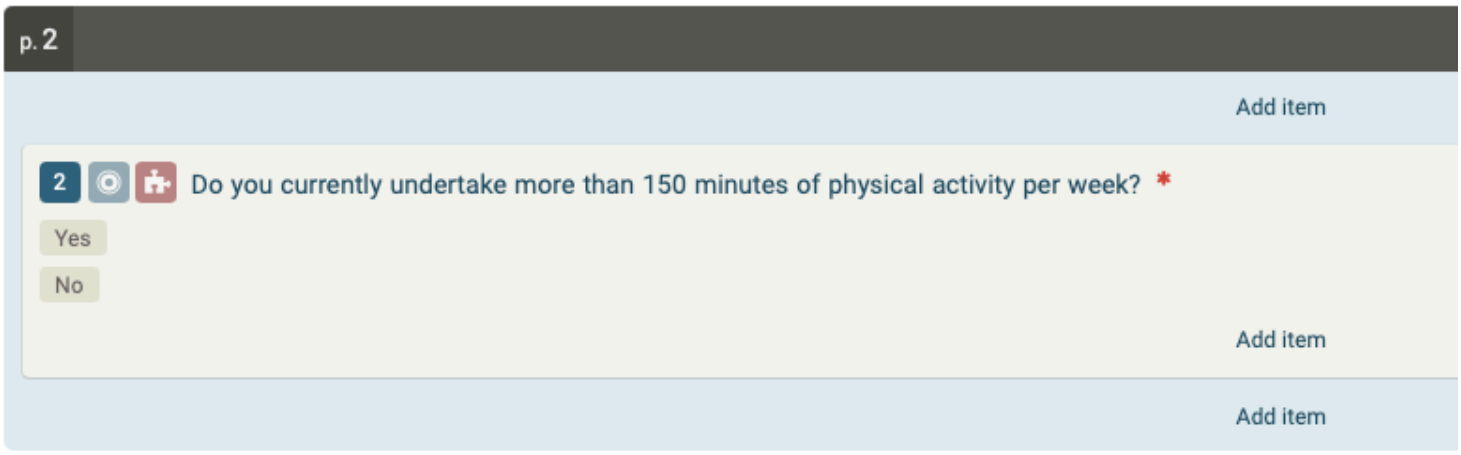
Add item

Appendix H: Fry's readability graph for the Secondary Exercise Addiction Scale



Appendix I: Survey questions for Chapter 4: Studies 1,2,3





p. 3 **Demographic information**

Add item

3 What is your age? *

Add item

Add item

4 What gender do you identify as? *

Male

Female

Prefer not to say

Add item

Add item

5 What is your height in centimeters?

Add item

Add item

6 What is your weight in KG?

Add item

p. 4

Add item

8 Please answer the following questions *

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Exercise is the most important thing in my life	☐	☐	☐	☐	☐
Conflicts have arisen between me and my family and/or my partner about the amount of exercise I do.	☐	☐	☐	☐	☐
I use exercise as a way of changing my mood (e.g. to get a buzz, to escape, etc)	☐	☐	☐	☐	☐
Over time I have increased the amount of exercise I do in a day	☐	☐	☐	☐	☐
If I have to miss an exercise session I feel moody and irritable	☐	☐	☐	☐	☐
If I cut down the amount of exercise I do, and then start again, I always end up exercising as often as I did before	☐	☐	☐	☐	☐

Add item

Add item

p. 5

Add item

9 Please answer the following 5 questions: *

	Yes	No
Do you make yourself sick because you feel uncomfortably full?	☐	☐
Do you worry you have lost control over how much you eat?	☐	☐
Have you recently lost more than one stone in a three month period?	☐	☐
Do you believe yourself to be fat when others say you are too thin?	☐	☐
Would you say that food dominates your life?	☐	☐

Add item

Add item

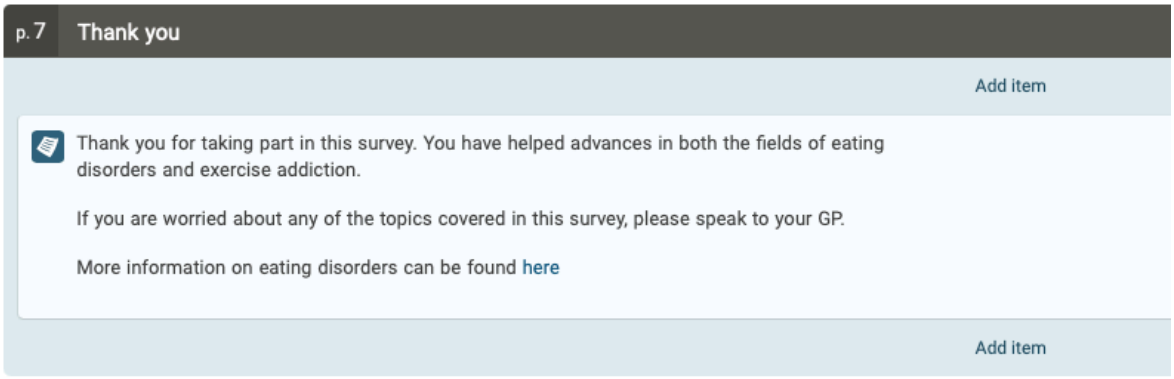
p. 6

Add item

10 Please answer the following questions: *

	1.Strongly disagree	2.	3.	4.	5.	6.Strongly agree
I often restrict my intake of food	☐	☐	☐	☐	☐	☐
I limit the number of calories I eat	☐	☐	☐	☐	☐	☐
I'm afraid of putting on weight	☐	☐	☐	☐	☐	☐
I feel that I look fat	☐	☐	☐	☐	☐	☐
I hate the way my body looks	☐	☐	☐	☐	☐	☐
People often say I look too thin	☐	☐	☐	☐	☐	☐
I often binge-eat on foods and feel that I cannot stop	☐	☐	☐	☐	☐	☐
I often eat lots of food in a short space of time	☐	☐	☐	☐	☐	☐
I have used medication, (e.g. laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months	☐	☐	☐	☐	☐	☐
Medication, fasting, and/or vomiting after meals helps me to lose weight	☐	☐	☐	☐	☐	☐
Exercise is my number 1 priority	☐	☐	☐	☐	☐	☐
I don't think I would manage very well without exercise	☐	☐	☐	☐	☐	☐
I find I need to exercise to improve my mood	☐	☐	☐	☐	☐	☐
Exercise is the only way I can deal with stress	☐	☐	☐	☐	☐	☐
I feel I need to do more exercise to get the same buzz	☐	☐	☐	☐	☐	☐
The more exercise I do, the more I need to keep doing to get the same feelings	☐	☐	☐	☐	☐	☐
When I take a break from exercise, I feel irritable and moody	☐	☐	☐	☐	☐	☐
I dread having to take a break from exercise (e.g. due to injury/illness/social commitments)	☐	☐	☐	☐	☐	☐
I often find my exercise habits affect my relationships (e.g. family/friends/partners)	☐	☐	☐	☐	☐	☐
I neglect friends/family/relationships because I want to exercise	☐	☐	☐	☐	☐	☐
The urge to exercise is stronger than my want to do less exercise.	☐	☐	☐	☐	☐	☐
If I were to stop exercising, I would start again at the same level as before.	☐	☐	☐	☐	☐	☐

Add item


p. 7
Thank you
Add item
Thank you for taking part in this survey. You have helped advances in both the fields of eating disorders and exercise addiction.
If you are worried about any of the topics covered in this survey, please speak to your GP.
More information on eating disorders can be found here
Add item

Appendix J: Survey questions for Chapter 4: Study 4

p. 1 **Participant Information and Consent**

Add item

1 My name is Mike Trott and I am currently studying my PhD in Sports and Exercise Science at ARU in Cambridge, currently performing a research project for the final project of my PhD. I am organising this research and am supervised by Dr Lee Smith, Dr Brendon Stubbs and Dr James Johnstone. My research is the validation of a new screening tool for exercise addiction and signs of disordered eating. This has the potential to stratify primary and secondary (with and without possible eating disorders) exercise addiction in a quick and easy way which will assist researchers and practitioners in this field. The study has received ethics approval by the School Research Ethics Panel (SREP) and ratified by the Faculty Research Ethics Panel under the terms of Anglia Ruskin University's Policy and Code of Practice for the Conduct of Research with Human Participants. You have been invited to take part in this study as you meet the following criteria: - You are over 18 and currently undertake at least 150 minutes of physical activity per week. Taking part is completely optional, you should only agree to take part if you are happy to do so. If you agree to take part, you must read the information carefully and answer all questions to the best of your ability. All questions must be answered in order to compete the survey. There are no risks or precautions to be taken when participating in this study. If you have any questions please feel free to contact me via email (1). All information collected from you during your participation in this research will be anonymised. The information will not be incorrectly distributed in any way. The final report will include your data – but it will not be possible to identify you from the data. (1) mike.trott@pgr.anglia.ac.uk I agree to take part in this study, I have read the information above. I understand what my role will be in this research, and all my questions have been answered to my satisfaction. I have been informed that the confidentiality of the information I provide will be safeguarded. I am free to ask any questions at any time before and during the study. By consenting to take part in this research you have not compromised your statutory legal rights. All information from your participation in this research will be collected and stored in accordance with the Data Protection Act 2018. Data Protection: I agree to the University (Anglia Ruskin University and its partner colleges) processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me. Once you have consented, information from completed and submitted surveys cannot be withdrawn. I give my consent to participate in this study *

Yes

No

Add item

Add item

p. 2

Add item

2 Do you currently undertake more than 150 minutes of physical activity (including walking, gardening, cycling, exercise) per week? *

Yes

No

Add item

Add item

p. 3 **Demographic information**

Add item

3 What is your age? *

Add item

Add item

4 What is your biological sex? *

Male

Female

Prefer not to say

Add item

Add item

5 What is your height in centimeters?

Add item

Add item

6 What is your weight in KG?

Add item

Add item

p. 5

Add item

8 Please answer the following questions

	Always	Usually	Often	Sometimes	Rarely	Never
Am terrified about being overweight.	☐	☐	☐	☐	☐	☐
Avoid eating when I am hungry.	☐	☐	☐	☐	☐	☐
Find myself preoccupied with food.	☐	☐	☐	☐	☐	☐
Have gone on eating binges where I feel that I may not be able to stop.	☐	☐	☐	☐	☐	☐
Cut my food into small pieces.	☐	☐	☐	☐	☐	☐
Aware of the calorie content of foods that I eat.	☐	☐	☐	☐	☐	☐
Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.)	☐	☐	☐	☐	☐	☐
Feel that others would prefer if I ate more.	☐	☐	☐	☐	☐	☐
Vomit after I have eaten.	☐	☐	☐	☐	☐	☐
Feel extremely guilty after eating.	☐	☐	☐	☐	☐	☐
Am preoccupied with a desire to be thinner.	☐	☐	☐	☐	☐	☐
Think about burning up calories when I exercise.	☐	☐	☐	☐	☐	☐
Other people think that I am too thin.	☐	☐	☐	☐	☐	☐
Am preoccupied with the thought of having fat on my body.	☐	☐	☐	☐	☐	☐
Take longer than others to eat my meals.	☐	☐	☐	☐	☐	☐
Avoid foods with sugar in them.	☐	☐	☐	☐	☐	☐
Eat diet foods.	☐	☐	☐	☐	☐	☐
Feel that food controls my life.	☐	☐	☐	☐	☐	☐
Display self-control around food.	☐	☐	☐	☐	☐	☐
Feel that others pressure me to eat.	☐	☐	☐	☐	☐	☐
Give too much time and thought to food.	☐	☐	☐	☐	☐	☐
Feel uncomfortable after eating sweets.	☐	☐	☐	☐	☐	☐
Engage in dieting behavior.	☐	☐	☐	☐	☐	☐
Like my stomach to be empty.	☐	☐	☐	☐	☐	☐
Have the impulse to vomit after meals.	☐	☐	☐	☐	☐	☐
I enjoy trying rich new foods	☐	☐	☐	☐	☐	☐

Add item

Add item

p. 6

Add item

9 Using the scale provided below, please complete the following questions as honestly as possible. The questions refer to current exercise beliefs and behaviors that have occurred past 3 months.

	1 Never	2	3	4	5	6 Always
I exercise to avoid feeling irritable.	☐	☐	☐	☐	☐	☐
I exercise despite recurring physical problems.	☐	☐	☐	☐	☐	☐
I continually increase my exercise intensity to achieve the desired effects/benefits.	☐	☐	☐	☐	☐	☐
I am unable to reduce how long I exercise.	☐	☐	☐	☐	☐	☐
I would rather exercise than spend time with family/friends.	☐	☐	☐	☐	☐	☐
I spend a lot of time exercising.	☐	☐	☐	☐	☐	☐
I exercise longer than I intend.	☐	☐	☐	☐	☐	☐
I exercise to avoid feeling anxious.	☐	☐	☐	☐	☐	☐
I exercise when injured.	☐	☐	☐	☐	☐	☐
I continually increase my exercise frequency to achieve the desired effects/benefits.	☐	☐	☐	☐	☐	☐
I am unable to reduce how often I exercise.	☐	☐	☐	☐	☐	☐
I think about exercise when I should be concentrating on school/work.	☐	☐	☐	☐	☐	☐
I spend most of my free time exercising.	☐	☐	☐	☐	☐	☐
I exercise longer than I expect.	☐	☐	☐	☐	☐	☐
I exercise to avoid feeling tense.	☐	☐	☐	☐	☐	☐
I exercise despite persistent physical problems.	☐	☐	☐	☐	☐	☐
I continually increase my exercise duration to achieve the desired effects/benefits.	☐	☐	☐	☐	☐	☐
I am unable to reduce how intense I exercise.	☐	☐	☐	☐	☐	☐
I choose to exercise so that I can get out of spending time with family/friends.	☐	☐	☐	☐	☐	☐
A great deal of my time is spent exercising.	☐	☐	☐	☐	☐	☐
I exercise longer than I plan.	☐	☐	☐	☐	☐	☐

Add item

Add item

p. 7 **Contact details**

Add item

10 To validate our study fully, we need to send you another very short survey in two weeks time, please provide an email address where we can send this (your email address will not be used for any other purpose). *

Add item

Add item

p. 8 **Thank you**

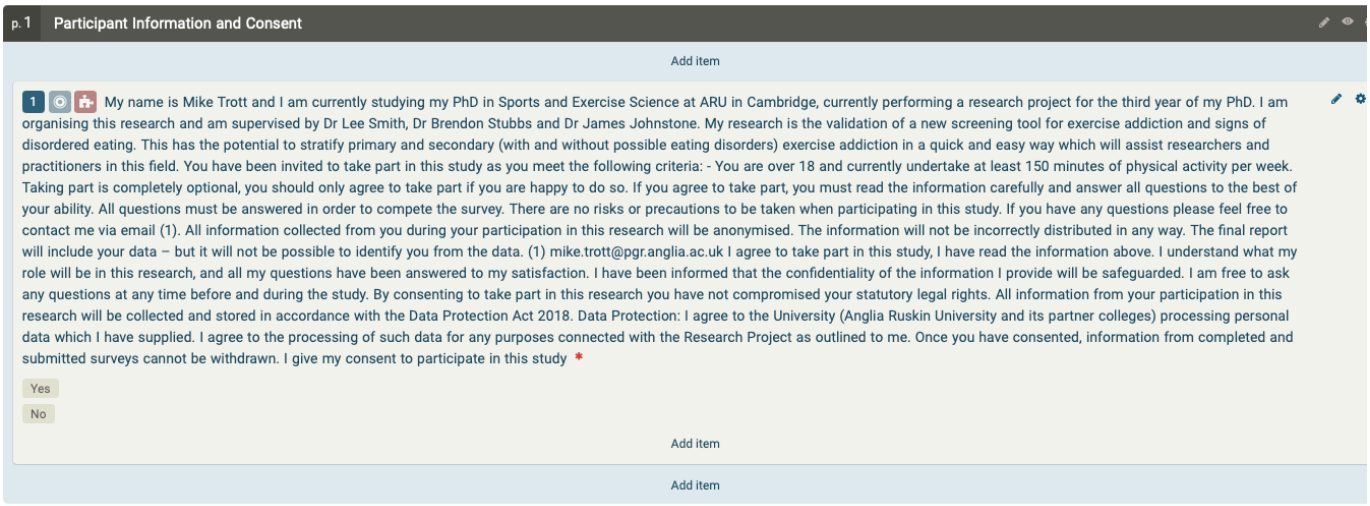
Add item

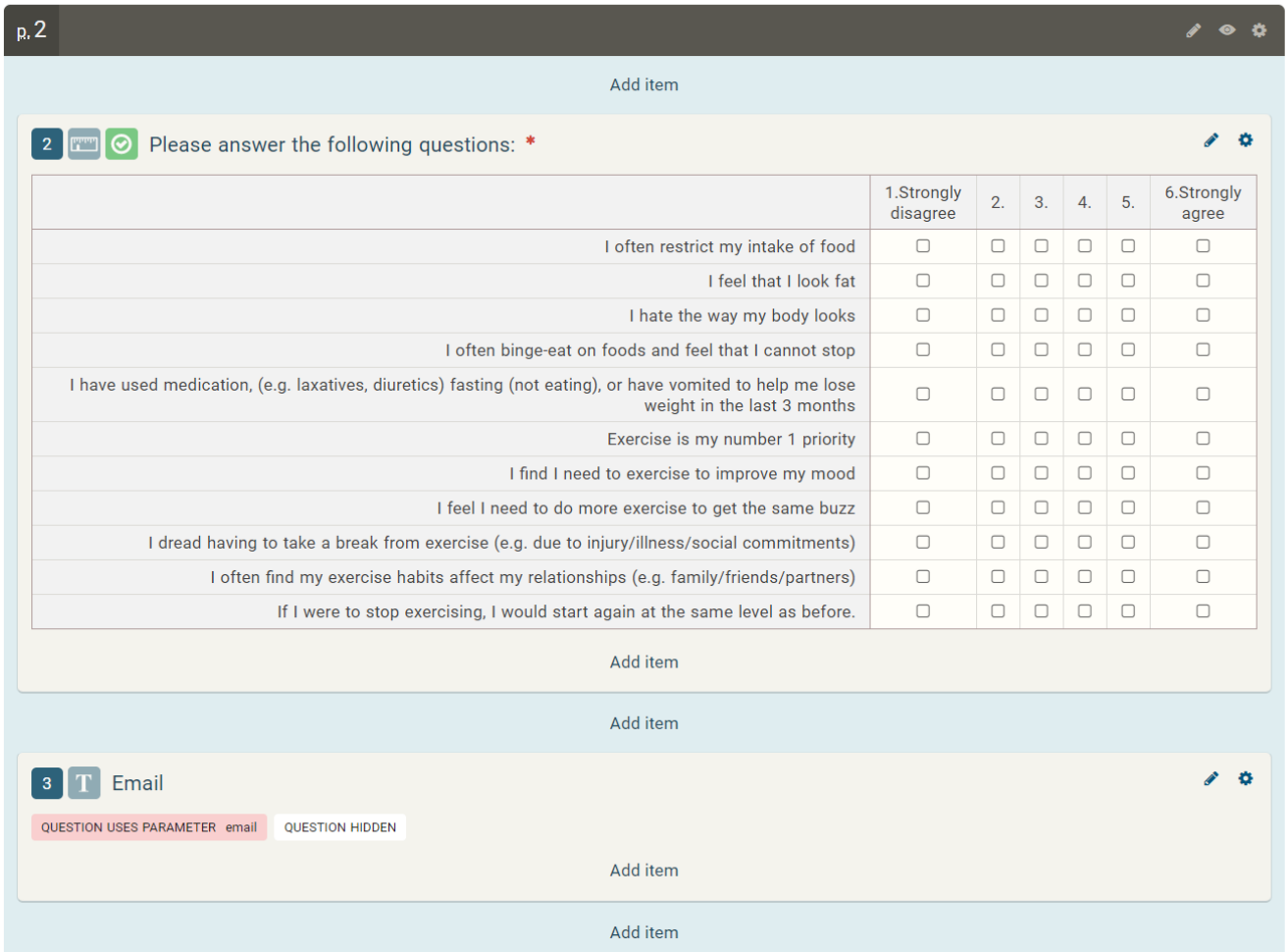
Thank you for taking part in this survey. You have helped advances in both the fields of eating disorders and exercise addiction.

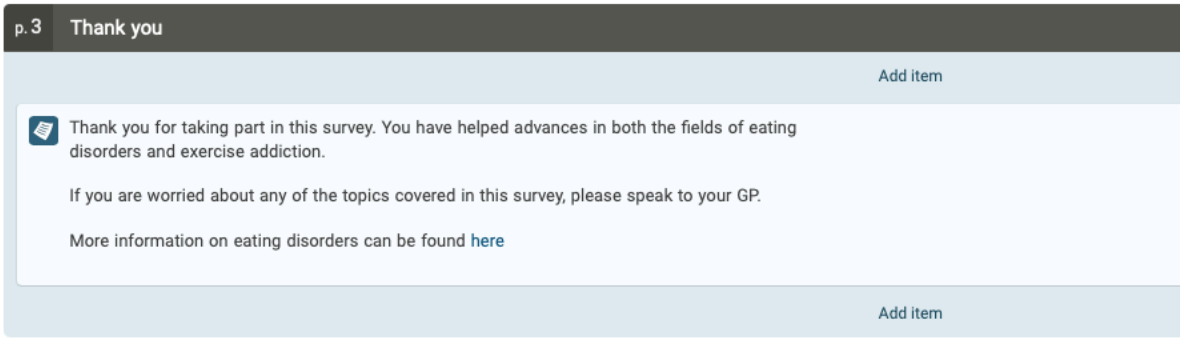
If you are worried about any of the topics covered in this survey, please speak to your GP.

More information on eating disorders can be found here

Add item


p. 1
Participant Information and Consent
Add item
1
My name is Mike Trott and I am currently studying my PhD in Sports and Exercise Science at ARU in Cambridge, currently performing a research project for the third year of my PhD. I am organising this research and am supervised by Dr Lee Smith, Dr Brendon Stubbs and Dr James Johnstone. My research is the validation of a new screening tool for exercise addiction and signs of disordered eating. This has the potential to stratify primary and secondary (with and without possible eating disorders) exercise addiction in a quick and easy way which will assist researchers and practitioners in this field. You have been invited to take part in this study as you meet the following criteria: - You are over 18 and currently undertake at least 150 minutes of physical activity per week. Taking part is completely optional, you should only agree to take part if you are happy to do so. If you agree to take part, you must read the information carefully and answer all questions to the best of your ability. All questions must be answered in order to compete the survey. There are no risks or precautions to be taken when participating in this study. If you have any questions please feel free to contact me via email (1). All information collected from you during your participation in this research will be anonymised. The information will not be incorrectly distributed in any way. The final report will include your data – but it will not be possible to identify you from the data. (1) mike.trott@pgr.anglia.ac.uk I agree to take part in this study, I have read the information above. I understand what my role will be in this research, and all my questions have been answered to my satisfaction. I have been informed that the confidentiality of the information I provide will be safeguarded. I am free to ask any questions at any time before and during the study. By consenting to take part in this research you have not compromised your statutory legal rights. All information from your participation in this research will be collected and stored in accordance with the Data Protection Act 2018. Data Protection: I agree to the University (Anglia Ruskin University and its partner colleges) processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me. Once you have consented, information from completed and submitted surveys cannot be withdrawn. I give my consent to participate in this study *
Yes
No
Add item
Add item


p. 2
Add item
2
Please answer the following questions: *
1.Strongly disagree
2.
3.
4.
5.
6.Strongly agree
I often restrict my intake of food
I feel that I look fat
I hate the way my body looks
I often binge-eat on foods and feel that I cannot stop
I have used medication, (e.g. laxatives, diuretics) fasting (not eating), or have vomited to help me lose weight in the last 3 months
Exercise is my number 1 priority
I find I need to exercise to improve my mood
I feel I need to do more exercise to get the same buzz
I dread having to take a break from exercise (e.g. due to injury/illness/social commitments)
I often find my exercise habits affect my relationships (e.g. family/friends/partners)
If I were to stop exercising, I would start again at the same level as before.
Add item
Add item
3
Email
QUESTION USES PARAMETER email
QUESTION HIDDEN
Add item
Add item


p. 3
Thank you
Add item
Thank you for taking part in this survey. You have helped advances in both the fields of eating disorders and exercise addiction.
If you are worried about any of the topics covered in this survey, please speak to your GP.
More information on eating disorders can be found here
Add item

Appendix K: Full version of ‘Prevalence and correlates of body dysmorphic disorder in health club users in the presence vs absence of eating disorder symptomology’ in the Journal Eating and Weight Disorders.

[Redacted in the open access version of this thesis]
A copy is available at https://arro.anglia.ac.uk/id/eprint/705863/

Appendix L: Full version of ‘Prevalence and correlates of exercise addiction in the presence vs absence of indicated eating disorders’ in the journal Frontiers in Sport and Active Living.

frontiers in Sports and Active Living

ORIGINAL RESEARCH
published: 10 July 2020
doi: 10.3389/fspor.2020.00084

Prevalence and Correlates of Exercise Addiction in the Presence vs. Absence of Indicated Eating Disorders

Mike Trott[1†], Lin Yang[2,3], Sarah E. Jackson[4], Joseph Firth[5,6,7], Claire Gillvray[8,9,10], Brendon Stubbs[11,12,13] and Lee Smith[1]*

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Despite the many benefits of regular, sustained exercise, there is evidence that exercise can become addictive, to the point where the exerciser experiences negative physiological and psychological symptoms, including withdrawal symptoms upon cessation, training through injury, and the detriment of social relationships. Furthermore, recent evidence suggests that the etiology of exercise addiction is different depending on the presence or absence of eating disorders. The aim of this study was to explore to what extent eating disorder status, body dysmorphic disorder, reasons for exercise, social media use, and fitness instructor status were associated with exercise addiction, and to determine differences according to eating disorder status. The key findings showed that the etiology of exercise addiction differed according to eating disorder status, with variables including social media use, exercise motivation, and ethnicity being uniquely correlated with exercise addiction only in populations with indicated eating disorders. Furthermore, body dysmorphic disorder was highly prevalent in subjects without indicated eating disorders, and could be a primary condition in which exercise addiction is a symptom. It is recommended that clinicians and practitioners working with patients who present with symptoms of exercise addiction should be screened for eating disorders and body dysmorphic disorder before treatments are considered.

Keywords: exercise addiction, exercise dependence, eating disorder, social media, reasons for exercising, exercise, pathological exercise

INTRODUCTION

Exercise can be defined as "structured, intentional physical activity for improving health and fitness" (Garber et al., 2011). Benefits of regular exercise in adults (18 years and over) include lower risk of all-cause mortality, improved cognitive function, and improvements in several areas of mental health (Ashdown-Franks et al., 2019; Powell et al., 2019).

There is evidence, however, that exercise can become obsessive, compulsive, or addictive, to the point where the exerciser experiences negative physiological and psychological symptoms, including withdrawal symptoms upon cessation, training through injury, and the detriments of social relationships (Symons Downs et al., 2019; Szabo et al., 2019). Several different terms have been used to label this phenomenon, including exercise addiction, exercise dependence, compulsive exercise, and obligatory exercise. For this study, we use the term *exercise addiction* (EA), as it encompasses aspects of both dependence and compulsion (Szabo et al., 2015). Overall prevalence of exercise addiction appears to be 3–14% of the exercising population; however, this varies depending on the population and method of exercise addiction measurement tool (Di Lodovico et al., 2019; Marques et al., 2019; Trott et al., 2020a).

Many theoretical models have been proposed to explain EA, including the Sympathetic Arousal Hypothesis [(Thompson and Blanton, 1987), the Cognitive Appraisal Hypothesis (Szabo, 1995), the IL-6 model (Hamer and Karageorghis, 2007), Four Phase model (Freimuth et al., 2011), and the Biopsychosocial model (McNamara and McCabe, 2012)]. Most recently, Egorov and Szabo (2013) updated the Cognitive Appraisal Hypothesis with their Interactional Model of EA (**Figure 1**), which describes a broad range of variables being conducive to developing EA, along with the acknowledgment that several variables' connection may be two-way.

One of the key determinants of EA in the Interactional Model is "sudden or progressively intolerable life-stress." The most researched of these is the presence (or absence) of eating disorders, with recent evidence concluding that subjects with indicated eating disorders have 3.5x higher risk of developing EA than subjects without indicated eating disorders (Trott et al., 2020b) broadly supporting this model. Further evidence to support this hypothesis, however, is sparse, mainly because the majority of EA literature fails to screen for the presence of eating disorders (Di Lodovico et al., 2019; Marques et al., 2019; Symons Downs et al., 2019). Another condition that could be characterized as an "intolerable life-stress" is the presence of Body Dysmorphic Disorder (BDD), a condition in which a person is concerned about real or perceived physical defects (such as body shape, skin, or hair) as repulsive (Buhlmann et al., 2009; American Psychiatric Association, 2013). Previous studies have shown BDD to be a predictor of exercise addiction in populations without indicated eating disorders (Grandi et al., 2011); however, the strength of this association in populations with indicated eating disorders is unknown. Several other correlates have been shown to associate with BDD, including social media use and sexuality, both of which have been shown to yield more negative body image feelings, with a positive relationship between time spent on social media and negative body feelings (Fardouly and Vartanian, 2016), and heterosexual women and homosexual men demonstrating higher levels of body dissatisfaction (Conner et al., 2004), indicating a potential link between EA, social media use, sexuality, and BDD. These links, however, have not been empirically explored to date.

Another key component of the Interactional Model of EA is "exercise-motivation," although few studies have explored reasons for exercise in exercise addicted populations. Serier et al. (2018) explored reasons for exercise in subjects with high levels of body dissatisfaction and found that EA subjects scored significantly higher in measures for "exercising for mood" and "enjoyment" compared to non-exercise addicted subjects, broadly supporting the Interactional Model. It has also been suggested that subjects with EA exercise for different reasons depending on the presence or absence of an eating disorder, with subjects with no indicated eating disorders exercising "as an end to itself," and indicated eating disordered subjects exercising to achieve another goal, such as weight loss (de Coverley Veale, 1987). Evidence to support these differing exercise motivations, however, has not been explored to date.

Further at the beginning of the Interactional Model is "personal" and "situational" factors. Of these, the amount of leisure time physical activity has been consistently shown to positively correlate with exercise addiction risk (Kovacsik et al., 2018). One unique job that could be related to EA is being a fitness instructor (especially group fitness instructors), as they are regularly required to exercise as part of their job, and have been noted at being at higher risk of fitness related injuries, especially when coupled with obligatory exercise tendencies (Thompson et al., 2001); however, whether this directly correlates with increased exercise addiction risk is yet to be explored.

Identifying the extent to which these variables are associated with EA has the potential to support, refute, or suggest modifications to the Interactional Model of EA. Furthermore, identifying how much these associations differ between subjects with and without indicated eating disorders is important, as it allows researchers to understand if there are any differences in the two populations, and therefore have suggested different etiology. The aim of this study, therefore, was to answer the following questions:

1. To what extent is eating disorder status, BDD, reasons for exercise, social media use, and fitness instructor status associated with exercise addiction in line with the Interactional Model?

Based on the Interaction Model, it is hypothesized that eating disorder and BDD status (conditions that could be considered a "sudden or progressively intolerable life-stresses") have the strongest association with EA. Exercise-motivations are hypothesized to have a smaller association, with the personal and situational factors (fitness instructor status and social media use) showing the smallest associations.

2. Do the associations between these psychological and social variables and exercise addiction differ according to eating disorder status?

We hypothesize that some correlates will differ according to eating disorder status.

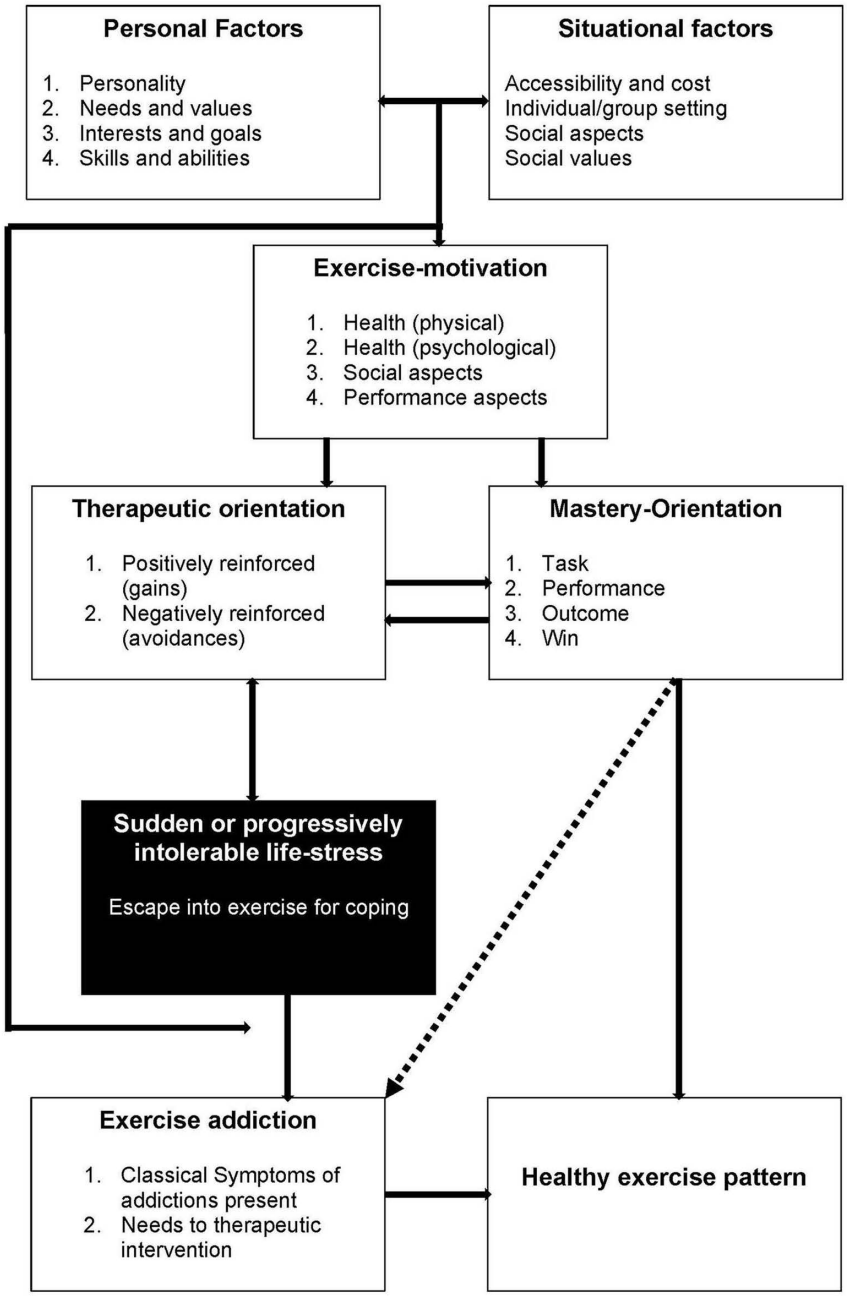

FIGURE 1 | The interactional model of exercise addiction (Egorov and Szabo, 2013).

Not only will this expand the understanding of exercise addiction, its relationship with eating disorders, and its relationship with the multiple variables described above, it has the potential to inform practitioners working with potentially "at risk" groups, such as physicians and fitness industry workers. Furthermore, this study will either support or refute the

most recent model of EA, which will steer the direction of future research.

MEASURES AND METHODS

Study participants were recruited via an international group fitness e-newsletter and through Facebook, Instagram, and Twitter from 8/4/19 to 31/7/19 through social media influencers and through the authors' personal social media accounts. Participants provided informed consent prior to taking part in the survey, including the right to withdraw and access to further support if any of the topics were distressing. To be eligible for the study, participants were required to be adult (>18 years) health club users. Participants were oriented to an online battery of questions hosted through an academic survey website (Jisc Online Surveys, 2020), including measures of age, sex, ethnicity, socio-economic status, life-limiting illness status, exercise addiction, leisure-time physical activity frequency, reasons for exercise, eating disorders, BDD, social media use, body mass index (BMI), and sexuality. Ethical approval was obtained from the Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-03).

Participants

Total, 1,864 participants completed the questionnaire. Of these, 199 (10.7%) failed to confirm that they were health club users and were excluded from further analysis. Of the remaining 1,665 participants, the mean age was 35.7 years (SD = 10.9), mean self-reported BMI was 23.9 kg/m^2 (SD = 3.9), and 1,428 (85.0%) subjects were female. Full demographic information is shown in Table 1.

TABLE 1 | Sample characteristics.

Variable	Total sample[a]	Indicated exercise addiction[a]	No indicated exercise addiction[a]
n	1,665	511 (30.7%)	1,154 (69.3%)
Age (years)	35.72 (10.92)	34.47 (10.41)	36.28 (11.10)
BMI (kg/m^2)	23.91 (3.93)	23.64 (4.22)	24.02 (3.79)
Sex (female)	85.00% (*n* = 1,428)	89.4% (*n* = 457)	84.10 (*n* = 971)
EAI[c] total	21.23 (4.31)	25.91 (1.73)	19.17 (3.40)
Indicated eating disorder (yes)	16.80% (*n* = 279)	32.90% (*n* = 168)	9.60% (*n* = 111)
EAT-26[b] Total	13.40 (12.43)	20.07 (14.83)	10.45 (9.86)
Fitness instructor (yes)	42.76% (*n* = 712)	42.90% (*n* = 219)	42.70% (*n* = 493)
Exercise hours for leisure (hour/week)	6.46 (4.04)	7.78 (4.50)	5.87 (3.67)
Life limiting illness (yes)	1.14% (*n* = 19)	0.60% (*n* = 3)	1.40% (*n* = 16)
Sexuality			
Heterosexual	88.00% (*n* = 1,477)	87.10% (*n* = 445)	89.40% (*n* = 1,032)
Homosexual	4.62% (*n* = 77)	4.50% (*n* = 23)	4.70% (*n* = 54)
Bisexual	4.50% (*n* = 75)	5.70% (*n* = 29)	4.00% (*n* = 46)
Prefer not to say	2.16% (*n* = 36)	2.20 (*n* = 11)	1.40% (*n* = 16)
Ethnicity			
White	91.23% (*n* = 1,519)	92.80% (*n* = 474)	90.6% (*n* = 1,045)
Black or African American	0.72% (*n* = 12)	0.40% (*n* = 2)	0.90% (*n* = 10)
Hispanic or Latino	1.62% (*n* = 27)	1.00% (*n* = 5)	1.90% (*n* = 22)
Asian	3.78% (*n* = 63)	3.30% (*n* = 17)	4.00% (*n* = 46)
Relationship status			
Single	28.89% (*n* = 481)	34.10% (*n* = 174)	26.60% (*n* = 307)
In a relationship	32.01% (*n* = 533)	31.10% (*n* = 159)	32.40% (*n* = 374)
Married	37.40% (*n* = 630)	33.90% (*n* = 173)	39.60 (*n* = 457)
Widowed	0.24% (*n* = 4)	0.20% (*n* = 1)	0.30% (*n* = 3)
Other	1.02% (*n* = 17)	0.80 (*n* = 4)	0.70% (*n* = 8)
Homeowner status (yes)	57.36% (*n* = 955)	53.40% (*n* = 273)	59.10% (*n* = 682)
BDD[d] status (indicated)	30.51% (*n* = 508)	48.70% (*n* = 249)	22.40% (*n* = 259)
REI[e] subscales			
Weight control	4.64 (1.27)	5.00 (1.30)	4.48 (1.23)
Fitness	5.88 (0.96)	6.05 (0.94)	5.81 (0.96)
Mood	5.35 (1.36)	5.81 (1.19)	5.14 (1.39)
Health	5.99 (1.02)	6.10 (1.03)	5.94 (1.01)
Attractiveness	4.68 (1.57)	5.13 (1.55)	4.48 (1.54)
Enjoyment	4.55 (1.51)	4.83 (1.52)	4.43 (1.49)
Tone	4.52 (1.51)	4.70 (1.53)	4.44 (1.50)
SMUIS[f] subscales			
Social integration and emotional connection	2.59 (1.12)	2.82 (1.16)	2.49 (1.08)
Integration into social routines	4.11 (1.18)	4.24 (1.20)	4.05 (1.17)

[a]*Data is presented as mean (standard deviation), unless otherwise stated.*
[b]*EAI, exercise addiction inventory.*
[c]*EAT-26, eating attitude test.*
[d]*BDD, body dysmorphic disorder.*
[e]*REI, reasons for exercise inventory.*
[f]*SMUIS, social media use integration scale.*

Measures

Exercise Addiction

The Exercise Addiction Inventory (EAI) (Terry et al., 2004) is a six-item questionnaire that assesses each component of Brown's theory of addiction (Brown, 1993) in an exercise context. Each question is scored on a Likert scale of 1–5, with a higher score indicating higher risk of exercise addiction. Subjects who score ≥24 are classified as "at risk" of exercise addiction (Terry et al., 2004). The EAI has been shown to have good reliability and validity across physically active populations (Terry et al., 2004; Griffiths et al., 2015; Lichtenstein and Jensen, 2016) and shows good internal reliability in the current study ($\alpha = 0.74$).

Note: Despite having a cut-off score, the EAI was used as a continuous variable indicting severity of exercise addiction risk because there are no clinically recognized diagnostic criteria for exercise addiction (American Psychiatric Association, 2013).

Social Media Use

Social media use was measured using the Social Media Use Integration Scale (SMUIS) (Jenkins-Guarnieri et al., 2013), a 10-item questionnaire with two sub-scales: social integration and emotional connection and integration into social routines. Each question is scored on a Likert scale of 1–6, with higher scores in each sub-scale indicating higher levels of its respective sub-scale. The SMUIS has shown good validity across several age ranges (Jenkins-Guarnieri et al., 2013; Maree, 2017) and shows excellent internal consistency in the current study (social integration and emotional connection sub-scale Cronbach's $\alpha = 0.88$; integration into social routines sub-scale Cronbach's $\alpha = 0.81$).

Reasons for Exercise

Reasons for exercise was measured using the Reasons for Exercise Inventory (REI) (Silberstein et al., 1988), a 24-item questionnaire with seven sub-scales: weight control, fitness, mood, health, attractiveness, enjoyment, and tone. Each question is scored on a Likert scale of 1–7, with higher scores in each sub-scale indicating higher levels in the respective sub-scale. The REI has been validated across several populations (Silberstein et al., 1988; Cash et al., 1994) and in the current study shows good internal consistency (Cronbach's αs: weight control $\alpha = 0.61$; fitness $\alpha = 0.83$; mood $\alpha = 0.86$; health $\alpha = 0.86$; attractiveness $\alpha = 0.85$; enjoyment $\alpha = 0.82$; tone $\alpha = 0.79$).

BDD

BDD was measured using the Body Dysmorphic Disorder Questionnaire (BDDQ) (Phillips, 2005), a questionnaire based on the *DSM-IV* (American Psychiatric Association, 2000) diagnostic criteria for BDD. Classification of BDD is made based on answering positively to questions 1 and 2, at least one part of question 3, and indicating spending one or more hours each day thinking about their appearance. The questionnaire has excellent reported sensitivity (94%) and specificity (90%) in non-clinical community populations (Brohede et al., 2013).

Eating Disorder Symptoms

Eating disorder symptomology was measured using the Eating Attitudes Test 26 (EAT-26) (Garner et al., 1982), a 26-item questionnaire scored on a Likert scale of 1–6. A score of ≥20 is sufficient to be classified as having possible pathological eating behaviors. The EAT-26 has been well-validated in athletic populations (Doninger et al., 2005; Pope et al., 2015) and has shown excellent internal consistency in the current study (Cronbach's $\alpha = 0.91$).

Health Club User

Participants were required to answer yes/no to indicate whether they were a current health club user.

Fitness Instructor

Participants were required to answer yes/no to indicate if they were currently a fitness instructor.

Leisure-Time Physical Activity

Participants were required to indicate how many hours per week they participated in physical activity (if the subject was a fitness instructor, this did not include exercise hours as part of work).

Data Analysis

All data were analyzed using SPSS Version 26 (IBM Corp., 2019).

Exercise addiction prevalence was also calculated in all the total sample and both indicated and non-indicated eating disorder populations.

A hierarchical multiple linear regression was run on the total sample to determine if the addition of variables significantly added to the total model with EAI score (as a continuous variable) as the dependent variable. The variables were added to the previous models in the following order:

Model 1: Age, gender, BMI, ethnicity, life limiting illness
Model 2: Eating disorder status
Model 3: BDD status
Model 4: Reasons for exercise (all items)
Model 5: Fitness instructor status
Model 6: Social media use (all items)
Model 7: Sexuality
Model 8: Exercise hours for leisure
Model 9: Relationship status

Furthermore, a linear regression was used to analyse associations between exercise addiction score (as a continuous variable) and: age, sex, BMI, ethnicity, eating disorder status, homeowner status, relationship status, both subscales of the SMUIS, all subscales of the REI, being a fitness instructor, leisure time physical activity, sexuality, and BDD status in two populations:

1. Indicated eating disorders (defined as scoring ≥20 in the EAT-26)
2. No indicated eating disorders (defined as scoring <20 in the EAT-26)

Any missing data was tested for randomness via Little's MCAR test (Little, 1988), and if confirmed random, deleted listwise from all regression analyses.

In order to explore whether associations varied according to eating disorder status, we repeated the multivariable analysis (model 9) in a series of linear regression models adding the interaction term (eating disorder status*respective variable) between eating disorder status and each potential correlate in turn (e.g., in the first analysis we included all variables in model 9 with the addiction of the variable "eating disorder status*age"; in the second analysis we included all variables in model 9 with the addiction of the variable "eating disorder status*gender", etc.).

RESULTS

Exercise Addiction Prevalence

The prevalence of exercise addiction, as defined by a score of ≥24 on the EAI (Terry et al., 2004), in the total sample was 30.7% (95%CI = 28.5–33.0%), 60.2% (95%CI = 54.2–66.0%) in the population who had an indicated eating disorders, and 24.7% (95%CI = 22.5–27.1%) in the population who had no indicated eating disorders.

Regression Assumption Testing

There was linearity in all samples as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals in all populations, as assessed by a Durbin-Watson statistic of 2.108, 1.087, and 2.036 in the total sample, indicated ED and no indicated ED samples, respectively. Homoscedasticity was as assessed by visual inspection of a plot of studentized residuals vs. unstandardized predicted values, with evidence of homoscedasticity in all three samples. There was no evidence of multicollinearity in any sample, as assessed by tolerance values >0.1. There were 23 studentized deleted residuals > ±3 standard deviations, which were kept in the analysis. The assumption of normality was met,

TABLE 2 | Hierarchical regression in the total sample (exercise addiction inventory scores as the dependent variable).

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8		Model 9	
	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change
	0.027	**NA**	**0.079**	**0.052****	**0.098**	**0.019****	**0.180**	**0.082****	**0.180**	**0.000**	**0.184**	**0.004****	**0.184**	**0.000**	**0.226**	**0.042****	**0.224**	**−0.002**
Variable	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*	Beta coefficients (95%CI)	*p*
Age	−0.106 (−0.156; −0.056)	<0.001**	−0.084 (−0.133; −0.036)	0.001	−0.056 (−0.105; −0.006)	0.027	−0.044 (−0.093; 0.005)	0.081	−0.045 (−0.094; 0.004)	0.073	−0.038 (−0.087; 0.012)	0.138	−0.036 (−0.086; 0.014)	0.156	−0.046 (−0.095; 0.002)	0.061	−0.042 (−0.102; 0.017)	0.165
Sex	−0.052 (−0.103; −0.002)	<0.001**	−0.022 (−0.071; 0.027)	0.385	−0.005 (−0.054; 0.044)	0.843	0.020 (−0.029; 0.069)	0.417	0.020 (−0.029; 0.068)	0.432	0.021 (−0.028; 0.070)	0.404	0.023 (−0.030; 0.075)	0.392	0.004 (−0.047; 0.055)	0.881	0.004 (−0.048; 0.055)	0.888
BMI	−0.064 (−0.115; −0.014)	0.012	−0.055 (−0.104; −0.006)	0.027	−0.067 (−0.115; −0.018)	0.007	−0.071 (−0.118; −0.025)	0.003	−0.071 (−0.118; −0.025)	0.003	−0.074 (−0.121; −0.028)	0.002	−0.074 (−0.121; −0.028)	0.002	−0.049 (−0.094; −0.003)	0.037	−0.048 (−0.094; −0.002)	0.039
Ethnicity: white vs. Hispanic	−0.013 (−0.062; 0.037)	0.613	−0.011 (−0.059; 0.037)	0.659	−0.011 (−0.059; 0.036)	0.643	−0.016 (−0.061; 0.030)	0.494	−0.017 (−0.063; 0.0.029)	0.465	−0.013 (−0.058; 0.033)	0.585	−0.016 (−0.062; 0.030)	0.500	−0.011 (−0.056; 0.033)	0.614	−0.011 (−0.056; 0.033)	0.620
Ethnicity: white vs. black	−0.091 (−0.140; −0.041)	<0.001**	−0.099 (−0.147; −0.051)	<0.001**	−0.094 (−0.142; −0.046)	<0.001**	−0.066 (−0.112; −0.020)	0.005	−0.066 (−0.112; −0.020)	0.005	−0.065 (−0.111; −0.019)	0.006	−0.068 (−0.113; −0.022)	0.004	−0.071 (−0.115; −0.026)	0.002	−0.071 (−0.116; −0.027)	0.002
Ethnicity: white vs. Asian	−0.020 (−0.070; 0.029)	0.423	−0.021 (−0.070; 0.027)	0.388	−0.015 (−0.063; 0.033)	0.530	−0.026 (−0.072; 0.020)	0.270	−0.025 (−0.071; 0.021)	0.290	−0.027 (−0.073; 0.019)	0.253	−0.029 (−0.075; 0.017)	0.216	−0.045 (−0.090; 0.000)	0.050	−0.048 (−0.094; −0.003)	0.038
Ethnicity: white vs. "other"	0.001 (−0.049; 0.051)	0.970	0.005 (−0.043; 0.053)	0.842	0.009 (−0.039; 0.057)	0.708	−0.005 (−0.050; 0.041)	0.843	−0.004 (−0.050; 0.042)	0.855	−0.004 (−0.050; 0.041)	0.855	−0.004 (−0.050; 0.041)	0.850	−0.005 (−0.050; 0.039)	0.817	−0.006 (−0.051; 0.039)	0.795
Life limiting illness	−0.040 (−0.089; 0.010)	0.120	−0.046 (−0.094; 0.003)	0.065	−0.041 (−0.089; 0.007)	0.096	−0.046 (−0.092; 0.000)	0.048	−0.046 (−0.092; 0.000)	0.050	−0.048 (−0.094; −0.002)	0.041	−0.051 (−0.097; −0.005)	0.031	−0.055 (−0.100; −0.011)	0.015	−0.055 (−0.100; −0.010)	0.017
Eating disorder status			0.233 (0.185; 0.282)	<0.001**	0.163 (0.109; 0.217)	<0.001**	0.135 (0.082; 0.188)	<0.001**	0.136 (0.083; 0.189)	<0.001**	0.135 (0.083; 0.188)	<0.001**	0.134 (0.081; 0.187)	<0.001**	0.106 (0.054; 0.158)	<0.001**	0.106 (0.054; 0.159)	<0.001**
BDD status					0.162 (0.107; 0.218)	<0.001**	0.123 (0.069; 0.178)	<0.001**	0.123 (0.068; 0.178)	<0.001**	0.117 (0.062; 0.172)	<0.001**	0.119 (0.064; 0.174)	<0.001**	0.112 (0.058; 0.165)	<0.001**	0.111 (0.057; 0.164)	<0.001**
REI weight control							0.067 (0.012; 0.122)	0.018	0.067 (0.012; 0.122)	0.018	0.065 (0.010; 0.120)	0.020	0.064 (0.009; 0.119)	0.023	0.060 (0.006; 0.113)	0.030	0.060 (0.006; 0.114)	0.030
REI fitness							0.067 (0.007; 0.127)	0.028	0.065 (0.005; 0.125)	0.035	0.062 (0.002; 0.122)	0.043	0.060 (0.000; 0.120)	0.052	0.043 (−0.016; 0.102)	0.154	0.044 (−0.015; 0.103)	0.144
REI mood							0.205 (0.150; 0.260)	<0.001**	0.205 (0.150; 0.260)	<0.001**	0.202 (0.147; 0.257)	<0.001**	0.201 (0.146; 0.256)	<0.001**	0.200 (0.147; 0.254)	<0.001**	0.199 (0.146; 0.253)	<0.001**
REI health							−0.051 (−0.115; 0.014)	0.122	−0.050 (−0.115; 0.014)	0.125	−0.036 (−0.101; 0.029)	0.281	−0.035 (−0.101; 0.030)	0.288	−0.021 (−0.084; 0.043)	0.521	−0.021 (−0.085; 0.043)	0.523
REI attractiveness							0.048 (−0.008; 0.104)	0.096	0.050 (−0.007; 0.106)	0.084	0.034 (−0.023; 0.091)	0.236	0.038 (−0.019; 0.095)	0.195	0.049 (−0.007; 0.105)	0.084	0.049 (−0.007; 0.106)	0.085
REI enjoyment							0.105 (0.054; 0.156)	<0.001**	0.101 (0.049; 0.152)	<0.001**	0.094 (0.042; 0.146)	<0.001**	0.095 (0.043; 0.146)	<0.001**	0.070 (0.019; 0.121)	0.007	0.068 (0.017; 0.119)	0.009
REI tone							−0.038 (−0.086; 0.010)	0.121	−0.040 (−0.088; 0.008)	0.105	−0.040 (−0.088; 0.008)	0.099	−0.041 (−0.089; 0.007)	0.092	−0.044 (−0.091; 0.002)	0.063	−0.044 (−0.091; 0.003)	0.068
Fitness instructor status									0.024 (−0.023; 0.071)	0.323	0.018 (−0.029; 0.065)	0.460	0.017 (−0.030; 0.064)	0.485	0.063 (0.016; 0.110)	0.009	0.063 (0.016; 0.111)	0.009
SMUIS social integration and emotional connection											0.086 (0.024; 0.148)	0.006	0.085 (0.023; 0.148)	0.007	0.084 (0.024; 0.145)	0.006	0.083 (0.023; 0.144)	0.007
SMUIS integration into social routines											−0.024 (−0.084; 0.036)	0.430	−0.024 (−0.084; 0.036)	0.436	−0.004 (−0.063; 0.055)	0.884	−0.003 (−0.061; 0.056)	0.932
Sexuality: heterosexual vs. homosexual													0.013 (−0.062; 0.087)	0.739	−0.013 (−0.086; 0.059)	0.723	−0.013 (−0.086; 0.061)	0.735
Sexuality: heterosexual vs. bisexual													0.024 (−0.042; 0.089)	0.481	0.001 (−0.063; 0.065)	0.983	0.002 (−0.062; 0.066)	0.950
Sexuality: heterosexual vs. "prefer not to say"													0.045 (−0.010; 0.099)	0.106	0.032 (−0.021; 0.085)	0.242	0.031 (−0.022; 0.085)	0.248

(Continued)

TABLE 2 | Continued

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8		Model 9	
	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change	R^2	R^2 change
	0.027	NA	0.079	0.052**	0.098	0.019**	0.180	0.082**	0.180	0.000	0.184	0.004**	0.184	0.000	0.226	0.042**	0.224	−0.002
Exercise hours for leisure (hour/week)															0.217 (0.170; 0.264)	<0.001**	0.214 (0.167; 0.262)	<0.001**
Relationship status: single vs. "In a relationship"																	0.001 (−0.075; 0.035)	0.969
Relationship status: single vs. married																	−0.020 (−0.088; 0.038)	0.477
Relationship status: single vs. widowed																	−0.025 (−0.033; 0.058)	0.442
Relationship status: single vs. "other"																	0.013 (−0.033; 0.058)	0.586

**Indicates significant to less than 0.01.

as assessed by a Q-Q Plot. The Little's MCAR test confirmed that all missing data was random ($p = 0.07$), and therefore were listwise deleted from all regression analyses.

Hierarchical Multiple Regression

In the total sample, each model significantly added to the total R^2, apart from models 5, 7, and 9 (the respective addition of fitness instructor status, sexuality, and relationship status into the previous model). The final multiple regression model (model 9) was statistically significant [$F_{(29,1,500)} = 16.227$, $p \leq 0.001$, adj. $R^2 = 0.224$]. The variables BMI, life limiting illness, being a fitness instructor, exercise hours for leisure, eating disorder status, REI "mood" and "enjoyment" subscales, SMUIS social integration and emotional connection subscale, BDD status, ethnicity black and Asian (vs. white) added significantly to the prediction ($p \leq 0.05$). Full coefficient results and changes in R^2 are shown in **Table 2**.

Indicated vs. No-Indicated Eating Disorders Sub-groups Multiple Regression

Both populations' full regression models were statically significant [indicated eating disorders $= F_{(27,231)} = 2.995$, $p \leq 0.001$, adj. $R^2 = 0.173$; no indicated eating disorders $= F_{(28,1,242)} = 12.383$, $p \leq 0.001$, adj. $R^2 = 0.201$]. In the indicated eating disorders population, the variables BMI, SMUIS social integration, and emotional connection subscale, and ethnicity black and Asian (vs. white) added significantly to the regression model ($p \leq 0.05$). In the no indicated eating disorders population, the variables REI "mood" and "enjoyment" subscales, being a fitness instructor, exercise hours per week, and BDD status added significantly to the regression model ($p \leq 0.05$). Full coefficients for both populations are shown in **Table 3**.

Eating Disorder Interaction Effects

There were significant interactions between eating disorder status and BMI, exercising for mood, exercising for attractiveness, and ethnicity (black vs. white). Full interaction data are shown in **Table 4**.

DISCUSSION

The present study explored the prevalence of exercise addiction among fitness club users, the extent to which age, BMI, gender, sexuality, social media use, BDD, fitness instructor status, eating disorder status, and reasons for exercise were associated with exercise addiction scores, and whether these correlates differed according to eating disorder status. The prevalence of exercise addiction in the total sample was 30.7%, with prevalence rates differing largely according to eating disorder status (indicated eating disorders 60.2%; no indicated eating disorders 24.7%). Characteristics associated with higher exercise addiction scores in multivariable models included: indicated eating disorder, being a fitness instructor, leisure-time physical activity, exercising to improve mood, enjoyment, and for weight control, indicated BDD, and using social media for social integration and emotional connection. Characteristics associated with lower exercise addiction scores included: a higher BMI,

TABLE 3 | Multiple linear regression summary of independent variables (dependent variable = exercise addiction inventory total score).

	Indicated eating disorders		No-indicated eating disorders	
	Beta coefficients (95%CI)	***p*-value**	**Beta coefficients (95%CI)**	***p*-value**
Age	0.027 (−0.140; 0.194)	0.751	−0.046 (−0.112; 0.020)	0.171
Sex	0.059 (−0.067; 0.184)	0.357	−0.011 (−0.069; 0.047)	0.708
BMI[a]	−0.189 (−0.316; −0.062)	0.004**	−0.013 (−0.064; 0.038)	0.616
Life limiting illness	−0.131 (−0.254; −0.008)	0.038*	−0.041 (−0.091; 0.009)	0.107
Fitness instructor status	−0.068 (−0.176; 0.060)	0.297	0.093 (0.040; 0.146)	0.001**
Exercise hours for leisure	0.156 (0.031; 0.280)	0.014*	0.246 (0.194; 0.298)	<0.001**
Homeowner status	0.009 (−0.138; 0.156)	0.903	0.006 (−0.056; 0.068)	0.852
REI weight control	0.008 (−0.125; 0.140)	0.907	0.065 (0.007; 0.122)	0.028*
REI fitness	0.100 (−0.061; 0.282)	0.277	0.024 (−0.039; 0.087)	0.456
REI mood[a]	0.055 (−0.102; 0.213)	0.491	0.244 (0.185; 0.302)	<0.001**
REI health	0.022 (−0.182; 0.226)	0.833	−0.015 (−0.082; 0.053)	0.668
REI attractiveness[a]	−0.046 (−0.188; 0.097)	0.528	0.078 (0.017; 0.139)	0.013*
REI enjoyment	0.028 (−0.117; 0.174)	0.700	0.075 (0.019; 0.131)	0.009*
REI tone	0.089 (−0.032; 0.211)	0.149	−0.078 (−0.130; −0.026)	0.003**
SMUIS social integration and emotional connection	0.204 (0.048; 0.361)	0.011*	0.067 (−0.001; 0.135)	0.054
SMUIS integration into social routines	−0.124 (−0.282; 0.033)	0.121	0.022 (−0.043; 0.088)	0.509
BDD status	0.056 (−0.076; 0.187)	0.405	0.103 (0.050; 0.157)	<0.001*
Sexuality: Heterosexual vs. homosexual	0.038 (−0.221; 0.297)	0.773	−0.025 (−0.104; 0.054)	0.539
Sexuality: heterosexual vs. bisexual	0.085 (−0.149; 0.319)	0.476	−0.029 (−0.098; 0.040)	0.411
Sexuality: heterosexual vs. "prefer not to say"	0.135 (−0.037; 0.308)	0.123	0.016 (−0.042; 0.074)	0.595
Relationship status: single vs. "in a relationship"	−0.051 (−0.193; 0.090)	0.476	−0.005 (−0.066; 0.057)	0.884
Relationship status: single vs. married	−0.070 (−0.227; 0.087)	0.381	−0.013 (−0.084; 0.058)	0.724
Relationship status: single vs. widowed	NA	NA	0.015 (−0.036; 0.065)	0.567
Relationship status: single vs. "other"	−0.026 (−0.147; 0.096)	0.675	−0.006 (−0.056; 0.045)	0.827
Ethnicity: white vs. Hispanic	−0.118 (−0.234; 0.003)	0.045*	0.004 (−0.046; 0.054)	0.871
Ethnicity: white vs. black[a]	−0.320 (−0.443; −0.196)	<0.001**	−0.005 (−0.055; 0.044)	0.832

(Continued)

TABLE 3 | Continued

	Indicated eating disorders		No-indicated eating disorders	
	Beta coefficients (95%CI)	***p*-value**	**Beta coefficients (95%CI)**	***p*-value**
Ethnicity: white vs. Asian	−0.139 (−0.261; −0.017)	0.026*	−0.024 (−0.075; 0.027)	0.358
Ethnicity: white vs. "other"	−0.038 (−0.156; 0.080)	0.524	−0.001 (−0.049; 0.051)	0.959

*$P < 0.05$; **$P < 0.01$.
[a]*Interaction terms showed correlate differs by eating disorder status.*

reporting a life-limiting illness, and ethnicity (black vs. white and Asian vs. white). There were significant interactions between eating disorder status and BMI, exercising for mood, exercising for attractiveness, and ethnicity (black vs. white).

Total Sample

The hierarchical regression showed that the addition of all variables into the model significantly increased the R^2, apart from the addition of fitness instructor status, sexuality, and relationship status, indicting their limited significance in explaining the total variance in EAI scores.

As hypothesized, the strength of associations of the two variables that could be interpreted as "sudden or progressively intolerable life-stress" (eating disorder status and BDD status) in the Interactional Model of EA were among the strongest. This concurs with several studies that have shown that eating disordered subjects suffer from higher EA (Fietz et al., 2014; Trott et al., 2020b), and several studies that show that negative self-body image is positively correlated with exercise addiction (Klein et al., 2004; Ertl et al., 2018). Moreover, this provides initial evidence that these two conditions could be listed in the Interactional Model as possible intolerable life-events. Another variable that had one of the strongest associations with EA was exerting to modify mood. Although this could be interpreted as "psychological health" on the Interactional Model, it also could be dealing with a sudden or progressively intolerable life stress, such as depression or anxiety, which would place this variable into this part of the model. Furthermore, this association broadly concurs with previous studies that have found that exercising for mood is positively correlated with exercise addiction (Serier et al., 2018). Due to this, we propose a modification to the Interactional Model: adding a direct link between "exercise motivation" and "sudden or progressive intolerable life-stress."

Unsurprisingly, leisure-time physical activity was a significant correlate of higher scores of exercise addiction, which concurs with the literature (Hausenblas and Downs, 2002; Adams et al., 2003; Allegre et al., 2007; Costa et al., 2013). One possible mechanism of this relationship could be the desire to increase levels of β-endorphins through increasing amounts of exercise, leading to a relative feeling of euphoria post-exercise (Leuenberger, 2006). Studies in other addictions have suggested that the endogenous opioid system is a key factor in generating addictions (O'Brien, 2004).

Analysis According to Eating Disorder Status

Lower BMI, using social media for social integration and emotional connection, and ethnicity (white vs. black, Hispanic, and Asian) were only positively associated with higher exercise addiction scores among health club users with indicated eating disorders, and fitness instructor status, exercising to improve mood, attractiveness, exercising for enjoyment, and BDD status were only associated with higher exercise addiction scores among health club users without an indicated eating disorder.

Lower BMI was a correlate of higher exercise addiction scores only in health club users who had an indicated eating disorder. This is consistent with the eating disorder literature which states that striving for a lower body weight (and therefore a lower BMI) via excessive exercise is a common symptom of both anorexia and bulimia nervosa (Abraham, 2016), adding to the evidence that exercise levels should be closely monitored in subjects with indicated eating disorders.

Participants who identified as fitness instructors had a slightly higher risk of higher exercise addiction scores than health club users who did not identify as fitness instructors; however, in the sub-populations this was only present in participants who showed no indicated eating disorders. One possible reason is because of the expectation of fitness instructors to exercise as part of their role, and the expectation of superior levels of fitness compared to regular health club users (Thompson et al., 2001); more research is needed to test this hypothesis. A recent study reported that fitness instructors are frequently worried about members in their centers who exhibit EA tendencies but are unsure on how to deal with these people (Colledge et al., 2020). These results suggest that fitness instructors should monitor their peers as well as their members.

Participants who reported exercising to improve their mood, to be more attractive, weight control, tone, and for enjoyment had higher exercise addiction scores; however, this was only seen in participants who had no indicated eating disorders. This is broadly consistent with previous studies that have found that exercising for mood, appearance, and enjoyment is positively correlated with exercise addiction (Serier et al., 2018). The finding that exercising for these reasons was only significant in participants without an indicated eating disorder was interesting as previous studies have found that people who exercise for

TABLE 4 | Interaction effects between independent variables and eating disorder status (dependent variable = exercise addiction inventory total score).

Independent variable by eating disorder status (indicated/not indicated)	Beta coefficients (95%CI)	*p*-value
Age	0.001 (−0.051; 0.052)	0.993
Sex[a]	0.017 (−0.030; 0.064)	0.480
BMI	−0.260 (−0.497; −0.023)	0.032
Life limiting illness[b]	−0.025 (−0.076; 0.025)	0.331
Fitness instructor status[c]	−0.053 (−0.112; 0.006)	0.081
Exercise hours for leisure	−0.069 (−0.162; 0.023)	0.140
Homeowner status[d]	−0.022 (−0.885; 0.045)	0.516
REI weight control	−0.185 (−0.403; 0.034)	0.097
REI fitness	−0.057 (−0.293; 0.179)	0.637
REI mood	−0.314 (−0.510; −0.119)	0.002**
REI health	−0.148 (−0.369; 0.073)	0.190
REI attractiveness	−0.196 (−0.365; −0.027)	0.023*
REI enjoyment	−0.089 (−0.217; 0.039)	0.172
REI tone	0.094 (−0.055; 0.243)	0.217
SMUIS social integration and emotional connection	−0.007 (−0.128; 0.114)	0.911
SMUIS integration into social routines	−0.113 (−0.281; 0.055)	0.187
BDD status[e]	−0.032 (−0.130; 0.066)	0.521
Sexuality: heterosexual vs. homosexual[f]	−0.099 (−0.246; 0.048)	0.187
Sexuality: heterosexual vs. bisexual[g]	0.041 (−0.010; 0.092)	0.112
Sexuality: heterosexual vs. "prefer not the say"[h]	0.021 (−0.029; 0.071)	0.413
Relationship status: single vs. "in a relationship"[i]	0.004 (−0.060; 0.068)	0.902
Relationship status: single vs. married[j]	−0.013 (−0.068; 0.042)	0.645
Relationship status: single vs. widowed[k]	NA (not enough data)	–
Relationship status: single vs. "other"[l]	−0.002 (−0.068; 0.064)	0.953
Ethnicity: white vs. Hispanic[m]	−0.043 (−0.091; 0.005)	0.077
Ethnicity: white vs. black[n]	−0.104 (−0.159; −0.049)	<0.001**
Ethnicity: white vs. Asian[o]	−0.048 (−0.098; 0.002)	0.059
Ethnicity: white vs. "other"[p]	−0.019 (−0.067; 0.029)	0.442

(Continued)

TABLE 4 | Continued

**P < 0.05; **P < 0.01; Dichotomous variable coding:*
[a]Female = 0, Male = 1.
[b]Life limiting illness: No = 0, Yes = 1.
[c]Fitness instructor: No = 0, Yes = 1.
[d]Homeowner status: No = 0, Yes = 1.
[e]BDD status: No = 0, Yes = 1.
[f]Sexuality: Heterosexual = 0, Homosexual = 1.
[g]Sexuality: Heterosexual = 0, Bisexual = 1.
[h]Sexuality: Heterosexual = 0, "prefer not to say" = 1.
[i]Relationship status: Single = 0, in a relationship = 1.
[j]Relationship status: Single = 0, married = 1.
[k]Relationship status: Single = 0, widowed = 1.
[l]Relationship status: Single = 0, other = 1.
[m]Ethnicity: White = 0, Hispanic = 1.
[n]Ethnicity: White = 0, black = 1.
[o]Ethnicity: White = 0, Asian = 1.
[p]Ethnicity: White = 0, other= 1.

mood and appearance reasons are more likely to demonstrate eating pathology (Macfarlane et al., 2016). This adds initial evidence that the links between exercise motivation and EA are different according to eating disorder status, and therefore indicates differing etiology for EA for the two sub-populations. This is important as if the two sub-populations have differing EA etiologies, then it is possible that therapeutic interventions would need to be different. Further research exploring potential mediating relationships between reasons for exercise, eating disorders, and exercise addiction would greatly add to the knowledge in this area.

Participants with indicated BDD were significantly more likely to yield higher exercise addiction scores, but only in participants without indicated eating disorders. Although this concurs with several studies that have shown that negative self-body image is positively correlated with exercise addiction (Klein et al., 2004; Ertl et al., 2018), this is the first study to our knowledge to show that this is not the case in populations with indicated eating disorders. This suggests that BDD is a primary condition in which exercise addiction is a symptom. This is important, as if BDD is a primary condition where EA is a symptom, then the treatment of BDD should yield lower levels of EA. It is therefore recommended that patients presenting with EA symptoms (who do not show evidence of eating disorders) should be screened for BDD before any treatments can be considered.

In the group with indicated eating disorders, participants from ethnic minorities (black, Hispanic, and Asian vs. being white) yielded higher exercise addiction scores. This is the first time such a finding has been reported, and this could be because of the long-recognized limited treatment barriers to eating disorders that subjects from ethnic minorities face (Cachelin et al., 2001; Becker et al., 2003; Coffino et al., 2019). Confirmatory and causal exploration is needed to confirm this relationship and explore interventions to address this.

Exercise Addiction Prevalence

The prevalence of exercise addiction was high in this sample, with 30.7% being classified as at risk of exercise addiction. Prevalence rates differed largely according to eating disorder status, with participants with indicated eating disorders yielding more than double the prevalence rates than those with no indicated eating disorders. These results are broadly in agreement with a recent meta-analysis that showed subjects with indicated eating disorders are over 3.5 times more likely to also have exercise addiction (Trott et al., 2020b). The overall exercise addiction prevalence rate is higher than in several reviews that have estimated prevalence between 3 and 14% (Di Lodovico et al., 2019; Marques et al., 2019). One potential reason could be because of the recruitment strategy and specific population group; this study used social media as a means of recruitment and was restricted to health club users, which is unique in this area of research. This is supported by our finding that using social media for social integration and emotional connection was a significant predictor for higher exercise addiction scores. Social media use has been shown to elicit feelings of negative body image (Perloff, 2014; Fardouly and Vartanian, 2016), which has been shown to be associated with exercise addiction. Social media is an appropriate platform to recruit from, however, primarily due to the number of people who routinely engage in social media. Recent data suggests that 2.2 billion people use social media on a daily basis (Facebook, 2019). The role of social media's influence in the etiology of exercise addiction warrants further exploration.

Limitations and Strengths

This study had several limitations. Firstly, due to the cross-sectional nature of the study design, the direction of correlation (and therefore causality) is impossible to determine. Further longitudinal analysis is required to determine the direction of the observed correlations. Secondly, it has been reported that the EAI can yield false-positive results in elite athletes (Szabo et al., 2015), and it is unknown whether the EAI over-estimates exercise addiction prevalence in other highly active populations who exercise as part of their job, such as fitness instructors. Further validation of this questionnaire in this sub-population is warranted. Thirdly, the variables accounted for a low percentage of the total variation. Moreover, the sample was restricted to health club users who were recruited via social media, making the generalization of the findings across populations difficult. Despite these limitations, the large sample size, novelty of measured correlates, and our findings that significant variables of EA vary according to eating disorder status mean that this study adds significant knowledge to the current EA literature.

CONCLUSION

The key findings from this study suggest a direct link between exercise motivations and EA, especially if the reason for exercising is to modify mood state. It is suggested that exercising to modify mood state, eating disorder status, and BDD status be included in the intolerable life-stress section of the Interactional Model of EA.

Furthermore, this study shows that the etiology of EA differs according to eating disorder status, with variables including social media use, exercise motivation, and ethnicity being uniquely correlated with EA only in populations with indicated eating disorders. Furthermore, BDD is also highly prevalent in subjects without indicated eating disorders and could be a primary condition in which exercise addiction is a symptom. It is recommended that clinicians and practitioners working with patients who present with symptoms of EA should be screened for eating disorders and BDD before treatments are considered, as both eating disorders and BDD have considerably higher co-morbid outcomes than EA, and therefore need to be treated as a primary condition. Furthermore, treatment programs already exist for these two primary conditions and therefore can be implemented easier. The development of screening tools that are able to stratify these populations would be beneficial to both researchers and practitioners.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Anglia Ruskin University Sport and Exercise Sciences Departmental Ethics Panel (ESPGR-03). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MT and LS: study design, data collection, data analysis, and write up. BS, JF, SJ, and LY: study design, data analysis, and write up. CG: study design and write up. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Appendix M: Full version of ‘Exercise addiction prevalence and correlates in the absence of eating disorder symptomology. A systematic review and meta-analysis.’ in the Journal of Addiction Medicine.

[Redacted in the open access version of this thesis]
A copy is available at https://arro.anglia.ac.uk/id/eprint/705350/

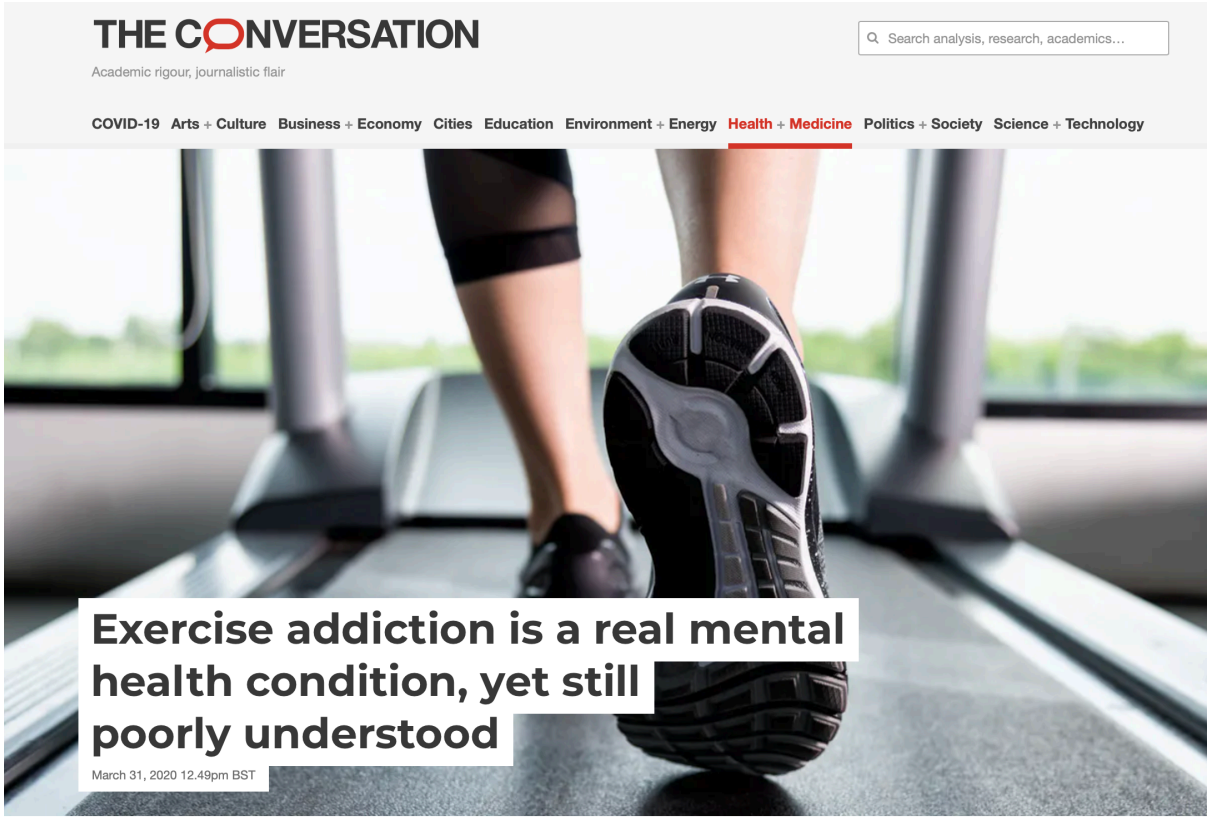
Appendix N: Full version of ‘A comparative meta-analysis of the prevalence of exercise addiction in adults with and without disordered eating.’ in the journal Eating and Weight Disorders

[Redacted in the open access version of this thesis]
A copy is available at https://arro.anglia.ac.uk/id/eprint/705056/

Appendix O: Full version of Changes in body dysmorphic disorder, eating disorder, and exercise addiction symptomology during the COVID-19 pandemic: A longitudinal study of 319 health club users in the journal Psychiatry Research

[Redacted in the open access version of this thesis]
A copy is available at https://arro.anglia.ac.uk/id/eprint/706346/

Appendix P: Full version of The Conversation article titled: Exercise addiction is a real mental health condition, yet still poorly understood.



People with exercise addiction might feel withdrawal symptoms if they don't exercise. Sorapop Udomsri/ Shutterstock

We might assume a person that goes to the gym every day is "addicted" to exercise. But in reality, exercise addiction is a complicated condition that researchers still don't fully understand.

Exercise addiction is different from going to the gym or for a run everyday. Rather, the condition is characterised by an obsessive or compulsive need to exercise, to the detriment of quality of life. For example, a person with the condition might skip a friend's wedding because they "need" to train.

Exercise addicts also experience strong withdrawal symptoms and train through injury, rather than following medical advice. One example of this is the case of Hope Virgo, who exercised so much and ate so little that she had a calcium deficiency, causing her to break bones while exercising.

Key symptoms of exercise addiction generally include:

- Feeling a compulsion to do more and more exercise, or feeling that you're not doing enough
- Training through injury
- Feeling strong withdrawal symptoms if exercise is stopped
- Missing important social events because you "have to" exercise.

Exercise addiction is not currently recognised by either the World Health Organization or the American Psychiatric Association due to a lack of research on the condition. However there's a growing body of research exploring exercise addiction.

How common the issue is seems to vary significantly between different types of exercise. It's estimated that between 0.3-0.5% of the total population (including people who don't exercise) are at risk of exercise addiction. In people who exercise regularly, between 3-7% of people are at risk of developing exercise addiction. However, we can't be sure how accurate these numbers are as there's currently no universally accepted diagnostic criteria for exercise addiction.

Complicated diagnosis

As such, current tools to diagnose exercise addiction assess a person's risk by using an educated guess of what to measure. Some tools are based on medical diagnostic criteria for substance abuse, while others compare symptoms against the experiences of self-defined "exercise addicts". This means that different methods of measuring exercise addiction are reporting on

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different things, which makes it pretty hard to say how common it really is.

Complicating matters further is the athlete paradox. Professional athletes train a lot – typically more than the average gym enthusiast. They definitely have to make sacrifices, often impacting their quality of life because of it – for example, they probably miss social events for training at times.

But if you ask them to analyse their own behaviour, they will often tell you they are just following their training schedule, that they have no choice. Athletes would therefore score highly on standard exercise addiction questionnaires.

Exercise addiction has also been shown to be linked to eating disorders, with a recent study showing that people with eating disorders are 3.7 times more likely to have exercise addiction. In fact, "excessive exercise" is part of the diagnostic criteria for both bulimia and anorexia. This is because people with eating disorders look to find ways to lose weight, and exercise is one way to burn calories.

Exercise addiction has been linked to other mental health conditions, including anorexia and body dysmorphic disorder.
Monkey Business Images/ Shutterstock

Links have also been found between body dysmorphic disorder (also known as body dysmorphia) and exercise addiction. Body dysmorphic disorder is an anxiety disorder in which a person might obsess over one or more perceived flaws in their appearance. This link suggests that negative body image might be intrinsically linked to exercise addiction.

There are also links between exercise addiction, eating disorders and obsessive-compulsive disorder (OCD). People with OCD demonstrate many of the same traits that are present in both exercise addiction and eating disorders such as a lack of control over a compulsion, such as exercise. This shows that exercise addiction could simply be another form of OCD.

Some researchers have argued that exercise addiction does not exist if another disorder isn't present. Yet the majority of research on exercise addiction doesn't screen for primary conditions like eating disorders or body dysmorphic disorder – instead they only looks for signs of exercise addiction.

This means that we just don't know whether or not exercise addiction is an independent condition or simply a symptom of something else. Future research should try focusing on screening for other disorders when looking at exercise addiction to see whether or not this condition exists if other conditions – like eating disorders – aren't present.

Current treatments for potential exercise addiction can include cognitive behavioural therapy, although its efficacy is questionable as limited studies have been conducted. When it comes to treatment, it's important to determine if exercise addiction is the primary condition, or whether it is a symptom of something else. If it's a symptom of another condition, treating the primary condition should be the priority.