

ANGLIA RUSKIN UNIVERSITY

FACULTY OF SCIENCE AND TECHNOLOGY

A TIME-MOTION, TECHNICAL AND TACTICAL ANALYSIS OF LIGHTWEIGHT WOMEN'S
JUDO

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A thesis in partial fulfilment of the requirements of Anglia Ruskin University for the degree of
PhD in Science

Submitted: September 2017

Acknowledgements

Firstly, to my supervisory team of Professor Mike Cole, Dr Mike Callan and Adrian Scruton, your guidance and patience throughout has been so vital to my development as a researcher and as a person. You have not only been fantastic academic supervisors but have been friends throughout.

Secondly, thank you of course to my PhD sponsors, Anglia Ruskin University (ARU). ARU is the only university that gave me a chance all those years ago as a budding undergraduate. Of course, this also includes all the members of the newly formed Department of Sport and Exercise Science who make working life unconventional and effervescent.

My family have always been there for me, my mother has always taught me that hard work will prevail, she has been an inspiration and a rock throughout my life, I have never met a more tenacious person. My sister, Emma, has always provided me with the competition I have needed in life to excel and has given me the greatest niece and nephew anyone could hope for. I love you all.

I would like to thank the members of Comberton Judo Club who have supported me throughout this process with proof reading, data collection and a lot of patience. I would particularly like to mention Tara Fitzjohn for her assistance in coding and Natasha Collins who has been a true friend for many years and counsellor for life.

I would not be the person I am today without judo. I would like to thank Jim McKenzie for keeping me in judo and believing in me when many didn't. I would also like to thank Mark Earle, Neil Adams, Mike Callan, Darren Warner, Daniel Lascau and the late Roy Inman for being coaches and mentors throughout this judo journey.

Finally, I would like to thank the careers advisor at my secondary school who told me it was lucky I had already received an enlistment to the British army because I lacked any other job prospects. Not only have I been able to think about this and chuckle when I really struggled to motivate myself I also learnt a lot about myself, learning, the world and life whilst I served and thus I can only presume your presumptions were precisely incorrect. Nothing I have ever done would have been possible without that discipline and guidance in early adulthood.

About the author

The author has been a British Judo Association coach since 1997. Prior to coaching he spent 4 years on the British Army judo team competing in the UK, USA, Canada, Gibraltar and Spain. He left the army in 1998 to train as a full-time judo player under the guidance of Neil Adams (two times Olympic Silver medallist and world champion) and stayed there for two years.

When he left full time training he studied for a BSc (Hons) in Sports Sciences and graduated in 2004. He also has a second BSc (Hons) in Sports performance and a PG cert in Learning and Teaching. Bob was in the first group to complete the European Judo Union Level 5 High Performance Coach award at the University of Bath, he later ran this course at Anglia Ruskin University from 2010-2016. He is currently a senior lecturer on a BSc (Hons) in Sports Coaching & Physical Education at Anglia Ruskin University where he specialises in athlete development, planning/periodisation and performance analysis.

Bob has coached at Comberton Judo Club since 1999. He is also regularly coaches the army and combined services squads on training camps and at competitions. In 2002 he was the assistant coach to the England judo team at the commonwealth games in Manchester. In 2008 Bob founded Anglia Ruskin Universities Judo club and ran a large judo programme at the university from 2010-2016. The programme consisted of performance athletes, a research group, the Advanced Apprenticeship in Sporting excellence and a community programme. During this period the university won the British university championships men's team event four times and also won bronze in the women's. The achieved 10 individual British university champions throughout the period also.

At Comberton Judo Club where he is currently the head coach there is an England Performance Pathway centre, the Advanced Apprenticeship in Sporting excellence and a number of athletes that train full-time coupled with a large children's programme. Bob regularly attends national squad training and training camps/competitions abroad with the athletes from the club and mentors a number of coaches.

ANGLIA RUSKIN UNIVERSITY

ABSTRACT

FACULTY OF SCIENCE AND TECHNOLOGY

DOCTOR OF PHILOSOPHY

A TIME-MOTION, TECHNICAL AND TACTICAL ANALYSIS OF LIGHTWEIGHT WOMEN'S
JUDO

DARREN G CHALLIS

Submitted: September 2017

Introduction: This study analysed lightweight women's judo from three common aspects, time-motion, technical and tactical in order to develop a deeper understanding of the demands placed specifically on this population and whether they differ to others. This information may allow coaches to develop specific training for this population.

Method: Analysing all the fights that included lightweight women in the 2010 and 2014 World Judo Championships, 251 athletes across 267 contests were analysed. Video was collected live and downloaded from youtube before being analysed in Sportscode Elite software and exported into Microsoft excel and SPSS for further analysis.

Results: Lightweight women appear to have similar time-motion characteristics to previous research across all weight categories. Of the 2284 attacks *Ippon-seoi-nage*, *Uchimata* and *Sode-tsuri-komi-goshi* have the highest frequency but the most efficient throws are *O-soto-gari*, *Morote-seoi-nage* and *O-uchi-gari*. The most prevalent and efficient category for *Tachi-waza* techniques was *Ashi-waza* and in *Ne-waza* it was *Osaekomi-waza*. The effects of laterality and handedness seen in previous research either does not apply to this population or its affects have diminished across judo.

Discussion and conclusion: There are similarities between previous reports across weight categories and lightweight women's judo for time-motion characteristics, types of technique used, category of techniques used, direction of attack, laterality and use of combinations. However, differences appear in the efficiency of counters with lightweight females being very effective at countering their opponents. The popularity of *Sode-tsuri-komi-goshi* should be closely considered by coaches and is likely to be an emerging theme across all weight categories. There is also significant difference in the data analysing the effect of laterality on performance with difference seeming to diminish, this may also be an emerging trend across all weight categories and possibly all sports. This research appears to be one of the first to tackle fatigue based upon elite level performance in judo and the first to categorise *Shido's* by the offence and shows the larger number of offences are for passivity. There are also large discrepancies noted between this research and the IJF databases.

Keywords: Laterality, Penalties, Fatigue, Time-Motion Analysis, Handedness

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Table of Contents

Acknowledgements	ii
About the author.....	iii
Table of Contents	vi
Table of Tables	x
Table of Figures.....	xiii
Glossary of Judo Terminology	xiv
Publications as a result of this research.....	xv
<i>Published</i>	xv
<i>From pilot studies</i>	xv
<i>Work in progress</i>	xv
Chapter 1: Introduction	2
Judo	2
<i>The origins and philosophy of judo</i>	2
<i>Judo as a sport</i>	3
Judo techniques and rules	6
Coaching judo as a sport.....	12
<i>The coaching process</i>	12
<i>The importance of feedback in sports coaching</i>	15
<i>Performance analysis and feedback</i>	15
Chapter 2: Review of Literature	17
Performance analysis	17
<i>Aims</i>	18
Sports specific literature.....	18
<i>Team sports</i>	18
<i>Individual sports</i>	20
<i>Performance analysis in combat sports</i>	22
Fencing and kendo	23
Boxing.....	23
Muay thai and kick boxing.....	24
Taekwondo	25
Karate	26
Wrestling.....	27
Performance indicators in the literature.....	32
Performance analysis in judo.....	35
<i>Technical analysis research in judo</i>	35
<i>Tactical analysis research in judo</i>	41
<i>Time-motion research in judo</i>	41

Other performance analysis research in judo	45
Context and significance of the study	49
<i>Context</i>	49
<i>Significance</i>	49
The aims of this study.....	51
Chapter 3 – Validity and Reliability in Performance Analysis	53
Validity.....	53
Reliability	54
<i>Intra and inter-operator reliability</i>	54
<i>Selecting key performance indicators</i>	57
Chapter 4: Global Methodology	59
Participants	59
Ethical approval.....	59
Equipment	59
Intra-operator reliability and Inter-operator reliability.....	60
Pilot studies	61
Data collection	61
Selection of key performance indicators.....	62
Individual methodologies	62
Chapter 5: A Time-Motion Analysis of Lightweight Women’s Judo.....	65
Introduction	65
Method for time-motion analysis	70
<i>Procedure</i>	70
<i>Reliability</i>	70
<i>Equipment</i>	70
<i>Data analysis</i>	72
<i>Key performance indicators</i>	72
Results	73
<i>Frequency</i>	73
<i>Duration</i>	74
<i>Fatigue</i>	75
Discussion on time-motion analysis in lightweight women’s judo	78
<i>Contest duration</i>	78
<i>Duration of KPI’s within the contest time</i>	79
<i>Hajime to Matte (work time)</i>	79
<i>Matte to Hajime (rest)</i>	80
<i>Ne-waza (ground work time)</i>	80
<i>Tachi-waza (standing work time)</i>	81
<i>Work to rest ratios</i>	82
<i>Frequency of KPIs</i>	82
<i>Fatigue</i>	83
<i>Limitations and future recommendations</i>	84
Conclusions on time-motion analysis in lightweight women’s judo.....	85
Chapter 6: An Analysis of the Technical Components of Lightweight Women’s Judo.....	87

Introduction	87
<i>Tachi-waza</i> in lightweight women's Judo.....	88
<i>Nage-waza versus Tachi-waza</i>	88
<i>Tachi-waza in the literature</i>	88
Tachi-waza research based upon individual profiles.....	88
Tachi-waza research by team/nationality	89
Tachi-waza research with general samples.....	91
<i>Method for Tachi-waza analysis</i>	95
Procedure.....	95
Key performance indicators.....	95
Reliability.....	95
Equipment.....	96
Efficiency.....	96
<i>Tachi-waza results</i>	98
<i>Ne-waza</i> in lightweight women's judo	101
<i>Katame-waza versus Ne-waza</i>	101
<i>Ne-waza in the literature</i>	103
<i>Method for Ne-waza analysis</i>	109
Procedure.....	109
Reliability.....	109
Efficiency.....	109
<i>Ne-waza results</i>	110
Osaekomi-waza.....	110
Submissions - Kansetsu-waza and Shime-waza	111
Discussion on technical components of lightweight women judo	114
<i>Types of techniques used</i>	114
<i>Efficiency of techniques used</i>	117
<i>Categories of techniques used</i>	120
<i>Limitations and future recommendations</i>	122
Conclusions on the technical analysis of lightweight women's judo	122
 Chapter 7: Analysis of the Tactical components of Lightweight Women's Judo	124
Method for tactical analysis study	125
<i>Direction</i>	125
<i>Handedness</i>	125
<i>Laterality</i>	125
<i>Combinations and counters</i>	125
<i>Penalties</i>	126
Laterality and Handedness	127
<i>Literature considering laterality and handedness</i>	127
Laterality	127
Handedness	131
<i>Results</i>	133
Discussion on laterality and handedness	136
Limitations and future research	136
Conclusions on laterality and handedness.....	137
Direction	138
<i>Literature considering direction of throw</i>	138

<i>Results</i>	140
<i>Discussion on direction of throw</i>	140
Limitations and future research	141
Conclusions on directions of throw	141
Combinations & counters	142
<i>Literature considering the use of combinations and counters</i>	142
<i>Results</i>	143
<i>Discussion on combinations and counters</i>	145
Limitations and future research	145
Conclusions on combinations and counters	146
Penalties in lightweight women's judo	147
<i>Current research on penalties in judo</i>	148
<i>Results</i>	151
<i>Discussion on penalties</i>	154
Prevailing shido's	155
Shido's not observed in this study	156
The use of Hansoku-make	156
Inaccuracies of the IJF databases	156
Limitations and future research	157
Conclusions of penalties	157
Chapter 8: Conclusions, Implications and Recommendations	159
Research context and questions	159
Findings from the literature	159
Empirical findings	160
<i>Time-motion analysis</i>	160
<i>Technical analysis</i>	161
<i>Tactical analysis</i>	162
Overview of original contribution	163
Implications for practice	164
Concluding thoughts	164
References	166
Appendices	193
Appendices 1: Challis, D.G., Scruton, A., Cole, M. and Callan, M., 2015. A Time-Motion Analysis of Lightweight Women's Judo in the 2010 World Championships. International Journal of Sports Science and Coaching, 10(3)	194
Appendices 2: Challis, D.G., 2013. A Temporal Analysis of the u52kg Women's Judo in the 2010 World Championships. 8th International Judo Federation World Judo Research Symposium, Rio de Janeiro, Brazil	195
Appendices 3: Challis, D.G., 2011. A Temporal Analysis of the u48kg Women's Judo in the 2010 World Championships. 7th International Judo Federation World Judo Research Symposium, Paris	196

Table of Tables

TABLE 1.1: QUALIFICATION FOR THE 2008 OLYMPIC GAMES. ATHLETES ACCUMULATED POINTS AT THE IJF WORLD RANKING EVENTS SHOWN AND THE TOP 23 MALES AND TOP 14 FEMALES WERE ALLOWED TO PARTICIPATE WITH ONLY ONE FROM EACH COUNTRY.	5
TABLE 1.2: EXAMPLES OF MINOR INFRINGEMENT (<i>SHIDO</i>) AND GRAVE INFRINGEMENTS THAT YIELD A DIRECT DISQUALIFICATION (<i>HANSOKU-MAKE</i>). FOUR <i>SHIDO</i> 'S ALSO CREATE <i>HANSOKU-MAKE</i> , THIS IS SIMILAR TO "YELLOW CARDS" IN FOOTBALL. RULE CHANGES FROM JANUARY 2014 FOR THE RIO 2016 OLYMPIC QUALIFICATION PERIOD	10
TABLE 2.1: A VARIETY OF LITERATURE THAT DEMONSTRATES THE FEASIBILITY OF ANALYSING INDIVIDUAL SPORTS FROM THE VARIOUS PERFORMANCE ANALYSIS PERSPECTIVES TO BE USED IN THIS CURRENT RESEARCH. THE TABLE SHOWS THE RESEARCH OFTEN COMBINES AREAS. COMBAT SPORTS WILL BE CONSIDERED SEPARATELY (TMA= TIME MOTION ANALYSIS).	22
TABLE 2.2: THE USES OF PERFORMANCE ANALYSING COMBAT SPORTS (EXCLUDING JUDO) ALSO SPANS THE SPECTRUM OF PERFORMANCE ANALYSIS AREAS.	31
TABLE 2.3: EXAMPLES OF KEY PERFORMANCE INDICATORS USED IN THE LITERATURE FOR TEAM SPORTS. THE VARIETY OF SPORTS AND THE MOVING ACROSS TECHNICAL, TACTICAL AND TIME-MOTION DATA MAKES IT DIFFICULT TO SURMISE THE MOST POPULAR KEY PERFORMANCE INDICATORS.	33
TABLE 2.4: EXAMPLES OF KEY PERFORMANCE INDICATORS USED IN THE LITERATURE FOR INDIVIDUAL SPORTS.	34
TABLE 2.5: THE 15 MOST FREQUENTLY USED TECHNIQUES DURING THE 1996 OLYMPIC GAMES RANKED AND SPLIT BY GENDER. CERTAIN TECHNIQUES HAVE MANY VARIANTS SUCH AS <i>SEOI-NAGE</i> (<i>ERI</i> , <i>IPPON</i> , <i>MOROTE</i>) AND IN THESE CASES, THEY ARE CLASSED AS ONE SINGLE TECHNIQUE. SIMILAR FOR <i>OSAEMI-WAZA</i> (<i>KUZURE</i> , <i>USHIRO</i> ETC). ADAPTED FROM STERKOWICZ & MASLEJ (1998). IT SHOULD BE NOTED THAT RECENT RULE CHANGES BY THE IJF HAVE BANNED SOME OF THESE TECHNIQUES (DENOTED BY*). .	36
TABLE 2.6: TABULATED RESULTS GIVEN IN FRANCHINI AND STERKOWICZ (1999) FOR THE PERCENTAGES OF ALL SCORING <i>NAGE-WAZA</i> TECHNIQUES FOR EACH CATEGORY OF <i>NAGE-WAZA</i> AND <i>NAGE-WAZA</i> OVERALL FOR THE 1996 OLYMPIC GAMES, 1995 AND 1997 WORLD CHAMPIONSHIP MEDALLISTS. ADAPTED FROM FRANCHINI AND STERKOWICZ (1999).	37
TABLE 2.7: COLLATED DATA FROM FRANCHINI AND STERKOWICZ (2000) SHOWING THE OVERALL PERCENTAGES OF ALL SCORING <i>NAGE-WAZA</i> TECHNIQUES FOR EACH OF THE FOUR THROWING CATEGORIES WITHIN THE 1996 OLYMPIC GAMES, AND THE WORLD CHAMPIONSHIPS OF 1995, 1997 AND 1999. ADAPTED FROM FRANCHINI AND STERKOWICZ, (2000).	37
TABLE 2.8: SACRIPANTI'S BIOMECHANICAL CLASSIFICATION THAT SPLITS THE <i>GOKYO</i> INTO 'COUPLING OF FORCE' AND PHYSICAL LEVER TECHNIQUES. ADAPTED FROM SACRIPANTI (2013).	39
TABLE 2.9: A COMPARISON OF THE TIME-MOTION ANALYSIS LITERATURE IN JUDO INCLUDING WORK SEGMENTS, REST SEGMENTS, NUMBER OF WORK BLOCKS AND TOTAL CONTEST TIME.	44
TABLE 3.2: INTERPRETING ALPHA SCORES	57
TABLE 3.1: INTERPRETING KAPPA SCORES	57
TABLE 5.1: KEY PERFORMANCE INDICATORS FROM MILLER <i>ET AL.</i> , (2015) THAT WERE UTILIZED IN THIS RESEARCH.	72
TABLE 5.2: THE VOLUME OF DATA CODING TO SHOW THE TEMPORAL COMPONENTS OF LIGHTWEIGHT WOMEN'S JUDO ACROSS ALL THREE WEIGHT CATEGORIES. TOTAL HOURS FOOTAGE AND NUMBER OF KPIS.	73
TABLE 5.3: THE MEAN NUMBER OF <i>HAIJIME</i> TO <i>MATTE</i> BLOCKS (WORK), <i>MATTE</i> TO <i>HAIJIME</i> BLOCKS (REST) AND TRANSITIONS/ <i>NE-WAZA</i> (GROUND WORK) FOR EACH WEIGHT GROUP WITH THE STANDARD DEVIATION.	73

TABLE 5.4: THE MEAN CONTEST DURATION IN MINUTES AND SECONDS (M.S) BY WEIGHT CATEGORY. A ONE-WAY ANOVA SHOWED NO SIGNIFICANT DIFFERENCE ACROSS WEIGHT CATEGORIES FOR EACH YEAR OR BETWEEN YEARS ($P < 0.05$).	74
TABLE 5.5: THE MEAN DURATION OF <i>HAJIME TO MATTE</i> BLOCKS (WORK), <i>MATTE TO HAJIME</i> BLOCKS (REST), <i>TACHI-WAZA</i> (STANDING) AND TRANSITIONS/ <i>NE-WAZA</i> (GROUND WORK) FOR EACH WEIGHT GROUP WITH THE STANDARD DEVIATION.	75
TABLE 5.6: FATIGUE DATA COMPARING FIRST FOUR AND LAST FOUR BLOCKS ACROSS FOUR DIFFERENT KPIS. AN INDEPENDENT SAMPLE T-TEST SHOWS A SIGNIFICANT DIFFERENCE BETWEEN FIRST FOUR AND LAST FOUR BLOCKS WITHIN YEARS FOR <i>HAJIME TO MATTE</i> (WORK) AND <i>TACHI-WAZA</i> (STANDING) AS WELL AS A SIGNIFICANT DIFFERENCE BETWEEN YEARS FOR SOME KPI'S.....	77
TABLE 6.1: THE TOP FIVE <i>TACHI-WAZA</i> TECHNIQUES ACCORDING TO EFFICIENCY FOR EACH OF THE FIVE COMPETITIONS.	94
TABLE 6.2: DEFINITIONS OF THE KPIS IN THE TECHNICAL CODE WINDOW.....	95
TABLE 6.3: VARIETY OF <i>TACHI-WAZA</i> TECHNIQUES USED, SCORES, NO SCORES AND TOTAL NUMBER OF ATTACKS SHOWN ALONGSIDE THE "SUCCESS RATE" FOR <i>TACHI-WAZA</i>	98
TABLE 6.4: MOST PROLIFIC THROWS - TAKEN FROM THE TOP 5 MOST PROLIFIC THROWS IN EACH WEIGHT I.E ATTEMPTED THE MOST TIMES. AN EMPTY CELL SHOWS THAT TECHNIQUE WAS NOT TOP 5 IN THAT WEIGHT/YEAR.	99
TABLE 6.5: EFFICIENCY OF THE TOP 5 MOST PROLIFIC THROWS IN EACH WEIGHT CATEGORY. AN EMPTY CELL SHOWS THAT TECHNIQUE WAS NOT TOP 5 IN THAT WEIGHT/YEAR	100
TABLE 6.6: NUMBER OF THROWS BY <i>TACHI-WAZA</i> CATEGORY.	100
TABLE 6.7: TAKEN FROM BOCIOACA (2014) SHOWING THE FREQUENCY OF TECHNIQUES AND THEIR EFFECTIVENESS.	106
TABLE 6.8: SHOWS ALL THE <i>OSA KOMI-WAZA</i> USED SORTED BY THE EFFICIENCY.....	110
TABLE 6.9: FREQUENCY OF <i>KANSETSU-WAZA</i> AND <i>SHIME-WAZA</i> BY WEIGHT CATEGORY AND YEAR.	112
TABLE 6.10: VARIETY OF <i>NE-WAZA</i> TECHNIQUES USED, SCORES, NO SCORES AND TOTAL NUMBER OF ATTACKS SHOWN ALONGSIDE THE "SUCCESS RATE" FOR <i>NE-WAZA</i>	113
TABLE 6.11: TOP 5 MOST FREQUENT TECHNIQUES AS CITED IN THE LITERATURE.	115
TABLE 6.12: FREQUENCY RANKED AS 5 TECHNIQUES BY AUTHOR.....	116
TABLE 6.13: EFFICIENCY OF TECHNIQUES RANKED WITHIN TOP 5 BY THE AUTHORS.	118
TABLE 6.14: TOP 5 MOST EFFICIENT TECHNIQUES AS CITED IN THE LITERATURE.	119
TABLE 6.15: CATEGORY OF <i>TACHI-WAZA</i> TECHNIQUES RANKED BY THE AUTHOR.....	121
TABLE 6.16: RANKING OF <i>TACHI-WAZA</i> GROUPS BASED UPON RELEVANT LITERATURE.....	121
TABLE 7.1: KEY PERFORMANCE INDICATOR DEFINITIONS FOR LATERALITY AND HANDEDNESS.....	126
TABLE 7.2: ADAPTED FROM STANKOVIC ET AL., (2015), GRIP CONFIGURATION BROKEN DOWN INTO LIGHT, MIDDLE AND HEAVY WEIGHT	131
TABLE 7.3: NUMBER OF TECHNIQUES USED IN <i>AI-YOTSU</i> AND <i>KENKA-YOTSU</i> SPLIT BY WEIGHT AND YEAR.....	133
TABLE 7.4: LIST OF PREVALENT TECHNIQUES IN <i>AI-YOTSU</i> AND <i>KENKA-YOTSU</i> AS WELL AS <i>TACHI-WAZA</i> CATEGORY	133
TABLE 7.5: HANDEDNESS BY WEIGHT CATEGORY AND YEAR.....	134
TABLE 7.6: COMBINING DATA FROM LATERALITY, HANDEDNESS, AND SCORES TO DEMONSTRATE EFFICIENCY OF LEFT AND RIGHT ATTACKS IN <i>AI-YOTSU</i> AND <i>KENKA-YOTSU</i>	135
TABLE 7.7 NUMBER OF COUNTER TECHNIQUES, DIRECT ATTACKS, <i>RENRAKU-WAZA</i> AND <i>RENZOKU-WAZA</i> BROKEN DOWN INTO WEIGHT CATEGORY AND YEAR.....	144

TABLE 7.8: MOST COMMONLY PRESENTED TECHNIQUES AS <i>KAESHI-WAZA</i> , DIRECT ATTACKS, <i>RENRAKU-WAZA</i> AND <i>RENZOKU-WAZA</i>	144
TABLE 7.8: SHOWS THE NUMBER OF PENALTIES BY CLASSIFICATION, WEIGHT CATEGORY AND YEAR	152

Table of Figures

FIGURE 1.1: COTE <i>ET AL.</i> , (1995) MODEL OF THE COACHING PROCESS HAS THE COACHES MENTAL MODEL OF THE ATHLETES' POTENTIAL AT THE CENTRE AND COMPETITION, TRAINING, ORGANISATION AS THE MAIN VARIABLE. ON THE OUTSIDE ARE OTHER INFLUENCING FACTORS. ADAPTED FROM COTE'S <i>ET AL.</i> , (1995).....	14
FIGURE 4.1: THE HIERARCHY OF CODING.....	63
FIGURE 5.1: TIME-MOTION ANALYSIS CODE WINDOW USED IN THIS STUDY.	71
FIGURE 5.2: LABELLING FUNCTION LINKED TO WORLD RANKING LIST FOR TIME-MOTION ANALYSIS CODE WINDOW. THE NAME, COUNTRY, GENDER AND WEIGHT CATEGORY WERE CHANGED FOR EACH FIGHT USING THIS METHOD.....	71
FIGURE 5.3: COMPARISON OF KPIS BETWEEN 2010 WORLD CHAMPIONSHIPS AND 2014 WORLD CHAMPIONSHIPS IN SECONDS. A PAIRED SAMPLES T-TEST SHOWED SIGNIFICANT DIFFERENCES BETWEEN <i>HAIJIME</i> TO <i>MATTE</i> (WORK) TIME AND <i>TACHI-WAZA</i> (STANDING) TIME ($P<0.05$).	82
FIGURE 6.1: DATA SHOWING THE RESULTS OF ADAM <i>ET AL.</i> , (2011b) FOR EFFICIENCY OF <i>TACHI-WAZA</i> CATEGORIES.....	94
FIGURE 6.2: THE TECHNICAL CODE WINDOW IN STATIC STATE.	97
FIGURE 6.3: THE TECHNICAL CODE WINDOW IN SHOWING THE TECHNIQUES WHEN A CATEGORY IS PRESSED, THIS MEANS THE CODER CANNOT FORGET THE CATEGORY.	97
FIGURE 6.4: THE TECHNICAL CODE WINDOW SHOWING THE LABELLING SYSTEM USING THE 'RENAME' FUNCTION.....	97
FIGURE 6.5: ARTICLE 16 OF THE INTERNATIONAL JUDO FEDERATIONS REFEREEING RULES (IJF, 2011).....	102
FIGURE 6.6: WORK TO REST TIME AND THE CONTRIBUTION OF <i>TACHI-WAZA</i> TO <i>NE-WAZA</i> AS PREVIOUSLY REPORTED IN CHAPTER 5.	103
FIGURE 6.7: <i>KUZURE-KESA-GATAME</i> VARIANT.	111
FIGURE 6.8: <i>MUNE-GATAME</i> OR <i>KUZURE-YOKO-SHIHO-GATAME</i> VARIANT.	111
FIGURE 6.9: <i>HIZA-GATAME</i> FROM <i>KESA GATAME</i>	112
FIGURE 6.10: TWO VARIANTS OF THE SAME STRANGLE DESCRIBED AS "OTHER"	113
FIGURE 7.1: ON THE LEFT <i>AI-YOTSU</i> , IN THIS CASE BOTH ATHLETES ARE RIGHT HANDED IN A SLEEVE LAPEL GRIP. NOTICE THEY ARE RIGHT FOOT TO RIGHT FOOT. ON THE RIGHT <i>KENK-YOTSU</i> , NOTICE IN THIS STANCE THE LAPEL ARMS ARE AGAINST EACHOTHER AND THE ATHLETES ARE LEFT FOOT TO RIGHT FOOT.	128
FIGURE 7.2: <i>IPPON-SEOI-NAGE</i> BY A RIGHT-HANDED ATHLETE CONDUCTED TRADITIONALLY FROM THE SLEEVE GRIP. THE ATHLETE TURNS IN THE DIRECTION A RIGHT-HANDED ATHLETE IS EXPECTED TOO (LEFT ROTATION/ANTI-CLOCKWISE).....	132
FIGURE 7.3: <i>IPPON-SEOI-NAGE</i> BY A RIGHT-HANDED ATHLETE WHO IS ATTACKING OFF THE LAPEL GRIP AND THEREFORE TURNS THE OPPOSITE WAY (RIGHT/CLOCKWISE).....	132
FIGURE 7.4: DIRECTIONS MOST COMMONLY SEEN IN LIGHTWEIGHT WOMEN'S JUDO WITH NUMBER OF ATTACKS AND MOST PREVALENT THROW IN THAT DIRECTION. GREEN FEET REPRESENT <i>TORI</i> AND RED FEET <i>UKE</i>	140
FIGURE 8.1: TECHNIQUE EFFICIENCY, FREQUENCY AND CATEGORY BASED UPON THE RESULTS OF THIS STUDY. THE FURTHER RIGHT A BUBBLE IS THE MORE EFFICIENT IT WAS AND THE LARGER THE BUBBLE MORE FREQUENT IT WAS.	162
FIGURE 8.2: WORDS USED MOST OFTEN THROUGHOUT THE THESIS. THE LARGER THE WORD THE MORE FREQUENTLY IT WAS USED. SOURCE: WWW.WORDLE.NET.	165

Glossary of Judo Terminology

Ai-yotsu - Same grip used by both persons, either right or left

Ashi-waza - Foot techniques

Ayumi-ashi - Ordinary pattern of walking

Eri - Collar, lapel

Fusen-gachi - Win by default

Golden score – a period of time at the end of the contest with no clear winner where any score or penalty wins

Hajime - Begin/Start

Hando-no-kuzushi - Unbalancing by reaction

Hansoku-make - Most serious penalty, disqualification

Hantei - Referee call for judge's decision

Happo-no-kuzushi - Kuzushi in 8 directions

Hiki-wake - No decision--tie or draw

Hikite - Pulling hand (usually the hand gripping a sleeve)

IJF – International Judo Federation

Ippon - Victory in one move, one point

Jigotai - Defensive posture

Jita-kyoei - Principle of mutual prosperity

Judogi - Judo practice uniform

Judoka - Person who studies judo

Kaeshi-waza - Counter techniques

Kake - Completion or execution of technique

Kansetsu-waza - Joint locking techniques

Katame-waza – grappling techniques, can be in standing position or on the ground

Kenka-kotsu - Opposite grips used by each person, one right/one left

Koshi-waza - Hip techniques

Kumi-kata - Gripping methods

Kuzure - Modified hold

Kuzushi - Unbalancing the opponent

Matte - Stop (wait)

Nage-komi - Repetitive throwing practice

Nage-waza - Throwing techniques

Ne-waza - Techniques on the ground

Osaekomi - Pin, referee call to begin timing

Osaekomi-waza - Pinning techniques

Randori - Free practice

Rei - Bow

Renraku-waza - Combination techniques in opposite directions

Renraku-waza – Combination techniques in the same direction

Shiai - Contest

Shido - Penalty

Shime-waza - Choking techniques

Sore-made - Finished, time is up

Sutemi-waza - Sacrifice techniques

Tachi-waza – techniques in a standing position

Tai-sabaki - Body control, turning

Tatami - Mat

Te-waza - Hand techniques

Toketa - Escape, stop timing of hold

Tokui-waza - Favorite or best technique

Tori - Person performing a technique

Tsugi-ashi - Walking by bringing one foot up to another

Tsukuri - Entry into a technique, positioning

Tsuri-te - Lifting hand

Uchikomi - Repeated practice without completion

Uke - Person receiving the technique

Ukemi - Breakfall techniques

Waza - Technique

Wazari - Near ippon or half point

Wazari-awasete-ippou - Two waza-ari together for *ippou*

Yuko - Score less than a waza-ari

Yusei-gachi - Win by judge's decision

Publications as a result of this research

Published

Challis, D.G., Scruton, A., Cole, M. and Callan, M., 2015. A Time-Motion Analysis of Lightweight Women's Judo in the 2010 World Championships. *International Journal of Sports Science and Coaching*, 10(3).

Challis, D.G., 2013. A Temporal Analysis of the u52kg Women's Judo in the 2010 World Championships. *8th International Judo Federation World Judo Research Symposium*, Rio de Janeiro, Brazil.

Challis, D.G., 2011. A Temporal Analysis of the u48kg Women's Judo in the 2010 World Championships. *7th International Judo Federation World Judo Research Symposium*, Paris.

From pilot studies

Miller, G., Collins, N., Stewart, M., and **Challis, D.G.**, 2015. Throw type and technique efficiency of *Nage-waza* used in the 2013 Junior and Senior British Judo Championships. *International Journal of Performance Analysis in Sport*, 15(1).

Collins, N. and **Challis, D.G.**, 2013. An Analysis of Kumi Kata at the Junior and Senior British Championships 2013. *8th International Judo Federation World Judo Research Symposium*, Rio de Janeiro, Brazil.

Work in progress

Challis, D.G., Scruton, A., Cole, M., Collins, N., and Callan, M. (in preparation). A Technical and Tactical Analysis of Lightweight Women's Judo at the 2010 and 2014 World Judo Championships: Effects of Rule Changes. TBC

Challis, D.G., Scruton, A., Cole, M., Collins, N., and Callan, M. 2017. A Temporal Analysis of Lightweight Women's Judo in the 2014 World Judo Championships: Effects of Rule Changes. TBC

Challis, D.G., Scruton, A., Cole, M., Collins, N., and Callan, M. (in preparation). Penalties Awarded in the Lightweight Women's Categories of the 2010 and 2014 World Championships. TBC

Callan *et al.*, (2018) Science in Judo. Routledge. Chapter 14. Notational Analysis in Judo.

Fitzjohn, T and **Challis, D.G.** (in preparation) Is Profiling *Judoka* Using Performance Analysis a Beneficial Coaching Tool? TBC.

Chapter 1: Introduction

Chapter 1: Introduction

Judo

The origins and philosophy of judo

In 1882 after more than four years of studying *Tenjinshinyo jujitsu* a young Jigoro Kano opened his own dojo in Tokyo and began to teach what he called *Kodokan judo* (Hoare, 2009 p56). Whilst Kano initially started learning *jujitsu* as a means of defence and to improve his comparatively frail physique he soon realised that modified *jujitsu* would make a fine physical training method and competitive exercise (Kano, 2005 p18-31; Hoare, 2009 p43-44; Stevens, 2013 p6 and Kodokan, 2009 p2). As an educator, academic, economist and politician Kano felt that learning a martial art should be more than self-defence and in 1888 finished a lecture to the Japanese education society with the following:

“Education, whether to advance the nation or society, was required to impart knowledge to the citizens, to train them in mind and body and to transmit enlightenment to this generation and the next. As for the individuals independent happiness, current education is biased towards intellectual training and failed to produce men of character. Since judo is the most appropriate form of physical and moral education, if it were put into the nation’s education curriculum not only would it correct the defects noted above but would without doubt foster, spirit, bravery and patriotism and help place Japan among the top nations in the world”

(Kano, 1888 during a lecture entitled ‘A summary of judo and its educational value’, cited in Hoare, 2009. p129).

Kano ultimately adopted two overriding principles of judo - *Seiryoku-zenyo* (moral use of body and mind; often referred to in English as “maximum efficiency”) and *Jita-kyoei* (mutual welfare and benefit) (Kodokan, 2009 p38-43; Stevens, 2013 p194).

Kano believed that judo could be a vehicle to the globalisation of Japan and Japanese culture. From one of the first foreign judoka to train in Japan, Captain H.E Hughes, in 1893 and the

first judo clubs outside of Japan, probably Seattle, US in 1903 and Cambridge, UK in 1906, judo has grown to become the sport with the second most participants in the world (Brousse and Matsumoto, 1999). There are currently 203 countries with national judo federations recognised by the International Judo Federation (IJF, 2015).

The exact origins of women's judo are not clear, but it is known that a Japanese woman named Ashiya Sueko was taught judo around 1893 by Tomita Tsunejiro with permission of Kano. It is also known that around 1900 Miyazawa Hisako was tutored by Kano himself. In 1904 Kano welcomed a woman named Noriko Yasuda as a co-researcher in return for tuition in judo. He was researching the effects of judo practice on health (Kodokan, 2009). Kano is known to have promoted women to dan grades in 1934 for the first time. Women's judo developed more quickly in other countries and women competed in the European Championships in 1975, the world championships in 1980 and the Olympic games from 1992 (Hoare, 2005).

Kano believed that there were three aspects to judo - (i) training for defence and attack, (ii) cultivation of the mind and body, (iii) self-perfection for the betterment of society. Kano also related this to three levels of judo. The lower level was considered to be the development and practice of defence and attack. The middle level is based upon the cultivation of mind and body and included observing others' methods, adapting these methods to suit oneself, and the development of self-control. Finally, the upper level means making the most effective use of the mental and physical energy you acquired at the lower and middle levels and contributing to society, thus the upper level requires the most creativity and has the widest application (Kano, 2005). It is acknowledged that the research undertaken in this thesis is aimed at developing what Kano describes as the lowest level of judo. However, it is hoped that by dissipating this knowledge to a wider community, in an academic context, whilst focussing on a lesser developed area and aligning it to academic research in other sports, this work can be seen as a contribution to society.

Judo as a sport

In 1964 judo became an Olympic sport for men and although it was not selected to be included in the 1968 Olympic games it has been since 1972 (Soames & Inman, 1990). This sportification of judo meant that it spread further afield but often with less emphasis on the founding principles described above and more emphasis on winning (Sato, 2013; Moshanov, 2004).

According to Daigo (2005) *Kodokan* Judo is based upon three training methods, *Kata* (Formal demonstrations), *Randori* (Free practice/sparring) and *Shiai* (Contests). However, the

sportification of judo brought about changes in training methodology, mental preparation, techniques and inevitably with the evolution of contest rules came the evolution of tactics. The inclusion of judo in the Olympic games has meant a bias towards the development of *Shiai* (Sikorski, 2005). The early years of sportification were also a period in which the application of science to sports was rapidly increasing particularly in Eastern Europe and the USA due to the cold war (Brokhin, 1978, Sikorski, 2005). These countries used a wealth of sport specific scientific knowledge to develop their sporting performance. Elements such as biomechanics, physiological testing, tactical analysis, psychology, motor learning principles and nutrition were all manipulated (Brokhin, 1978).

A major development in judo was the inclusion of women in the 1992 Barcelona Olympic games. Women had the same number of weight categories as men and therefore could win the same number of medals. They had previously been included on the 1988 Seoul Olympic games as a demonstration event.

A second major development in judo was the collapse of the former Soviet Union. This collapse resulted in one competitive judo nation becoming 15. In addition, there was an influx of Chechen wrestlers to Turkey and Georgian wrestlers to Greece further strengthening the competitive ability of nations. The emphasis of judo in the former Soviet Union coupled with the mix of various traditional wrestling systems (Moshanov, 2004; Petrov, 2014) meant that judo saw a large increase of nations wishing to compete at Olympic level from the 1996 Olympic games onwards. As a result, the International Judo Federation (IJF) was forced to introduce the Olympic qualification system limiting the number of athletes who could compete in any one Olympic games. It is important that the International Olympic Committee (IOC) has the ability to control the number of athletes and demographics of these athletes to ensure the universality of the Olympic games. Qualification for an Olympic games is based upon the number of points awarded for competing at specified championships. Points are awarded based upon the position an athlete finishes in. Table 1.1 shows the point distribution for the London 2012 Olympic qualification period. The qualification system changed from the pre-Beijing 2008 system to a new London 2012 system (IJF, 2010) in order to make the system even more inclusive and fair. On the 1st December 2008, the International Judo Federation (IJF) announced significant changes to its Olympic qualification system that would start from January 2009 (IJF, 2008; Wicks, 2009).

Qualification for the 2008 Olympic games was based predominantly on a continental quota system with a further six places per weight group qualifying directly from the world championships. There were also 14 places, one per weight group, reserved for the host nation

and 20 places reserved as invitation places. These invitation places were reserved for national Olympic committees to nominate athletes based upon previous results, injury during qualification period or lack of representation from a nation (Canadian Olympic Committee, 2008).

The total of ranking points for each player will amount to the sum of his/her five highest point scores during each 12-month period. In the first 12 months after the tournament the points will count 100%. After 12 months, the points will be reduced to 50%. After 24 months, the points will be reduced to zero and not accounted anymore. At the end of May in the Olympic year the top 23 male athletes and top 14 female athletes compete in the Olympic games (top one from each country).

Table 1.1: Qualification for the 2008 Olympic games. Athletes accumulated points at the IJF world ranking events shown and the top 23 males and top 14 females were allowed to participate with only one from each country.

Points	World cup	Grand Prix	Grand Slam	Masters	World champs	continental champs	OG
1st place	100	200	300	400	500	180	600
2nd place	60	120	180	240	300	108	360
3rd place	40	80	120	160	200	72	240
5th place	20	40	60	80	100	36	120
7th place	16				80	28	96
1/16th	12	24	36		60	20	72
1/32nd	8	16	24		40	12	48
1 fight	4	8	12		20	8	24
participation					4		

The qualification for the 2012 Olympic games was split as follows:

- As previously there were 14 places reserved for the host nation and 20 “invitation places”
- Direct qualification was through the world ranking list (WRL) and for the top 22 male athletes in each weight group (7 x 22= 154 places) and the top 14 females (7 x 14= 98 places). If a nation had two players ranked within this direct qualification they could select which player competes.

- A further 100 places reserved for continental qualifications based upon the continent.

The result of the two qualification systems was that 92 countries competed in judo in 2008 Olympics (IJF, 2008) with 25 countries winning medals (Judo Inside, 2008) and 134 countries competing in London 2012 with 23 winning medals (Judo Inside, 2014). For the first time Japan did not top the medal table with this accolade going to Russia.

Between the 1992 Olympics in Barcelona and the 2012 Olympics Games in London (including the London Games) 47 men from former Soviet Union countries won Olympic medals, through the same period only two women from former Soviet Union countries won Olympic medals. The break-up of the former Soviet Union means there are now 15 countries that can win a medal rather than just one. These countries often have judo and wrestling traditions (Moshanov, 2004) but due to religious beliefs, traditions and past experience within the Soviet Union these countries have far fewer female participants. For example, a resolution drawn up by the USSR Sport Committee in 1973 discouraged women from taking part in sports that were “harmful to the female organism” and “encouraged male voyeurism.” Sports singled out for were physical-contact activities like soccer, wrestling and judo (Riordan, 1991).

Judo techniques and rules

According to Kano (1994) and Daigo (2005) there are two forms of judo technique that make up the official techniques of sport judo (a third form of technique is *Atemi-waza* but this is not allowed in judo as a sport) - these are: *Nage-waza* (throwing techniques) and *Katame-waza* (grappling techniques). *Nage-waza* are further divided into five categories, known as the *Gokyo*: *Te-waza* (hand throws); *Ashi-waza* (leg throws); *Koshi-waza* (hip throws); *Mae-sutemi-waza* (front sacrifice throws) and *Yoko-sutemi-waza* (side sacrifice throws). *Katame-waza* is subdivided into *Osaekomi-waza* (Holding/pinning techniques), *Kansetsu-waza* (Joint locking techniques, usually of the elbow), and *Shime-waza* (Strangulation/choking techniques). Any of these used quickly and effectively can terminate a contest prematurely. The leading authority on these techniques and their classifications is the *Kodokan* Judo Institute in Tokyo.

In 1882, on graduation, Kano was appointed as a lecturer in politics and economics, in the *Gakushuuin*, a private school for the higher classes, this was also the year he formed his own jujitsu school, known as the *Kodokan*. The *Kodokan* was held in a small room containing eight mats in Eishoji Temple, a Buddhist monastery, (Kano, 2005). Incorporating a number of educational philosophies, the aim was to make the most efficient use of mental and physical

energies. Judo was developed as a competitive sport and a way of life. It was a physical expression of Kano's ideas about education (Callan, 2008).

Although these techniques and classifications rarely change there is a chronological list of changes on the *Kodokan* website (Kodokan, 2011). However, in the sport of judo there are many innovations and adaptations of techniques in order to gain an advantage over the opponent. In 2005 Inman presented to the IJF recommendations of *Shin-Kokusai-Shiai-Waza* or "Classification of Innovative International Competition Techniques." These were recognised by the IJF but do not appear on the officially recognised *Kodokan* Institute website (Kodokan, 2011). Since Inman's presentation rule changes have banned many of these *Shin-Kokusai-Shiai-Waza* because *Tori* (the attacker) grasps the legs with his hand or both hand; thus, they are no longer seen in competitive judo.

The rules of judo change in a periodic manner in an attempt to bring back a more traditional upright style of judo, distance judo from other combat sports and encourage the time spent in combat (IJF, 2013b, IJF, 2016, EJU 2013). Abdel-Raouf and Abdelhalem (2011) and the International Judo Federation (2009) explained how the rules were amended by the IJF for the period from 1/01/2010 until 31/12/2012, the main summary of those rules is below:

All direct attacks or blocking by gripping the leg (below the belt) with one or two hands are prohibited. The punishment after the first attack is *Hansoku-make* (disqualification)

Grips of the legs are authorised in sequence of a technique or a counterattack if it's real and well-differentiated in time. A real technique is the opposite of a false attack, it is a technique with an intention to make the opponent fall

Gripping the leg is also authorised when the opponent takes a cross guard grip; however, if the cross guard has occurred by the judoka ducking their head under the opponent's arm, they are not authorised to grip the leg, if they do so the punishment would be *Hansoku-make*.

It could have been predicted that these new rules would affect the physiological demands in competition. For example, Meir *et al.*, (2001) reported an even greater demand was placed on the aerobic capabilities of rugby league athletes after the 10-meter rule change was brought in. However, to date there has been no research on changes in physiological demands on *Judoka* changing based upon time-motion analysis with regards to changes in competition rules. Time motion research in judo will be considered in the literature review.

The IJF 2010-2012 rules (IJF, 2011) cause three techniques within the *Nage-waza* category to become prohibited and punishable by *Hansoku-make* (disqualification). These techniques are *Kani-basami* (scissors throw), *Kawazu-gake* (leg entanglement throw) and *Daki-age* (high lift) (Adam, Smaruj and Pujso, 2012). Furthermore, throws that often include the grabbing of the opponents' leg, such as *Morote-gari* (two handed reap) or *Kata-guruma* (shoulder wheel) are seldom seen within competition judo, again due to the changes in the IJF rules and regulations which at the time prohibited a direct leg grab (Adam *et al.*, 2012). Some throws are rarely applied within competition due to their complexity and/or their inability to be performed in such situations, for instance *Obi-otoshi* (belt drop) and *Tawara-gaeshi* (Rice bag reversal throw) (Adam, Smaruj and Pujso, 2012).

There were further rule changes in January 2014 for the Rio 2016 Olympic qualification period. These are outlined below and copied verbatim from the IJF rules update configured in Ljubljana 28 October 2013.

Referees and judges:

One referee on the mat with a radio communication system is connected to the two referees on the table of the mat who will assist with a video CARE system. This system allows the referees at the table to review the footage repeatedly and in slow motion if required until a decision can be made. At major tournaments, the system is also linked the IJF refereeing commission who can review live.

Technical assessment:

- *Ippon*: To give more value and to take into account only the techniques with a real impact on the ground on the back. When the fall is rolled without real impact, it is not possible to consider it *Ippon*.
- *Yuko*: When a contestant throws his opponent, with control, and the opponent falls on the side of the upper body it should be *Yuko*.

Landing in the bridge position:

All situations of landing in the bridge position will be considered *Ippon*.

Penalties:

During the fight, there will be three *Shidos*, and the fourth will be *Hansoku-make* (3 warnings and then disqualification). *Shidos* do not give points to the other fighter, only technical scores can give points on the scoreboard. At the end of the fight, if scoring is equal on the scoreboard,

the one with less *Shidos* wins. If the fight continues to Golden Score, the first receiving a *Shido* loses, or the first technical score will win. Examples of minor infringements (*Shido*) and major infringements (*Hansoku-make*) are shown in Table 1.2.

Shido will be given to the fighter deserving it, in place, without having both fighters return to the formal start position (*Matte – Shido – Hajime*) except when a *Shido* is given for leaving the contest area.

There are three types of *Hansoku-make* (i) accumulation of four *Shido*'s (ii) direct *Hansoku-make* for grave infringement that is technical in nature i.e. To “dive” head first onto the tatami by bending forward and downward while attempting to perform techniques such as *Uchi-mata*, *Harai-goshi*, etc and (iii) direct *Hansoku-make* for something that is against the spirit of judo. The two former *Hansoku-make* result in the contest being awarded to the opponent whilst the latter can result in disqualification from the tournament.

Duration of Contests

No time limit for Golden Score (*Hantei* is cancelled). Contest times are five minutes for senior men and four minutes' senior women.

Table 1.2: Examples of minor infringement (*Shido*) and grave infringements that yield a direct disqualification (*Hansoku-make*). Four *Shido*'s also create *Hansoku-make*, this is similar to “yellow cards” in football. Rule changes from January 2014 for the Rio 2016 Olympic qualification period

<i>Shido</i> (Minor infringement)	<i>Hansoku-make</i> (disqualification)
Breaking the grip of the opponent with two hands	To apply <i>Kansetsu-waza</i> anywhere other than to the elbow joint
Cover the edge of the <i>Judogi</i> jacket to prevent the grip	To lift off the <i>Tatami</i> the opponent who is lying on the <i>Tatami</i> and to drive him back onto the <i>Tatami</i>
Cross gripping should be followed by an immediate attack. Same rule as for belt gripping and one side gripping	To apply <i>Kawazu-gake</i> . (To throw the opponent by winding one leg around the opponent's leg while facing more or less in the same direction as the opponent and falling backwards onto him)
Contestant does not engage in a quick <i>Kumi-kata</i> or who tries not to be gripped by the opponent. If one of the contestants breaks the <i>Kumi-kata</i> twice in the gripping period then the third time they will receive a <i>Shido</i>	All attacks or blocking with one or two hands or with one or two arms below the belt in <i>Tachi-Waza</i> . It is possible to grip the leg only when the two opponents are in a clear <i>Newaza</i> position and the <i>Tachi-Waza</i> action has stopped
Pistol and Pocket Grip on the bottom of the sleeve without immediate attack is penalised by <i>Shido</i>	To reap the opponents supporting leg from the inside when the opponent is applying a technique such as <i>Harai-goshi</i> etc
To hug the opponent for a throw (Bear hug). It is not a <i>Shido</i> when the competitor has <i>Kumi-kata</i> with a minimum of one hand	To disregard the Referee's instructions
To take the wrist or the hands of the opponent only to avoid the grip or the attack on him should be penalised by <i>Shido</i>	To make unnecessary calls, remarks or gestures derogatory to the opponent or Referee during the contest
False attack - <i>Tori</i> has no intention of throwing, <i>Tori</i> attacks without <i>Kumi-kata</i> or immediately releases the <i>Kumi-kata</i> , <i>Tori</i> makes a single attack or a number of repeated attacks with no breaking of the opponents' balance	To attempting to perform techniques such as <i>Uchi-mata</i> , <i>Harai-goshi</i> , etc. or to fall directly backwards while performing or attempting to perform techniques such as <i>Kata-guruma</i> whether standing or kneeling
One foot outside of the contest area without immediate attack or not returning immediately inside the contest area	Any action against the spirit of judo may be punished by a direct <i>Hansoku-make</i> at any time in the contest

Regardless of rule changes judo is a constantly evolving sport in terms of techniques and tactics as athletes and coaches attempt to gain the upper hand. Almost every major championship sees new variations of existing techniques or even completely new techniques. Tracking technical research though does suggest there is a constant in the types of techniques used. *Seoi-nage* and *Uchi-mata* have consistently been seen as the highest scoring techniques over the years (Sterkowicz & Maslej, 1998, Adam *et al.*, 2012; IJF Statistics manage, n.d.; Miller *et al.*, 2015). However, Miller *et al.*, (2015), did find a reduction in the number of *Te-waza* techniques and this is likely to be the case with the elimination of leg grabs in the most recent rule changes (2010-2013 and 2014-2016).

Research from Otaki (1954) and Thibault (1963) considered the most effective techniques used by Japanese judoka from 1929-1952 and 1956-1960 respectively. The results shown by Otaki (1954) confirm that during the period between 1929 and 1952 the most used types of techniques based on their *Gokyo* categories were: *Ashi-waza* (54.2%), *Koshi-waza* (27.1%), *Te-waza* (16.2%) and *Sutemi-waza* (2.5%). The most common single techniques were; *Uchi-mata*, *O-soto gari*, *Harai-goshi* and *Seoi-nage*. Almost the same results were described by Thibault (1963) for the years 1956-1960, with the break down being *Ashi-waza* (53%), *Koshi-waza* (23.4%), *Te-waza* (18.1%) and *Sutemi-waza* (5.5%) and the major techniques being the same with the addition of *Tsuri-komi-goshi* (lifting, pulling hip throw).

These were the same techniques exhibited at the 2010 World Judo Championships by the Japanese team (Adam, Tyszkowski and Smaruj, 2011). *Ashi-waza* was still the most dominant and efficient throw type. A high usage of *Uchi-mata*, *De-ashi-harai*, *Ko-uchi-gari*, *O-uchi-gari*, *O-soto-gari* and *Ko-soto-gari* these similarities, with three of the six within the top 10 effective techniques (*Tachi-waza* and *Ne-waza*). *Te-waza* within this study showed higher frequency and efficiency than *Koshi-waza*, slightly deviating from the results of 1929 – 1960 Japanese judo.

The two research papers on male Japanese *Judoka* (Abdel-Raouf and Abdelhalem, 2011 and Adam *et al.*, 2011) analysed the same team from the same tournament, with very differing results. Abdel-Raouf and Abdelhalem (2011) only analysed 15 contests out of the full 78 analysed by Adam *et al.*, (2011), therefore providing a less representative sample. This tournament was dominated by the Japanese, after an unsuccessful World Championships in 2009, they rose to the top of the medal table within this tournament.

Abdel-Raouf and Abdelhalem (2011) presented the order; *Ashi-waza* (33.33% of all contest ending techniques), *Sutemi-waza* (33.33%), *Te-waza* (13.33%) and *Koshi-waza* (6.6%), for a

chosen sample of the same fighters within the same contests, looking at match-winning techniques within the final and semi-final matches in which Japanese *Judoka* participated. The majority of the attacks were direct (61.5% of all contest ending *Tachi-waza*) and counterattacks (30.77%), with the remaining ~8% from combinations. It is apparent that analysing all techniques from all contests has provided a highly diverse set of results in comparison to analysing match winning techniques from only a select number of contests.

Judo as a sport is coached within a sporting context, and although there are technical, cultural and physiological differences it is recognised that the vast majority of coaching contexts follow a similar pattern - this is known as the coaching process. According to Lyle (1999) the term 'coaching process' is the most appropriate one to use when describing the purposeful engagement of the athlete and the coach for the purpose of improving performance. Corlett (1996) describes the coaching process and states that *"the supportive pedagogical component in the athlete-mentor [coach] relationship is vital in allowing performances of courage, originality and even genius to occur."*

Coaching judo as a sport

The coaching process

Sports coaches both teach and coach sport. Teaching is what coaches do with new and intermediate athletes, they develop new techniques and skills whereas coaching is what coaches do with athletes who have a general understanding of the sport. Coaching is about refining performance (Lyle, 2002a). It is also about developing athletes based upon their individual strengths and weaknesses. Teaching is often referred to as a linear process, for example the student is taught, then tested and then moves on. Coaching on the other hand is seen as a cyclical process, one where the athlete is trying to perfect their performance in a given field. Coaching athletes is a process that academics have tried to model in order to provide clarity (Cushion, 2007; Cote et al., 1995; Abraham et al., 2006; Potrac et al., 2000; Lyle 1999).

Despite these models providing clarity in terms of academic understanding and theoretical understanding the actual process of coaching is far more complex in nature, as described by Lyle (2002b) who argues that the models do provide some conceptual clarity but:

“that conceptual clarity appears to strip the process of its human, social and emotional character. Identifying the essential elements of the coaching process is important for the development of the conceptual framework, but it should be remembered that the actual engagement of athletes and the coach is an extended period of social activity, commitment, success and failure, emotional highs and lows, interaction within organisations, personal ambition and status, personal cost and achievement, and a mix of short term, medium and long-term satisfaction and enjoyment.”

(Lyle, 2002b p 44)

In 2006 Cushion *et al.*, critically examined current conceptualisations ‘for’ (idealistic representations) and ‘of’ (empirically based) the coaching process, principally in terms of how they had been generated and their contribution to coaching knowledge. By exploring models ‘for’ and ‘of’ the coaching process, they examined the model’s nature and conceptual underpinnings, in an attempt to position them within a broader framework of understanding coaching and the coaching process. They concluded that the current set of models result in a representation of the coaching process that is often reduced in complexity and scale, and the essential social and cultural elements of the process are often underplayed.

One model that considers this complexity is Cote *et al.*, (1995). Their model is show below in Figure 1.1

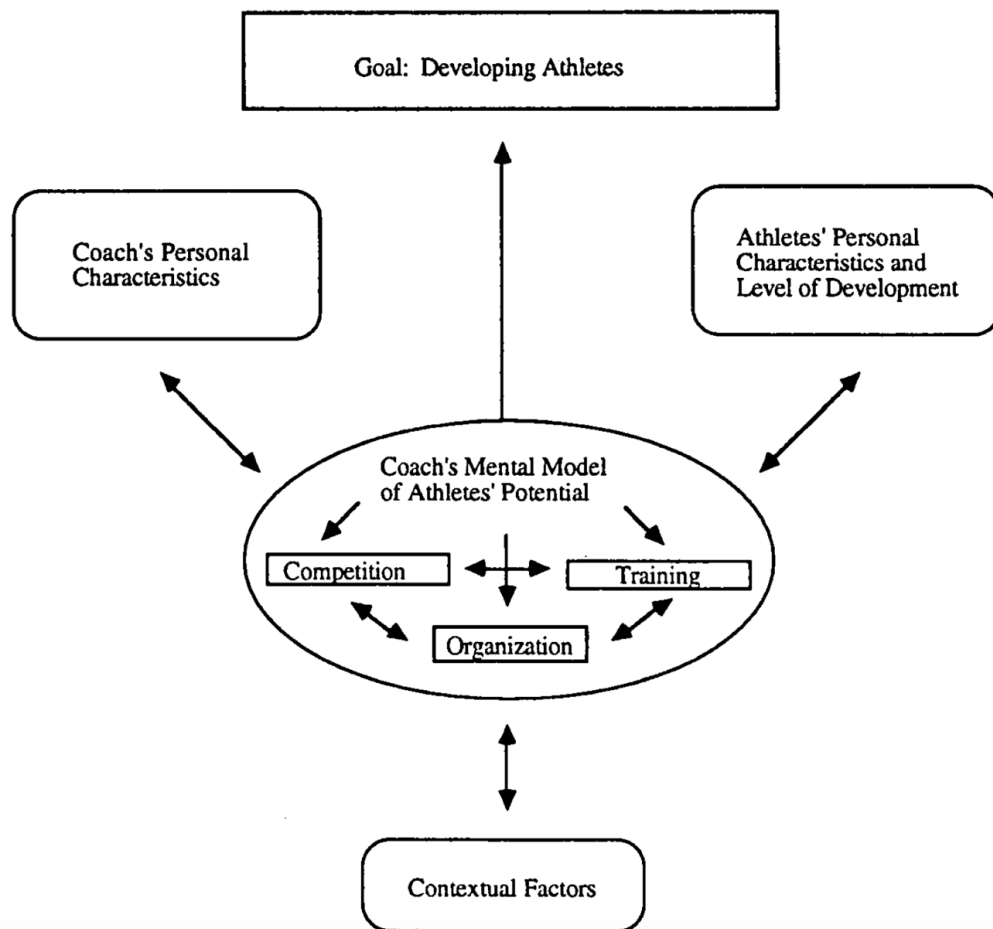


Figure 1.1: Cote *et al.*, (1995) model of the coaching process has the coaches mental model of the athletes' potential at the centre and competition, training, organisation as the main variable. On the outside are other influencing factors. Adapted from Cote's *et al.*, (1995).

Despite there being a lack of consensus on the content and structure of the coaching process there do appear to be two key components that are generally agreed - the presence of social interaction and therefore the need for emotional intelligence and that there is always feedback to the athlete. Chan & Mallet (2011) cited Mayer and Salovey's (1997) definition of emotional intelligence as the most appropriate one to use in the context of high performance sports coaching, this definition is "*an individual's ability to effectively manage the interplay between emotion and cognition*" and in many ways, sums up what authors have tried to depict in the models of the coaching process.

The role of objective feedback within the coach process is directly related to the purpose of this thesis. Judo has been described as a multifaceted sport that is complex in nature (Nishioka, 2000 p15-16) and an open skill (Franchini *et al.*, 2008) but if judo is broken down into its key elements, such as the gripping, the techniques used and duration of temporal

segments then it is possible to see trends. These trends are described below in the literature review and it is presupposed that understanding the technical, temporal and tactical elements of a specific population of judo athletes can help judo coaches specify judo training and be objective in their assessment. Examples of this in judo are how the gripping differs between a lightweight and a heavy weight athlete and how *Ne-waza* differs between male and female athletes.

The importance of feedback in sports coaching

In its most simple form the coaching process is the coaching watching the athlete in training or competition and making an assessment of what needs to be improved. Following this assessment, the coach recommends changes aimed to improve overall performance - this is augmented feedback (Denison, 2007 p91-92; Hughes and Franks, 2008 p23-28, Jones and Kingston, 2013, p37-40). The issue is that often this feedback is subjective and coaches, particularly high-performance coaches, strive to make their feedback as objective as possible. This objectivity, coupled with experience and craft knowledge, allows coaches to better improve performance.

Research suggests performance analysis support can help enhance the coaching process, and thus improve performance through feedback to the performer and coach (Maslovat and Franks, 2008; Hughes, 2004a).

Performance analysis and feedback

Objectively providing feedback within sport is now a crucial element within the coaching process and in providing ample opportunity to improve sporting performance. Improving the objectivity of analysis has been recognised since Franks' and Millers' (1986, cited in Hughes & Franks, 2008) findings that a coach can only recall 30-40% of critical events from 45 minutes of sporting action. This research is often cited to justify the requirement and now frequent use of methods of analysis as augmented feedback within the coaching process. These analysis methods have evolved over the years from hand notation and the scribbling of shorthand code, to computerised systems linked with databases and more recently the internet. This makes a wealth of timely information available to coaches, teams and individuals before, after and even during competition. Advances in technology coupled with greater affordability, size of equipment and ease of use have made computerised performance analysis systems more accessible, accurate and precise, thus objective information is available in abundance, central to the performance improvement process (Hughes, 2004b; Smith, Hammond and Gilleard, 2005).

Chapter 2: Review of Literature

Chapter 2: Review of Literature

Performance analysis

The major goal of any sports coach is to elicit changes in behaviour that improve performance (Hughes and Franks, 2004). This is done via the coaching process where the athlete performs and receives feedback in order to implement changes. Feedback comes from both intrinsic and extrinsic sources. Intrinsic feedback comes from the body's own proprioceptors such as muscle spindles and joint receptors; extrinsic feedback, also known as augmented feedback, normally comes from the coach and is usually in the form of 'knowledge of results' and 'knowledge of performance' (Hughes and Franks, 2008 p2; Denison, 2007 p90-92). The delivery of this feedback, its objectivity, reliability and the normative values it is measured against have come under much scrutiny (Hughes & Franks, 2004; Franks *et al.*, 1993) and it is now common acceptance that many of the variables can be eliminated by the use of quality performance analysis (Niesser, 1982).

Performance analysis covers a range of analysis including biomechanics and notation. According to Bartlett (2001) biomechanical analysis involves *"analysis, [of] fine-detail, individual sports techniques and their science is grounded in mechanics and anatomy"* and notation analysis *"studies gross movements or movement patterns in team sports, is primarily concerned with strategy and tactics"*. This current work is more concerned with notation analysis, which Hughes (2004a) further defines as *"an objective way of recording performance so that key elements of that performance can be quantified in a valid and consistent manner"*. The applications of notation analysis are defined by Hughes and Franks (2004) as:

- Tactical evaluation
- Technical evaluation
- Analysis of movement
- Development of a database and modelling
- Educational of coaches, referees and players

There appears to be a general acceptance of these applications within the literature as well as recognition that it is not always possible to separate these elements either in applied notation or research-based notation (Hughes and Franks, 2004; Bartlett, 2001, O'Donoghue, 2010; Hughes and Bartlett 2002; Carling, Reilly, & Williams, 2009; Hughes and Franks, 2008).

O'Donoghue, (2010) advocates performance analysis of sport suggesting it focuses on actual sports performance rather than the assessment of activities that take place in a laboratory or the analysis of data from self reports or interviews.

Aims

This literature describes the use of performance analysis in team sports, individual sports and combat sports before focussing on previous performance analysis research specifically in the sport of judo from 1954 to 2013, more recent research will be covered in the relevant experimental chapters.

Sports specific literature

Team sports

In the last ten years there has been a plethora of notational research in team sports across all of the applications cited above. Technical notation is concerned with several elements of performance including the frequency of techniques, where they occur on the pitch and the particular players performing them. Technical notation is seen in many team sports including rugby (van Rooyen *et al.*, 2010; Sayers & Washington-King, 2005), soccer (Dellal *et al.*, 2010; Kelly & Drust, 2009; Rampinini *et al.*, 2009), volleyball (Nikos, *et al.*, 2009; Patsiaouras *et al.*, 2010), basketball (Bogdanis *et al.*, 2007; Huciński & Tymański, 2006) and netball (Bruce *et al.*, 2009). Tactical notation examines strategy and tactical advantage within the game, this may include attack tempo, loss/gaining of the ball in specific areas of the pitch/court, ball possession, deception strategies and other tactical ploys. Tactical notation is seen in rugby (Eaves & Broad, 2007), basketball (Remmert, 2003) and volleyball (Alfonso *et al.*, 2010; Castro & Mesquita, 2010). In soccer, much of the recent research has focussed on the youth game (Costa *et al.*, 2010a; Costa *et al.*, 2010b; Costa *et al.*, 2010c) but there is still research into performance level tactics (Lago-Peñas & Dellal, 2010; Shestakov, 2007).

Analysis of movement or the temporal components is often defined as “time motion analysis” and pertains to an understanding of the physical demands of the sport. Understanding these physical demands is a prerequisite for designing any training programme (Davidson & Trewartha, 2008). Time motion analysis (TMA) is common place in performance analysis based research and particularly in team sports. Obtaining positional information that is

accurate about sports players is of interest to coaches and high-performance support teams because of the potential to relate performance to tactics, and to assist in the design of better training programmes (Barris *et al.*, 2008). It is also necessary to attain information about physiological demands of a sport as fatigue can impact on the ability to execute the skills required to implement a particular game strategy (Rampinini *et al.*, 2009). Having a detailed knowledge of a sports movement patterns and physiological demands are crucial when creating a strength and conditioning programme (Petersen *et al.*, 2010).

Time-motion analysis has been performed in a number of different sports including Australian football (Dawson *et al.*, 2004), Basketball (Bishop & Wright, 2006; Narazaki *et al.*, 2009), Cricket (Christie *et al.*, 2008; Rudkin & O'Donoghue, 2008), Field- Hockey (Spencer *et al.*, 2004), Futsal (Barbero-Alvarez *et al.*, 2008), Rugby (Kay & Gill, 2003; Sirotic *et al.*, 2009; King *et al.*, 2009; van Rooyen & Noakes, 2006; Duthie *et al.*, 2006; Deutsch, Kearney, & Rehrer, 2007; Duthie, Pyne, & Hooper, 2005), Soccer (Bangsbo Mohr, & Krstrup, 2006; Clark, 2010), Gaelic football (King & O'Donoghue, 2003), Tennis (O'Donoghue 1998), Australian rules football (Gray & Jenkins, 2010) and Water Polo (D'Auria & Gabbett, 2008; Tan *et al.*, 2009). O'Donoghue & Longville (2004) addressed the issue of reliability in time-motion analysis, producing a version of the kappa statistic. This algorithm computes the proportion of observation time, where two independent observations of the same performance agree on the movement class being performed, adjusting this for the proportion where they could be expected to agree by chance. Reliability will be discussed in detail later in this work.

The development of databases and modelling refers to the creation of normative profiles. This is often used to profile opposition in an applied setting but is also used in research, for example Castelloano-Paulis *et al.*, (2007) asked "*Has soccer changed in the last three World Cups?*" These authors analysed 56 matches to perform a variance analysis of four facets (World Cup, area, result and interaction contexts) and used different techniques to estimate variance components. Through this analysis, they defined which facets provide more information and which facets of the tool should be optimised.

Individual sports

The large amount of research applied to team sports contrasts markedly with the amount of data published in individual sports. There is technical, tactical and time motion research in tennis (Hughes & Meyers, 2005; Loffing *et al.*, 2009; O'Donoghue & Brown, 2008; Takahashi *et al.*, 2008; Takashi *et al.*, 2009; Theodoros, 2008). Alcock and Cable (2009) compare singles and doubles in Badminton, whilst Hughes *et al.*, (2006) expand previous research in normative profiles in squash. These analysis of racket sports generally include, rally time, number of shots played in the rally, score (sets, games and points) at the start of the point, score (sets, games and points) at the start of the point, whether the point emanated from a first or second service, type of point (ace, double fault, serve winner, return), aces per match, double faults per match, players rankings and percentages such as, serve games won (%), return games won (%), first serve percentage (%), first serve points won (%), second serve points won (%), break points saved (%), first serve return points won (%) second serve return points won (%) and break points won (%).

Brown, Lauder, and Dyson (2011) considered elite *versus* sub-elite athletes using notational analysis in sprint kayak in order to establish the fundamental characteristics of on-water paddling technique in terms of both body movement and boat and paddle motion. Participants were 78 international, 38 national and 19 club level athletes (n=135). Temporal variables included stroke rate, stroke cycle time, pull and glide time, pull and glide time as a percentage of stroke cycle time and race time; in addition to these 22 qualitative spatial variables were measured using a ranking system between 0-5. They concluded that paddling ability was directly linked to race time with the higher ability paddlers producing lower times and consequently higher average velocity. Differences in technique across ability levels included variables of trunk rotation, stroke width, forward reach, blade contact time with the water and the motion overall of the kayak. Higher level paddlers had greater stroke rate, reduced glide time, greater trunk rotation and great motions of the legs with less lateral motion of the body.

Yiannis (2008) explored the basic characteristics of men's and women's beach volleyball in the 2004 Athens Olympic Games. In each of the men's and women's tournaments there were 24 pairs, which, in the preliminary phase, were divided into six groups of four teams. Sixteen teams, i.e. the first two from each group plus the four best third teams, qualified for the final play-offs. 31 matches from the final stages were analysed (16 men and 15 women), providing a total of 1407 points from the men's matches and 1251 from the women's matches. The analysis included technical characteristics of the game such as, service, reception, attack, block and defense. Serves were classified as floating, jump floating and jump power serves

and further classified with respect to its outcome in two ways: firstly, which team won the point and secondly whether the serving team won the point immediately with an ace and whether the receiving team won the point immediately by a faulty serve of the serving team (lost serve). The proportion of points won by the serving team in Beach Volleyball was 30% regardless of the gender, set and the serve kind. Although the relative proportion of points won by the serving and receiving team are practically the same in both genders, this comes as a result of actions, which vary distinctly in power in all skills, starting from the jump power serve, to the smashing spike at the net, forcing one of the players of the opposing team to make a block defense.

The use of performance analysis in individual sports is more directly related to this work and therefore a clear overview of the types of research is shown in Table 2.1. Performance analysis specific to combat sports will be discussed in detail below followed by research specific judo.

Table 2.1: A variety of literature that demonstrates the feasibility of analysing individual sports from the various performance analysis perspectives to be used in this current research. The table shows the research often combines areas. Combat sports will be considered separately (TMA= Time Motion Analysis).

Author & Year	Sport	Technical	Tactical	TMA	Other
O'Donoghue & Ingram (2001)	Tennis	√		√	Also consider gender and playing surface
O'Donoghue (2002)	Tennis		√		
Hughes & Meyers (2005)	Tennis			√	
Yiannis (2008)	Beach Volleyball	√			
Hughes, Fenwick & Murray (2006)	Squash		√		Considered momentum
O'Donoghue & Brown (2008)	Tennis		√		
Theodoros, Antonios, & Kariotou (2008)	Tennis	√			
Takahashi <i>et al.</i> , (2008)	Tennis		√	√	
Alcock & Cable (2009)	Badminton			√	
O'Donoghue & Brown (2009)	Tennis		√		Considered momentum
Perez-Turpin <i>et al.</i> , (2009)	Beach Volleyball			√	
Brown, Lauder, and Dyson (2011)	Sprint Kayak	√			Considered elite vs sub-elite
Loffing, Hagemann & Strauss (2009)	Tennis	√			Considered left vs right handedness
Malagoli Lanzoni, Lobietti, and Merni (2010)	Table Tennis	√			
Vuckovic & James (2010)	Squash			√	
Hizan, Whiip & Reid (2011)	Tennis	√			Also compared gender
Malagoli Lanzoni, Lobietti, and Merni (2013)	Table Tennis	√	√		
Vuckovic' <i>et al.</i> , (2014)	Squash		√		

Performance analysis in combat sports

With a large variety of combat sports this section is broken down by combat sport, starting with combat sports with a weapon, then striking combat sports, and lastly grappling combat sports as these are the closest to judo.

Fencing and kendo

Wylde, Tan & O'Donoghue (2013) studied 100 international women's foil fencing bouts to identify the differences between 15-touch, 5-touch and team bouts. Five movement classifications were used during the data collection: stationary, walking (both classed as low activity), engaged (classed as moderate activity) and attack/defend, burst (high level activity). This study found that high-intensity movements accounted for $6.2 \pm 2.5\%$ of total bout time in elite women's foil fencing. These high-intensity movements had a mean duration of 0.7 ± 0.1 s with a mean recovery period of 10.4 ± 3.3 s and there was no significant difference between test group, thus suggesting similar training plans could be used to physically prepare fencers for 15-touch, 5-touch and team bouts.

Okumura *et al.*, (2012) focussed upon the interpersonal space between two *Kendoka*. Based upon 6 participants analysis indicated that players tended to step towards and away from their opponents based on two distances, 1.00–1.10m and at 2.70–2.80m. The interpersonal distance around 1.00–1.10m represented the situation in which the distances between two opponents were at their closest and where they continued contacting each other. The interpersonal distance between two players of about 2.70– 2.80m represented a neutral posture that allowed a balance between offensive and defensive techniques with maintenance of a ready stance. The distance between athletes is also considered important in judo with a Japanese style preferring distance and an Eastern European style preferring more contact (Iatskevitch, 1999).

The research on these two combat sports shows high intensity sports, where a key factor is the distance between the competitors and reaction time.

Boxing

A technical and tactical profile of the 15th Bosnia and Herzegovina boxing championships was conducted by Kapo *et al.*, (2008), they considered 25 key performance indicators that were broken down into hand punches, basic defence against hand punch and advanced defence against a hand punch. They also considered application of tactics, knockout technique, number of knockouts, manner of winning and injury. They concluded the most used punches were direct punches with the frequency of 3153 (48.2 %), and the hook punch with the frequency of 3145 (48.1 %). They suggested the reasons for these were because of the

advantages presented by the direct punch in terms of speed, ease and precision, whilst the hook performance is most probably because hook is one of the most natural ways of punching.

Another boxing study was by Ashker, (2011) who compared winners to losers in a sample of 66 first-ranked male elite boxers in 33 fights (11 finals; 22 semi-finals) participating in the national boxing competition, Cairo 2010. The results concur with Kapo *et al.*, (2008) above that direct punches were most prolific, hook punches were also highly rated and upper cuts were rarely seen. Ashker presents the same reason for this as Kapo *et al.*, suggest a low skill level.

Muay thai and kick boxing

Ouergui *et al.*, (2014) used time-motion analysis to assess kickboxing observing the 2009 and 2011 world championships. The the duration and number of sequences of each time variables were determined and classified into three phases:

- 1) High-intensity activity (HIA): offensive/defensive actions
- 2) Low-intensity activity (LIA): preparation and observation
- 3) Referee pauses

The ratio between the time duration of HIA and the sum of LIA and referee pause's time (i.e., $HIA/[LIA + \text{pause}]$) was calculated. Result indicated that the intensity of the combats was lower in the earlier rounds and pause time was also shorter. No differences were seen across weight categories. The overall combat data presented highlighted the intermittent activity pattern of international kickboxing. An average of 2.2 ± 1.2 seconds of fighting activities (i.e., HIA) was typically interjected with 2.2 ± 0.7 seconds of nonfighting activities (i.e., LIA) with an average interval of 3.4 ± 1.2 seconds between 2 subsequent high-intensity activities. Furthermore, there was an average referee pause of 5.4 ± 4.5 seconds.

Silva *et al.*, (2011) analysed time structure and effort level in Muay Thai and Kick-Boxing amateur level matches. They assessed 13 contests considering the time structure and three levels of effort: observation (periods of little effort, no contact or no activity), preparation (exchanges of blows, at low intensity and the application of techniques without subsequent connections) & interaction (periods of high intensity, fast and powerful motor actions, the sequence and chance of strikes applied by the fighters). They concluded that there were no temporal differences in Muay Thai *versus* Kick-Boxing amateur matches when the same effort levels are considered. It was also noted that the observation period was longer than other

phases, suggesting similar physiological and technical-tactical demands, and high-intensity intermittent profiles for both combat sports.

Myers *et al.*, (2013) compared 32 elite Muay Thai fighters from Great Britain and Thailand. They compared differences in technique frequency and key performance indicators and found that Thai fighters more defensive and attacking techniques, particularly with the knees and with roundhouse kicks and push kicks. Similarly to Okumura *et al.*, (2012) study on Kendo, they contributed much of this to the distance between the athletes.

The literature on Muay Thai and kick boxing suggests a high intensity combat sport where aggressive action and often the simplest techniques prevail.

Taekwondo

In recent years research on taekwondo has increased, possibly due to its inclusion in the Olympic Games. In 2013, Kazemi studied youth taekwondo athletes to identify trends in anthropomorphic attributes and competitive strategies of medalists and non-medalist at the Youth Olympic Games 2010. Results were then compared to adult taekwondo Olympic athletes in 2000, 2004 and 2008 Olympic Games. Using publically accessible data they considered participants in each category, participants body mass, height, date of birth, country, each round fought report, points obtained, warnings, deduction points, defensive kicks, offensive kicks, offensive and defensive punches, list of referee and judges with country of origin. No Significant differences were found within the anthropometric data, logistical regression analysis revealed that non-medalists did not score any punches during combat. Winners used defensive punches to score more often than offensive punches. The common techniques used by winners were trunk kick followed by a head and then body shot that involved rotation. Penalties were also thought to be very influential. Kwok, (2012) also considered medalists versus non-medalists, she also found the roundhouse kick to be high scoring and found as were the cut down kick and the push kick. A Mann-Whitney U test revealed significant differences in the utilization of back side kick, push kick, reverse kick and punch between medalists and non-medalists.

Falco *et al.*, (2012) analysed the kicking performance of medalists' taekwondo athletes across 45 matches in university level championship. Kicking actions were grouped into three categories; circular, linear and with a pre-vious spin kicks. The criteria they based kicking performance on was, the type and height of the kicks employed, the attacking and

counterattacking nature of the kicking actions, and the scoring profiles of these. Both males and females showed circular kicks to be most frequent, agreeing with the research previously cited, and kicks to the chest were more common than to the head. Lastly attacking kicks were more common than counter kicks.

The last article based upon taekwondo reviewed in this work also considers medallist *versus* non-medalists. Cular, Krstulovic & Tomljanovic, (2011) analysed 152 fights from the 2008 Olympic Games in Beijing. Key Performance Indicators included, warnings, penalty points, offensive kicks to the trunk, offensive kicks to the head, defensive kicks to the trunk, defensive kicks to the head, given points, and received points. Medalists had significantly different results in comparison to the others, among the variables defensive kicks to the trunk, given points and received points in the male competitors, whereas in the female competitors, the variables penalty points, offensive kicks to the trunk, offensive kicks to the head, defensive kicks to the trunk, given points, and showed statistically significant differences.

In the combat sport of taekwondo, the literature appears to suggest a prevalence of circular or round house kicks and defensive actions/counter strikes appear to be most successful.

Karate

An analysis of scoring techniques in karate (Laird & McLeod, 2009), showed that *Gyaku-zuki* to the body (reverse punch) was the most frequently scored technique. It was 43.28% of the overall techniques used across the 17 fights and 67 scores. It made up 89.65% of the techniques used by winners. The authors suggest this is because of the speed the punch can be delivered.

Franchini, Loterco and Nakamura, (2015) review the literature on performance analysis in karate. They consider lower limb techniques and upper limb techniques both in official *Shiai* (competition) and simulated *Shiai*. Considering the studies that investigated official *Shiai* they concluded that:

- a) there was a longer period of fighting activity in percentage of total for the matches in the World Championship compared to others and they suggest this is because of the finals and the elimination contests
- b) the general effort-pause ratio is around 1:1, although slightly different ratios were observed for middle (1:2) and heavy weight categories (1:1)
- c) the high-intensity action to pause ratio was around 1:11 - 1:8

- d) the time-motion match structure is similar between winner and defeated athletes in national and international competitions
- e) punching techniques are applied more frequently than kicking techniques, which seems to be related to the fact that punching techniques are faster, demand less energy and it is easier to avoid counterattacks
- f) techniques are directed mainly to the head
- g) the *Gyaku-tsuki-jodan* is the most used punching technique, while *Kisa-mawashi-geri-chudan* is the most used kicking technique,
- h) in international-level competition winners executed blocks more frequently than defeated athletes, and females counterattacked less frequently than males

Overall *Karate* is described as high intensity and similar to Muay Thai and Kickboxing the more simple and quickest techniques appear to prevail.

Wrestling

Atan & İmamoğlu (2005) considered technical and tactical parameters of Greco-Roman and free-style world wrestling championships and compared this to the Turkish national team. 334 Greco-Roman and 311 free-style fights were recorded and analysed. Key performance indicators included winning, the finishing times, the technique numbers, the points and the passivity numbers of the whole and the classifying matches; the techniques that the Turkish Team used and applied were also determined. The most executed techniques in Greco-Roman wrestling were:

- gut wrench (29.62 %),
- tying salto (14.81 %) and
- counter to gut wrench (9.25 %)

In free-style wrestling the most commonly executed techniques were:

- leg tackle (36.36 %),
- gut wrench (16.66 %) and
- head drag (12.12 %)

The Turkish Greco-Roman wrestling team executed mostly gut wrench (33.33 %) and warning point (11.76 %); mostly exposed to gut wrench (21.62 %) and throw back (16.21 %). The Turkish Free-Style wrestling Team executed mostly leg tackle (24.3 %) and gut wrench (20 %); exposed to mostly leg tackle (28.30 %), gut wrench (13.20 %) and double leg tackle (13.20 %). They concluded that in order to win the Turkish national team must be more offensive in attack and less exposed as were their more successful rivals.

Kajmovic *et al.*, (2014c) compared winning and losing cadets in the Greco-Roman wrestling European Championship in 2010. The results indicated the existence of differences in the application of techniques in the standing position and in techniques in the parterre position (ground work) used by the cadet winners in relation to the defeated competitors. The analysis of individual techniques of throwing in a standing position confirmed the existence of differences, with two techniques of throwing there weren't any differences, shoulder throw and sagging bodylock. This is the reason why winners as well as defeated ones seek to apply these two techniques during the fight in order to achieve a good result. These results differ to those shown above by Atan & İmamoğlu (2005) but given the age differences and Atan & İmamoğlu (2005) focus on one nationality these differences are not surprising. However, Kajmovic *et al.*, (2014) did agree with Atan & İmamoğlu (2005) in finding a high frequency of the gut wrench technique.

Kruszewski, *et al.*, (2012) analysed 212 athletes from 49 countries across 240 contests from the 2009 youth championships. Russian competitors were seen to be the most successful and predominantly used takedown and roll-through actions. The most offensive nationality was Azerbaijan, the most defensive was Iran. They also showed a dominance in the ground work, agreeing with Kajmovic *et al.*, (2014) and therefore wrestling research should consider if this is a growing trend or due to the analysis of youth athletes in both of these research articles.

Wrestling research appears to show trends in attacking from the rear and a predominance in ground work, however these results are based upon three studies and two of these were youth studies, therefore these conclusions should be interpreted with caution.

Mixed Martial Arts (MMA)

In order to start an understanding of the technical and tactical components in MMA Adam *et al.*, (2015) broke down a single 13-minute fight. The two athletes contrasted with Athlete 1 limiting the technical elements in stand-up fighting to striking. Athlete 2 showed greater diversity of techniques in stand-up fighting but limited himself in ground fighting. Being limited

to one fight and two athletes this data is limited, it is not possible to speculate whether the lack of diversity in standing work and on the floor by athlete one was limited due to ability or tactics.

Miarka *et al.*, (2016d) studied female MMA athletes, the sample consisted of 174 female MMA matches, separated by outcomes (Split Decision n=54; Unanimous Decision n=72; KO/TKO n=28; Submission n=20) from 2012, 2013 and 2014 UFC matches. Time-motion characteristics included time spent performing low and high intensity activity per round, frequency of technical and tactical actions, time in standing combat and time in groundwork combat. Technical performance indicators were - strikes attempts, head strike attempts, body strikes attempts, leg strikes attempts, takedowns attempts, submission attempts, locks attempts, chokes attempts, advances to half guard, advances to side, advances to mount and advances to back. The results suggest that the technical- tactical skills associated with female athletes who finalized the matches by KO/TKO and submission had higher values of striking and grappling actions during the groundwork combat, while those who had Split or Unanimous Decision outcomes showed higher values of striking actions during stand- up combat.

Other studies considered for review in this section have predominantly considered simulated matches (Coswig *et al.*, 2016; Kirk, Hurst, and Atkins, 2015) and therefore were excluded. Research in MMA is relatively new and therefore it is hard to draw conclusion about this sport from a technical, tactical or time-motion perspective.

Brazilian Jiu-Jitsu (BJJ)

BJJ and judo have similar origins and therefore BJJ is possibly the closest combat to judo (Cairns, 2011; Green & Svinth, 2010; Andreato *et al.*, 2016).

A systematic review of the literature related to time-motion analysis and BJJ was conducted by Andreato *et al.*, (2016), they suggest little is known regarding athletes' patterns during a match and therefore considered research that included both official contests and simulated contests. In BJJ time-motion analysis efforts last between 85 and 290 seconds, with pauses from 5 to 44 seconds. The results were similar among simulations and real matches. They went on to compare the data to judo and wrestling, recommending the time structure is considerably different from that reported of 2:1 and 3:1 for judo (20 and 30 seconds of effort periods and 10 seconds of pauses) and 2:1 for wrestling (37 seconds of effort and 14 seconds of pause). They also considered intensity, BJJ athletes spend most of the effort time in low intensity although high-intensity actions are short from 2 to 4 seconds.

Whilst Andreato *et al.*, (2016) suggest there is little literature in this area, and most of what is available is simulated matches they reviewed all the available articles found for this review and therefore the conclusions here are the same as Andreato *et al.*, (2016) in that *“Intermittency is the main physical characteristic of BJJ. The effort/pause ratio reported in BJJ matches was from 6:1 to 13:1, with effort periods of 85 – 290 seconds and pauses from 5 to 44 seconds. Low-intensity efforts last longer than those with high intensity, demonstrating the aerobic metabolism predominance.”*

The use of performance analysis in combat sports is directly related to this work and therefore a clear overview of the type of performance analysis research conducted in combat sports is shown in Table 2.2.

Table 2.2: The uses of performance analysing combat sports (excluding judo) also spans the spectrum of performance analysis areas.

Author & Year	Sport	Technical	Tactical	TMA	Other
Kapo <i>et al.</i> , (2008)	Boxing	√	√		
Ashker (2011)	Boxing	√	√		
Andreato <i>et al.</i> , (2016)	Brazilian <i>Jiu-Jitsu</i>			√	
Wylde, Tan & O'Donaghue (2013)	Fencing			√	
Atan & İmamoğlu (2005)	Greco and free style wrestling	√	√		
Staller (2013)	<i>Jiu-Jitsu</i>	√	√		Primarily concerned with the role of performance analysis
Laird & McLeod (2009)	<i>Karate</i>	√	√		
Lapresa <i>et al.</i> , (2011)	<i>Karate</i>	√		√	
Chaabène <i>et al.</i> , (2013)	<i>Karate</i>			√	Also compared physiological data
Okumura <i>et al.</i> , (2012)	<i>Kendo</i>		√		Considered the distance between the players
Miarka <i>et al.</i> , (2016d)	Mixed Martial Arts	√	√	√	Considered female athletes only
Silva <i>et al.</i> , (2011)	<i>Muay-Thai</i> & Kick boxing			√	
Culara & Krstulovicb, (2011)	<i>Taekwondo</i>	√	√		
Falco <i>et al.</i> , (2012)	<i>Taekwondo</i>	√	√		
Kazemi, Ciantis & Rahman (2013)	<i>Taekwondo</i>	√	√	√	Also considered anthropometric data
Curby (2005)	Wrestling	√			

Performance indicators in the literature

Sports are broken down into subcategories dependent on the rules of scoring and the key aspects of the sport, then from this KPIs are developed (Hughes and Franks, 2004). For example, rugby could be broken down into units of play such as forwards (attacking play), backs (defensive play) and set pieces. Judo is generally broken down into *Tachi-waza* (standing) and *Ne-waza* (groundwork); these can then be divided further for example *Kumi-kata* can be broken down into lead grip & main grip. When undertaking research, the importance of each variable needs to be considered along with the reliability of data collected (O'Donoghue, 2010). Examples of KPIs within the literature for team sports and individual sports are shown in Table 2.3 and 2.4 respectively.

Habitually match analysis is used to evaluate the frequency or duration of particular KPI's that make up a performance. The application of these methodologies by analysts to different sports has led to the identification of work rates, technical and tactical models and predictive models of performance of athlete, coaches and officials in events (Hughes and Franks, 2004).

Table 2.3: Examples of key performance indicators used in the literature for team sports. The variety of sports and the moving across technical, tactical and time-motion data makes it difficult to surmise the most popular key performance indicators.

Author and year	Sport	Type(s) of analysis	Key Performance indicators assessed
Lehto <i>et al.</i> , (2010)	Basketball	Technical & Tactical	Type of defence, type of offence, final play in offence, type of shot, quality of shot, number of pick 'n' rolls, number of passes, "panic" - offence, player position, court position, effectiveness
Huciński & Tymański (2006)	Basketball	Technical & Tactical	Fast Break, one on one front to basket, one on one back to basket, pick and roll, rebounding shot, other elements, attacks 2-6 together, all attacks, attacks inside 3 second zone and attacks outside 3 second zone.
Rudkin & O'Donoghue (2008)	Cricket	Time motion analysis	Stationary, walking, shuffling, jogging, running, high-intensity fielding, low-intensity fielding
Vurgun <i>et al.</i> , (n.d.)	Handball	Technical	Attack number, throw efficiency, shot efficiency, fast- break goal in each competition, fast-break efficiency, goalkeeper efficiency, saved shot by goalkeeper, turnover number per match, 2 seconds punishment numbers in each match, position shot efficiency (wing, pivot, back field, parallel diving, fast-break and 7 meter shots)
Sirotic <i>et al.</i> , (2009)	Rugby	Time motion analysis	Physical performance (time, intensity of exercise, frequency, repeated-sprint ability, and speed measures) and game-specific skill measures (ball carries, supports, ball touches, play-the-balls, and tackles)
Eaves & Broad (2007)	Rugby league	Tactical	Possession, post-ruck action, time spent in zones, tackle type
Lago-Peñas <i>et al.</i> , (2011)	Soccer	Tactical & Technical	Total shots, shots on goal, effectiveness, passes, successful passes, crosses, offsides committed and received, corners, ball possession, crosses against, fouls committed and received, corners against, yellow and red cards, venue, and quality of opposition
Vuckovic <i>et al.</i> , (2009)	Squash	Tactical	Location from which shot was played Preceding shot type
Malagoli, Lanzoni & Merni (2010)	Table tennis	Technical	Footwork technique (stepping patterns), strokes and efficacy
Alfonso <i>et al.</i> , (2010)	Volleyball	Tactical	Blockers' starting position, zone of first contact, setting zone, type of set, middle-attacker's availability, blocker's anticipation, attack zone, attack tempo, block opposition, attack efficacy

Table 2.4: Examples of key performance indicators used in the literature for individual sports.

Author and year	Sport	Type(s) of analysis	Key Performance indicators assessed
Wylde, Tan & O'Donoghue (2013)	Fencing	Time motion analysis	Stationary, walking, engaged, attack/defend & burst
Laird & McLeod (2009)	Karate	Technique and tactics	Punches (straight punch, reverse punch, back fist), kicks (roundhouse kick, reverse roundhouse kick, back kick, front kick, side kick) penalties, contact area (head or body) and point value
Vučković & James (2010)	Squash	Time motion analysis	Very short rallies (<4 seconds), short rallies (4–12 seconds), medium rallies (12–25 seconds), long rallies (>25 seconds)
Kazemi, De Ciantis & Rahman (2013)	Taekwondo	Technical	Compared types of score to gender and weight category from existing public data
Hizan, Whipp, & Reid (2011)	Tennis	Tactical	Percentage of first serves in, aces per match, double faults per match, percentage of first serve points won, percentage of second serve points won
Pérez-Turpin <i>et al.</i> , (2009)	Volleyball	Time motion analysis	Defensive movements (reception, block, defence), Offensive movements (placement, approach attack and attack) & movement (advance, lateral step added, lateral extension, post)
Atan & Imamoğlu (2005)	Wrestling	Technique and tactics	Applied techniques, exposed techniques, taken points, loosen points, taken passivity, given passivity & tying salto. They also analysed a variety of techniques - leg tackle, gut wrench, double leg tackle, throw back, head drag, warning point, arm grab, ankle twist, crotch lift, slip out, tying salto, takedown by waist, tackle, counter to gut wrench, shoulder throw, cravat, counter to shoulder throw

Performance analysis in judo

As well as the combat sports listed above, judo has a growing base of performance analysis research. Many aspects of judo have been considered, these are normally broken down into technique (Doi, 1971, Adam, 1984, Sikorski, 1985; Sterkowicz & Maslej, 1998); and tactics (Boguszewski and Boguszewska, 2006; Boguszewski, 2011). Time-motion analysis is not easy to conduct in the sport of judo, however, Miarka *et al.*, (2011 & 2012), Sterkowicz & Maslej (1998), Marcon (2010) are examples of authors who have conducted research in this area.

Technical analysis research in judo

Technical analysis of judo is not a new concept. Even the first appearance of judo in the Olympic games was videoed and analysed for successful technical elements (Doi, 1971). Further to the research cited earlier by Otaki (1954) and Thibault (1963), who considered the most effective techniques used by Japanese judoka from 1929-1960, as early as 1978 there was published research analysing judo contests in the Bulletin of the Association for the Scientific Studies on judo at the *Kodokan* (Matsumoto *et al.*, 1978). Similar studies were conducted in Eastern Europe (Adam, 1984; Sikorski (1971 & 1985).

Sterkowicz & Maslej (1998) studied technical differences in male and female *Judoka* during the Atlanta Olympic games analysing 527 contests. They found *Nage-waza* lead to the majority of victories in the case of women and men (59.6% and 65.9% respectively). *Seoi-nage* played a decisive part in the case of the women.

The second decisive factor in victory was penalties for both women and men (27.7% and 22.2% respectively). Penalties (*Shido*) were given for passivity (6.6% in women and 9.0% in men) false attacks (1.9% and 2.9% respectively), stepping outside the contest area (1.4% and 0.3%), and *Jigo-tai* (1.4% and 1%).

The third important techniques were holds in groundwork - *Katame-waza*. Successful *Kansetsu-waza* (armlocks) accounted for early contest termination (*Ippon* or injury) for female competitors in 5.2% and the men in 6.4% of contests.

Sterkowicz and Maslej went on to present the most used techniques in the Atlanta Olympic games by both male and female *Judoka*. This data is shown below in Table 2.5.

Regardless of the gender, *Ashi-waza* (foot techniques) and *Te-waza* (hand techniques) were most frequent while strangulation techniques *Shime-waza* were rarest. It was also noted that *Sutemi-waza* (sacrifice throws) by male *Judoka* lead to victory more frequently than females and *Osaekomi-waza* (holds) led to victory more in females.

Table 2.5: The 15 most frequently used techniques during the 1996 Olympic games ranked and split by gender. Certain techniques have many variants such as *Seoi-nage* (*eri*, *ippon*, *morote*) and in these cases, they are classed as one single technique. Similar for *Osaekomi-waza* (*kuzure*, *ushiro* etc). Adapted from Sterkowicz & Maslej (1998). It should be noted that recent rule changes by the IJF have banned some of these techniques

Rank	Techniques frequently used in Women's contests	n	%	Techniques frequently used in Men's contests	n	%
1	<i>Seoi-nage</i>	40	13.2	<i>Seoi-nage</i>	60	12.3
2	<i>O-uchi-gari</i>	33	11	<i>Uchi-mata</i>	39	8
3	<i>Uchi-mata</i>	22	7.3	<i>O-uchi-gari</i>	38	7.8
4	<i>Harai-goshi</i>	20	6.6	<i>Ko-uchi-gari</i>	27	5.6
5	<i>O-soto-gari</i>	16	5.3	<i>Ko-soto-gake</i>	19	3.9
6	<i>Ko-soto-gake</i>	15	5	<i>Kata-guruma*</i>	19	3.9
7	<i>Ko-uchi-gari</i>	13	4.3	<i>O-soto-gari</i>	18	3.7
8	<i>Kuchiki-taoshi*</i>	9	3	<i>Ude-hishigi-juji-gatame</i>	17	3.5
9	<i>Ude-hishigi-juji-gatame</i>	9	3	<i>Kuchiki-taoshi*</i>	17	3.5
10	<i>Kesa-gatame</i>	9	3	<i>Tomoe-nage</i>	15	3.1
11	<i>Yoko-shiho-gatame</i>	9	3	<i>Sukui-nage*</i>	14	2.9
12	<i>Ko-soto-gari</i>	7	2.3	<i>Ko-soto-gari</i>	14	2.9
13	<i>Tani-otoshi</i>	7	2.3	<i>Tani-otoshi</i>	13	2.7
14	<i>Tate-shiho-gatame</i>	6	2	<i>Yoko-shiho-gatame</i>	13	2.7
15	<i>Tai-otoshi/Sukui-nage*</i>	6	2	<i>Tai-otoshi</i>	12	2.5
	Other	80	26.6	Other	151	31
	Total	301	100	Total	486	100

* Techniques now banned using their traditional form

Sterkowicz and Maslej concluded that 15 technical elements contributed to 73.4% of women's successful attacks and 69% of successful attacks for men. The following techniques used by the female contestants proved to be the most effective: *Seoi-nage*, *Kuchiki-taoshi*, among the hand throws; *O-uchi-gari*, *Uchi-mata*, *O-soto-gari*, *Ko-soto-gake*, *Ko-uchi-gari*, and *Ko-soto-gari* predominated among *Ashi-waza*, *Harai-goshi* dominated *Koshi-waza*, and finally *Tani-otoshi* was the most frequent of all the *Sutemi-waza*.

According to Franchini and Sterkowicz, (1999) international judo for male medallist in the 1996 Olympic games, and the 1995 and 1997 World Championships was dominated by *Ashi-waza*, as seen in Table 2.6. *Ashi-waza* provides the large majority of all scoring techniques in each of the tournaments in each of the instances, outperforming *Te-waza* techniques by 6-18% in any one case. *Sutemi-waza* and *Koshi-waza* contribute to less of the total scores.

Table 2.6: Tabulated results given in Franchini and Sterkowicz (1999) for the percentages of all scoring *Nage-waza* techniques for each category of *Nage-waza* and *Nage-waza* overall for the 1996 Olympic games, 1995 and 1997 World championship medallists. Adapted from Franchini and Sterkowicz (1999).

Medal	<i>Te-waza</i> (%) (Hand)	<i>Ashi-waza</i> (%) (Foot)	<i>Koshi-waza</i> (%) (Hip)	<i>Sutemi-waza</i> (%) (Sacrifice)
Gold	34.21	52.63	6.14	7.01
Silver and Bronze	31.58	41.41	9.82	17.20
Total	32.33	44.62	8.77	14.28

In 2000 Franchini and Sterkowicz furthered their research considering 1996 Olympic games, and the world championships of 1995, 1997 and 1999. Their data unsurprisingly found similar results and *Ashi-waza* again was the most dominant category of *Nage-waza*. Table 2.7 shows this data.

Table 2.7: Collated data from Franchini and Sterkowicz (2000) showing the overall percentages of all scoring *Nage-waza* techniques for each of the four throwing categories within the 1996 Olympic games, and the World championships of 1995, 1997 and 1999. Adapted from Franchini and Sterkowicz, (2000).

Year	<i>Te-waza</i> (%) (Hand)	<i>Ashi-waza</i> (%) (Foot)	<i>Koshi-waza</i> (%) (Hip)	<i>Sutemi-waza</i> (%) (Sacrifice)
1995	33.64	42.51	6.10	17.74
1996	31.56	42.67	6.44	19.33
1997	36.23	42.45	5.15	16.16
1999	34.18	43.68	6.98	15.16

Conversely to this dominance of *Ashi-waza* shown by Franchini and Sterkowicz (1999 & 2000) research of international tournaments during 2005 – 2008 show a supremacy of *Te-waza* over all other forms of *Nage-waza*, and more specifically *Seoi-nage*. *Te-waza* provided the highest scoring and most frequently attempted technique over taking *Ashi-waza* as dominant in international judo (Boguszewski, 2010; Boguszewski, 2011; Sertic, Segedi and Vucak, 2009a; Sertic, Segedi and Vucak 2009b; Witkowski *et al.*, 2012 & Adam *et al.*, 2012). High frequencies and efficiencies of *Kuchiki-taoshi*, *Kata-guruma* and *Sukui-nage* were the driving factor for this change (Witkowski *et al.*, 2012). A general trend, in terms of technical usage during 2005 – 2008 was: *Te-waza*; *Ashi-waza*; *Sutemi-waza*; and finally, *Koshi-waza*. Only one research article provided data which did not adhere to this trend (Boguszewski, 2010) in which it was reported that *Koshi-waza* techniques were more frequently applied than *Sutemi-waza*. This could be because data on only male athletes were analysed.

Adam *et al.*, (2012) was one of the first researchers to conduct an analysis of the techniques used in male competition during the world championships and Olympic events during the last Olympiad (2008 – 2012), which spanned the 2010-2012 rule changes. One of the main components of these rules changes was the removal of a direct attack of the legs with the hands; this meant a change in the dominant group of techniques used in international judo. It was found that the efficiency of *Te-waza* decreased, whereas the efficiency of *Ashi-waza* increased, with *Seoi-nage* (shoulder throw; *Te-waza*) being the dominant technique throughout, despite this increase in *Ashi-waza*. *Te-waza* showed dominance over *Ashi-waza* during 2008 and 2009, prior to the rule changes, however as soon as the rule changes were implemented, *Ashi-waza* replaced *Te-waza* for the 2010 and 2011 world championships. The efficiency of *Te-waza* based techniques falls dramatically after the 2010 rule change, by 36% from 2009-2010. During this time, *Koshi-waza* and *Ashi-waza* increased in efficiency by 44% and 36% respectively. The most dominant technique throughout the years, despite the fall in frequency and efficiency of *Te-waza* techniques remained *Seoi-nage*.

Some of the most recent technical research comes from Sacripanti (2013) and Pujszo *et al.* (2013). The latter selected aspects of rearwards attacks in the men's +100kg category before and after the 2010 changes of judo regulations on the basis of the World Judo Championships in 2009 and 2011. They assessed all rearward attacks - scored, not scored, non-scored that yielded a penalty for tori and the time within the contest these occurred. Their analysis showed the same frequency of backwards attacks and the same number of fights finished before the time-limit due to a backwards attack. However, the temporal structure of a fight showed it's a completely different image; the collected material suggested the necessity for increased defence activities limiting backwards attacks, particularly in the initial part of the fights.

Sacripanti (2013) continued his 2010 research into the biomechanical classification of judo techniques (as opposed to the *Kodokan* classification generally used) and examined the frequency of various techniques within their biomechanical classification during the London 2012 Olympic games. Sacripanti has divided the *gokyo* into two broad categories - coupling of force techniques and physical lever techniques, these are then both sub-divided into four categories each. Table 2.8 shows these.

Table 2.8: Sacripanti's biomechanical classification that splits the *Gokyo* into 'coupling of force' and physical lever techniques. Adapted from Sacripanti (2013).

Coupling of forces*	Physical levers
Uses arms only such as <i>Kibisu-gaeshi</i> , <i>Kakato-gaeshi</i> and <i>Te-guruma</i>	Minimum Arm Lever (fulcrum under <i>Uke's</i> waist) such as <i>O-guruma</i> , <i>Ura-nage</i> , <i>Kata-guruma</i>
Uses arm(s) and leg such as <i>De ashi barai</i> , <i>O uchi gari</i> , <i>Okuri ashi barai</i> , and <i>Ko uchi gake</i>	Medium Arm Lever (fulcrum under <i>uke's</i> knees) such as <i>Hiza-guruma</i> , <i>Ashi-guruma</i>
Uses trunk and legs such as <i>O- soto-guruma</i> , <i>O -soto-otoshi</i> , <i>Uchimata</i> , <i>Ko-uchi -sutemi</i> and <i>Harai- goshi</i> .	Maximum-Arm Lever (fulcrum under <i>uke's</i> ankle) such as <i>Uki-otoshi</i> , <i>Yoko-guruma</i> , <i>Yoko-otoshi</i> , <i>Yoko-wakare</i> , <i>Sumi-otoshi</i> , <i>Seoi-otoshi</i>
Uses trunk and arms such as <i>Morote- gari</i> .	Variable Arm (variable fulcrum from <i>uke's</i> waist to his knees) such as <i>Tsuri-komi goshi</i> , <i>Kubi-nage</i> , <i>O-goshi</i> , <i>Sode-tsuri komi-goshi</i> , and <i>Koshi-guruma</i>

Coupling of forces is two forces that are equal in magnitude but opposing in direction, thus the resulting force is zero. Coupling force in relation to judo is discussed in detail in Sacripanti, 2010).

Sacripanti concluded that technical actions grouped according to biomechanical criteria revealed a hierarchy of judo throws used at the London 2012 Olympic games. The technique preferred during the fight depended on gender and weight category of the *Judoka*. In *Nage-waza* (standing judo), male and female *Judoka* usually used the same throwing techniques, but females rarely performed techniques of physical lever by variable arm. In *Ne-waza*, females were subject to more *Shime-waza* (strangle) attacks. Specific differentiation of the frequency of effective techniques and penalties for non-combativity in fighting occurred between extra lightweight and heavy weight categories. This conclusion supports the requirement for this proposed study in that it is specifically on one gender and specific to lightweight categories.

Adam *et al.*, (2013) assessed the techniques and tactics of the Russian men's judo team in the 2012 Olympic games. They analysed 423 Russian attacks of which 24 were successful and 384 attacks by their opposition of which 5 were successful (successful was defined as eliciting a score). They concluded that the Russian athletes attacked more frequently and therefore their opponents received more penalties, they also suggested that the Russian team was particularly more effective in *Kansetsu-waza* and *Koshi-waza* than their opposition, they had 100% efficiency in defence in *Ne-Waza* and were generally very effective in defence. The techniques most used by this team were *Harai-goshi* and *Tani-otoshi* in *Tachi-waza* and *Kuzure-kesa-katame* and *Juji-gatame* in *Ne-waza*.

Three papers consider techniques specifically in Women *Judoka* (Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; and Boguszewski, 2010). The general consensus derived from the three papers, as well as the case study of Joanna Majdan (Adam and Majdan, 2011), is that lightweight women's (-48, -52 and -57kg) judo is dominated by *Te-waza*. These studies provide evidence for *Te-waza* being the most frequent and most effective form of *Tachi-waza*, with *Ashi-waza* also being frequent, although to a lesser degree.

Adam, (2012) and Adam and Szczepańska, (2011) suggest middleweight female *Judoka* (-63 and -70kg), utilise *Ashi-waza* to score the majority of their points. Boguszewski (2010) and Sertic, Segedi and Sterkowicz (2007) support this suggesting *Ashi-waza* being a major factor within this category of women's judo at both a senior and junior level, showing it to be the most used and most effective of the throwing groups. It is also shown to be the most used in heavyweight women (-78 and +78kg), however the effectiveness of *Koshi-waza* seems to be superior (Boguszewski, 2010). Sterkowicz (1999) suggests *Osaе-komi-waza* is most prevalent in women's judo. He also suggests that there is a lower frequency of action in

women's judo when compared to men's, but one similarity is the use of "surprise attack" to defeat the opponent.

Tactical analysis research in judo

Tactical analysis considers both tactics and strategy. During competition in any sport tactics are not directly observable; yet an indication of what strategy and tactics are being applied can be seen through the different skills performed, and the location and timing of these skills (O'Donoghue, 2010). A simple tactic, for example, might be the use of combination techniques (*Renraku-waza* & *Renzoku-waza*) to create instability through action-reaction or possibly the use the edge of the combat area to elicit a penalty for the opponent (stepping out can be punishable by *Shido*).

According to Boguszewski and Boguszezwska, (2006) and Boguszewski, (2011) defensively males most often applied *Te-waza* (*Sukui-nage*) counter attacking techniques, whereas females used *Ashi-waza* (*Ko-soto gari*) more regularly. Frequency aside, *Sutemi-waza* proved to be the most effective, scoring more points than any other type of *Kaeshi-waza*. *Sumi-gaeshi* and *Tani-otoshi* were the main counters used by men and women respectively. Counter attacks within champion fighters (gold medallists) were highly efficient, with up to 66% of all attempted counters producing a score.

Time-motion research in judo

Dobson and Keogh (2007) suggested time motion analysis involves the study of movement patterns thus, providing information such as speed, duration and distance covered. This can provide knowledge of the time spent in various modes of combat in a contest (for example *Tachi-waza* compared to *Ne-waza*) or the energy systems utilised by allowing work to rest ratios to be calculated.

Castarlenas and Planas (1997) and Sikorski *et al.*, (1987) used time motion analysis to assess judo contests, they concluded that there are 11 bouts of 15-30 seconds work with 10 seconds intervals. Sterkowicz's (1999) found comparable results as he suggested a contest contained 12 segments.

Research by Franchini *et al.*, (2011) also used time motion analysis to determine the physiological and metabolic demands of a contest via the temporal components. It was suggested an athlete will typically have 5 to 7 fights per competition in order to gain a medal. Each fight would typically last 3 minutes; consisting of 20-30 second bouts of activity with 5-10 seconds rest intervals. Depending on the scores achieved by the contestants a fight could last anything between a few seconds and 8 minutes.

Other authors have found a slightly longer overall average duration of 7.18 minutes per contest (Degoutte *et al.*, 2003), yet this study only took men into account. Sikorski (2010) analysed temporal blocks at several events including the European championships (1985, 1986 and 1999), World cup (1986), Olympic games (1988-1996 and 2008). The average time of each temporal block ranged between 18-25 seconds with 10 second rest intervals; totalling a contest length between 5-8 minutes which corresponded with Degoutte *et al.*, (2003).

Some authors have proposed that the temporal structure has been altered since the new rule changes. Hernandez-Garcia *et al.*, (2009) observed a contest duration of 6.15 minutes \pm 30.39 seconds. They suggest that bouts of work have increased and the number and duration of rest periods has decreased. The reason for this has not been concluded in the research but is likely to be because of the enforcement of penalties more frequently.

Miarka *et al.*, (2011) compared time-motion indicators across four age bands. The key performance indicators were: total combat time, pause time, standing combat time, displacement without contact, gripping time, groundwork combat time. The results showed that there was a median of 7 *Hajime* -> *Matte* blocks within a contest, this is lower than other authors (Casterenas and Planas, 1997; Sikorski *et al.* 1987; Sterkowicz, 1999) who generally found 11-12 work segments. They also showed the average duration of each block by age group, pre-juvenile (21s \pm 8s), juvenile (16s \pm 6s), junior (22s \pm 10s) and senior (30 \pm 33s).

Miarka *et al.*, (2012) is one of few authors who have attempted to identify the duration of Key Performance Indicators (KPIs) within a work block *i.e.* the amount of time spent standing, in groundwork, in gripping etc. Their KPIs were:

- Total combat time (duration of the entire contest)
- Standing combat time
- Displacement without contact
- Gripping time

- Groundwork combat time
- Pause time (matte)

They noted that there were differences between age group in several parameters, significantly senior athletes had less displacement without contact and juniors had less time spent in *Ne-waza*. They demonstrated that for seniors mean work block was 30s (± 33), mean standing combat time was 24s (± 27), mean time for displacement without contact was 5s (± 8), mean time gripping was 14s (± 15), mean time in *Ne-waza* was ± 15 s (± 14) and the mean pause time (matte) was 11s (± 10). In 2010 Marcon *et al.*, conducted a small study where ten male *Judoka* fought three times each with an opposition of similar body weight. A total of 276 *Hajime* to *matte* sequences were evaluated, with a mean of 11 action sequences per combat, they noted an average preparation time (displacement without contact) 4.1s; mean gripping time of 17.4s, mean time in *Ne-waza* of 13s. Other research noted to have broken down these components was Gutierrez-Santiago *et al.*, (2011) who studied visually impaired athletes, they found mean standing combat time was 11.7s for men and 7.8s for women. For mean time in *Ne-waza* they found 11.7 s (men) and 7.8 s (women). The findings of Miarka *et al.*, (2012) and Marcon *et al.*, (2010) seem to differ from those of Gutierrez-Santiago *et al.*, (2011), this is possibly due to the methodology used but more likely due to differences in able bodied and visually impaired athletes. The time-motion research is summarised in Table 2.9 below.

Table 2.9: A comparison of the time-motion analysis literature in judo including work segments, rest segments, number of work blocks and total contest time.

Author and Year	Work Blocks (seconds)	Rest Blocks (seconds)	Number of blocks (per contest)	Total time (min.sec)
Sikorski <i>et al.</i> , (1987)	15-30	10	11	
Casterenas and Planas (1997)	15-30	10	11	
Sterkowicz (1999)	15-30	8-17	12	Men: 3.06 Women:2.54
Degoutte <i>et al.</i> , (2003)				7:18
Hernandez-Garcia <i>et al.</i> , (2009)				6.15 ($\pm 30.39s$)
Sikorski (2010)	18-25	10		5:00 - 8:00
Franchini <i>et al.</i> , (2011)	20-30	5-10		3:00
Miarka <i>et al.</i> , (2012)	Junior: 22 Senior: 30	Junior: 7 Senior: 11		Junior: 3.05 Senior: 3.59
García & Luque (2007)	19 \pm 6	9 \pm 4	9.57	4.44 \pm 2.52
Gutierrez-Santiago <i>et al.</i> , (2011)*	Men: 22 Women: 9.7	Men: 19.6 Women: 21.1	Men: 12.4 Women: 11.7	Men: 4.43 Women: 4.03
Marcon <i>et al.</i> , (2010)		7 \pm 1	11	
Monteiro (1995) (studied juniors)	24.2 \pm 10.4	12.08 \pm 9.0		
Wicks (2006)	30	10		
Boguszewski, (2011)				2010: 4.24 2005: 2.54
Sterkowicz and Maslej (1998)	25.1	10.3		
Van Malderen <i>et al.</i> (2006)	Male: 18.8 \pm 9.0 Female: 19.9 \pm 7.3	Male: 9.13 \pm 5.1 Female: 7.5 \pm 6.2		
Franchini <i>et al.</i> , (2013)	10-63	1-22		

Data is presented with \pm standard deviation where possible. * studied visually impaired athletes

Franchini, Artioli, & Brito (2013) summarised time-motion data in judo. They observed that periods of activity vary from 10s to 63s and pause periods vary from 1s to 22s, while the frequency of the activity-pause ratio is normally 2:1 or 3:1. This appears to be similar between men's and women's competitions. This work gives much broader work and rest periods than the majority of previous research, possibly because the work of Miarka (2012) found work periods of $30s \pm 33s$ and rest periods of 11 ± 10 in regional and state level competition. The next largest work period found was $27s \pm 9.7s$ (Monteiro, 1995) who considered work:rest ratios at the 1994 Junior European championship by minute of contest i.e. 1st minute, 2nd minute, 3rd minute etc. It can be suggested that the work of Miarka (2012) sits outside the normative data.

Other performance analysis research in judo

In order to analyse the efficiency and effectiveness of judo contests Ploszaj *et al.*, (2007) used indexes of technical and technical preparation originally defined by Adam (1982) and studied 142 contests from the Barcelona, Atlanta and Sydney Olympics as well as in the World Championships from 1993, 1995 and 1997 and questioned -

- Is it possible to determine the models of particular weight categories in men's judo on the ground of indexes of the technical-tactical preparation?
- Should men's training consider the differentiation in particular weight categories?
- Is there a different way of solving the tactical takes in the examined athletes (concentration analysis)?
- What parameters of technical-tactical preparation decide final success in a men's judo contest?

To analyse the efficiency and effectiveness of the judo contests they used indices of technical and technical preparation from (Adam, 1982). They concluded that -

- In the two lightest weight categories in men, the dependent variable, in the regression model, was the efficiency of attack
- In the under 71kg weight category, beside the variable of efficiency of attack, the coefficient of effectiveness of attack was also an important element which affects the final efficiency dependent variable

- In the under 78kg weight category, the model of regression was made up of a wide technical potential and efficiency of attack
- In the under 86kg, the contest results were determined by a significant number of attacks their effectiveness and technical-tactical versatility
- In the under 95kg and over 95kg, the number of successful attacks in comparison to the total number of attack and effective techniques determined the final efficiency dependent variable

Based upon this study, it can be suggested that it is possible to determine the model of particular weight categories. The complex nature of the problem calls for further studies considering the quantitative and qualitative analysis for particular techniques as well as time structure of men's judo contests. Qualitative research has not yet been seen in this context and would most likely consist of experts watching techniques and describing the elements for further analysis. This would remove limits to the data collection because any elements could be described.

Several studies split the findings in terms of technical usage and effectiveness within each specific weight category or collection of categories (Frachini and Sterkowicz, 2000; Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; Kruszewski *et al.*, 2008; Carratala, Garcia and Fernandez, 2009; Boguszewski, 2010; and Witkowski *et al.*, 2012). None of these studies were based solely on female athletes, four were male only studies, and three considered both genders combined.

Light weight males (-60 and -66kg; including -55kg for cadets) were, in most instances, dominated by *Te-Waza*, with high frequency and efficiency of *Seoi-nage* and *Kata-guruma* (prior to the 2010 rule change). All but one other study shows *Ashi-waza* as the next most effective category. The study that shows differing results is Carratala, Garcia and Fernandez (2009), who focus on Spanish athletes, they suggest *Sutemi-waza* and *Koshi-waza* play a bigger role. One reason for this could be their classification of *Sukui-nage* which they classify as *Sutemi-waza*, whereas the Kodokan classify it as *Te-waza*.

The definition of a middle weight *Judoka* differs in the research with some authors using the u73kg, u81kg weight groups only and some authors using the the u73kg, u81kg and u90kg categories, none-the-less there is literature focussing on, or including middleweights. Witkowski *et al.*, (2012) shows an increased effectiveness of *Sutemi-waza* within the middleweight categories in relation to the lighter weights. Carratala, Garcia and Fernandez

(2009) highlight a fairly even distribution of techniques used to score points, with *Sutemi-waza* and *Koshi-waza* increasing, and on occasion *Te-waza* and *Ashi-waza* decreasing slightly. *Seoi-nage*, *Kata-guruma* and *O-soto-gari* are among the most used and effective techniques. Heavyweight males (-100 and +100kg; and in some cases -90kg) show a large decrease in usage and effectiveness of *Te-waza* techniques within all shown studies, in relation to that of the lighter weight males. There is an increase in the percentages of scores and contests won for both *Ashi-waza* and *Sutemi-waza* within the heavier categories. Franchini, (2001) suggests this difference could be due to these techniques being best applied by individuals with a low center of mass and greater relative strength, traits more commonly seen in lighter categories. Franchini and Sterkowicz (2000) also show an increase in *Koshi-waza* in comparison to the lighter weight males within the same study. Boguszewski (2010) concurs with this and suggests *Koshi-waza* is the most effective type of throwing technique for heavyweights. In addition to the types of *Nage-waza* used, Witkowski *et al.*, (2012) suggest that for the heaviest category (+100) *Nage-waza* decide a lower percentage of contests than all other weight categories. To date no literature has focussed solely on how lightweight women's judo differs from others. With Franchini (2001) suggesting differences due to lower centre of mass and greater strength between male weight categories it is be hypothesised that women's judo will also differ.

Ploszaj (2007) attempted to model the differences between men's weight categories. He concluded that on the basis of the examinations it is possible to determine the model of particular weight categories using statistical methods successfully and noted some differences between the weight categories.

In a more applied setting, Lacerda, Pereira and Mataruna (2013) used performance analysis as a motivational tool by creating montages to music. The planning and preparation were discussed based on interdisciplinary definitions in performance analysis, sports psychology and neuroscience. In order to produce the videos a questionnaire to identify competition moments, fights and songs that were motivational for each athlete was used with the Brazilian national team. The findings suggest that the strategy of using songs and positive images through videos can be a good motivational tool to stimulate the mental fixation for the competition for the Brazilian judo players in the pre-games training.

This review has shown that Hughes and Franks' (2004) definition of performance analysis crossing the spectrum of technical, tactical, and time-motion data still holds fast today in a myriad of sports. In terms of performance analysis within a judo context there appears to be some common themes:

1. Many authors have confirmed *Te-waza* as either the most dominant or second most dominant category of techniques in international judo (Sterkowicz, 1998; Franchini and Sterkowicz, 2000; Boguszewski, 2010 and 2011; Sertic, Segedi and Vucak, 2009a & 2009b; Witkowski *et al.*, 2012 and Adam *et al.*, 2012). The issue with this is that 5/15 *Te-waza* techniques require the attacker to grasp the leg and would therefore now lead to a *Hansoku-make* (Direct disqualification)
2. Furthermore, only three articles consider techniques specifically in female *Judoka* (Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; and Boguszewski, 2010). The general consensus derived from the three papers, as well as the case study of Joanna Majdan (Adam and Majdan, 2011), is that lightweight women's (-48, -52 and -57kg) judo is dominated by *Te-waza*. This suggests a need for developing an understanding of how the new rules have change lightweight women's judo
3. Ploszaj *et al.*, (2007) suggested that it is possible to determine the model of particular weight categories and recommended that the complex nature of the problem calls for further studies considering the quantitative and qualitative analysis for particular techniques as well as time structure
4. Various authors have considered techniques based upon weight category and found technical differences between weight category and some between gender as well as weight category (Franchini and Sterkowicz, 2000; Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; Kruszewski *et al.*, 2008; Carratala, Garcia and Fernandez, 2009; Boguszewski, 2010; and Witkowski *et al.*, 2012). Few of these have considered females only and no research to date appears to have focussed upon differences in time-motion data or focussed solely on *Ne-waza* differences

Based upon the four observations above it is suggested that there is a requirement to consider female judo separately from male judo from a technical, tactical and temporal stand point whilst also consider the effect of weight category. Coaches will be able to underpin their physical training programmes, technical training and tactics based upon the evidence provided.

Throughout the literature the terms contest, match, fight and *Shiai* are used interchangeably. When citing others literature this work will use the same term as the authors but the preferred term used for this research is contest or Japanese term *Shiai*.

Context and significance of the study

Context

As a sport judo has fourteen weight categories, seven for men and seven for women. Whilst the literature review above has identified a growing body of research into this combat sport, there is little that focusses solely on women in particular (Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; and Boguszewski, 2010). With seven Olympic gold medals available from women's judo and 28 in total it can be justified to consider them separately. Furthermore, it has been noted that there are differences in weight categories (Franchini and Sterkowicz, 2000; Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; Kruszewski et al., 2008; Carratala, Garcia and Fernandez, 2009; Boguszewski, 2010; and Witkowski et al., 2012) and thus it can be argued that women's judo should be studied from the perspective of gender and weight category. This study will focus upon the three lightweight women's weight categories - under 48kg, under 52kg and under 57kg. The reasons for focussing on only three weight categories is that a smaller sample size will allow greater depth in the analysis and therefore allow assessment of more elements (technical, tactical and temporal) hopefully identifying where differences may occur overall for females.

Significance

Arguably the largest sporting stage in the world is the Olympic games. Various agencies and authors have argued that in terms of viewing figures and income the Soccer World Cup and Super bowl are larger. However, in terms of global politics, national nostalgia and global reach the Olympic games is far greater (Roche, 2006; Pappous & Hayday, 2015). Since very early on in the history of the modern Games they have been seen as a vehicle for articulating a nations identity (Miah & Garcia, 2012. pp 28). Furthermore, despite attempts to keep the Olympic games politically neutral this is often not the case, for example non-attendance or boycotting by governments - Melbourne, 1956 (Egypt, Iraq, Lebanon, the Netherlands, Peoples Republic of China, Spain & Switzerland); Tokyo, 1964 (North Korea & Indonesia) and possibly most well-known, the cold war boycotts of Moscow and Los Angeles. There is often

also individual protest for example, in 1968, Tommie Smith and John Carlos of the USA used their “podium lime-light” to give their ‘black power’ salute in support of African American civil rights and the intervention of the Olympic torch lighting ceremony by Jean-Francois Julliard from the Press Freedom Association ‘reporters without borders’ (Miah & Garcia, 2012. pp 68-69).

Indeed, the Olympic Games are viewed by billions - estimated at around 1 billion for the Seoul and Barcelona Games in 1988 and 1992, 2 billion for the Atlanta Games in 1996, and 3.5 billion for the Sydney and Athens Olympics (Roche, 2006). Furthermore, the Olympic family has more member states than the United Nations, 205 to 192 respectively.

In judo, there are 56 medals presented across 14 weight categories (one gold, one silver and two bronze). Each nation can qualify a maximum of 14 athletes (one per weight category) and therefore there are 14 medals available per nation (only one athlete per category). The financial cost of winning medals in an Olympic Games is large, in the Olympic cycle leading to Beijing Great Britain invested £235,103,000 into Olympic sports for high performance alone (UK Sport, n.d.) and won 47 medals (British Broadcasting Corporation, 2008), this is a cost of £5,002,191 per Olympic medal for “articulating national identity”. British judo had the opportunity to win up to 14 medals (one in each weight category), seven male and seven female and UK sport invested £7,484,100 for the London 2012 Olympic cycle, and British judo won two medals, both by heavy weight women. This level of funding is consistent as for the Rio de Janeiro 2016 cycle they invested £7,366,200, where they only won a single bronze medal, this was in the woman’s middle weight. Therefore, it can be suggested that in the London 2012 Olympic games British judo was cost effective with a cost of £3,742,050 per medal compared to the Team GB average of £5,002,191 per Olympic medal. However, in the Rio de Janeiro 2016 Olympic games British judo was less efficient with its single medal costing £7,366,200 and the Team GB average costing £4,096,500.

With so much government money invested in winning medals and 14 medals available in one sport it is important to understand the demands of the sport so that training can be efficient. Whilst there is a growing body of research into the demands of judo, much of this is focussed on mixed groups (male and female, heavy weight and lightweight) or on males alone (Sterkowicz & Maslej, 1998; Franchini & Sterkowicz, 1999; Kruszewski *et al.*, 2008; Garcia & Fernandez, 2009). There is limited research that focusses on females only (Franchini & Sterkowicz, 2003; Sertic, Segedi & Sterkowicz, 2007; Boguszewski, 2010). There is also large difference associated with lightweights versus heavy weights and therefore it is important to single out one and focus on these demands (Witowski *et al.*, 2012; Franchini, 2001; Ploszaj, 2007).

The aims of this study

As a consequence of the differences presented in the literature when comparing gender and weight the aims of this research are threefold:

1. To identify the technical qualities of lightweight women's judo in terms of techniques used, the frequency of them and their efficiency
2. To identify the tactical qualities of lightweight women's judo
3. To quantify the temporal components of lightweight women's judo in order to allow coaches to develop strategy and specific training

Lightweight women's judo was selected for this PhD as there is already a larger base of research into men's judo and heavy weight women's judo is potentially not as developed as lightweight women's judo.

Chapter 3: Reliability and Validity in Performance Analysis

Chapter 3 – Validity and Reliability in Performance Analysis

Validity

External validity is the extent to which the results of a study can be generalised. This requires participants who are representative of the population of interest (O'Donoghue, 2010). In the case of understanding elite performance in judo from various perspectives methods that could be employed include physiological testing, technical assessment and psychological assessment but in order to complete these you require physical access to athletes and use of their time. Using performance analysis allows the assessment of many parameters in a natural competitive setting increasing the validity of the research.

According to Currell and Jeukendrup (2008) and O'Donoghue (2010) there are four types of validity that can be applied to performance analysis - logical validity, criterion validity, content validity and construct validity.

- Logical validity - is where the variable is valid by definition, for example distance, height, angles and duration
- Criterion validity - is where a criterion is set against a “gold standard” that has been accepted as a measure of the concept. This type of validity is rarely used because of the need for a consensus of opinion for the gold standard
- Content validity - in performance analysis this type of validity often revolves around the performance indicators chosen and whether they actually predict the performance outcomes they're supposed too
- Construct validity - the validity of a construct that tests or measures a parameter that is not directly observable. For example, does the observations and quantification of *Shido's* actually represent tactics and/or strategy?

Reliability

O'Donoghue (2007) defined seven steps that improve reliability in performance analysis research:

1. Identify the performance indicators of interest and define these as precisely as possible. Where the performance indicator represents a complex pattern that is difficult to define in words, example video sequences for each value of the indicator may be required to train operators.
2. Identify the values of performance indicators for different types of performances (tactically, technically or in terms of energy systems).
3. Select a reliability statistic that will have construct validity.
4. Determine what value of this performance indicator represents an acceptable level of reliability (based on step 2 of these recommendations).
5. Train the operators using intra-operator reliability studies.
6. Undertake an inter-operator reliability study. This stage could be to compare reliability of performance indicators using a system with those published in media or internet sources.
7. If the level of reliability achieved by the operators is poor, consider using a less precise categorical version of the performance indicator.

Steps 1 to 4 are relevant during system development and steps 5 to 7 should be applied by each new operator using the system.

Intra and inter-operator reliability

Given the expense of automated systems, much performance analysis research continues to use methods that involve human observation. There is a need to train researchers/operators and have clear procedures to avoid data being entered inaccurately, variable observer reaction to events, and different interpretations of performance being made (Bloomfield, Polman, & O'Donoghue, 2007). A culmination of these controls helps eliminate subjectivity. McLaughlin and O'Donoghue (2001) identified the possibility of error suggesting one observer had a tendency to record 10% more of a certain activity than the other observer in an inter-operator reliability study involving 28 subjects. Conversely, Bloomfield *et al.*, (2007) and Deutsch et al (2007) found good reliability of measurement of soccer and rugby performance respectively suggesting that observational methods can provide reliable data.

Hughes, Cooper and Nevill, (2002) analysed 67 performance analysis research articles to assess the use of reliability tests specifically in performance analysis research. They found that 70% of these had no reliability test whatsoever and a further 15% only reported correlations as reliability tests. However, reliability tests have been reported in the literature. McInnes *et al.*, (1995) measured the activity and movement patterns during male elite basketball. One match quarter was analysed twice for four players with a spacing of three weeks from the original analysis. Method errors for the different categories of movement (standing and walking, jogging, running, striding, sprinting, shuffling, jumping) ranged from 4.9-10.6% (mean = 7.0%) for the total percent time spent in each category and from 3.9-11.7% (mean = 9%) for the duration of each period of high intensity. Duthie *et al.*, (2003) determined the level of agreement in an individual observer repeated time-motion in a rugby match by analysing ten players twice using visual observation. Movement was categorised as stationary, walking, jogging, striding, sprinting, static exertion, jumping lifting or tackling. The reliability of the total time spent in movement categories of stationary, walking, jogging, striding, sprinting and static exertion ranged from 5.8%-11.1% (mean 8.3%) Typical Error Measurement (TEM) which the author accepted as being moderate reliability. The reliability of mean duration in each category was slightly better with TEMs of 7.1-9.3% (mean 7.7%). The movement category of stationary and higher intensity categories had the poorest reliability whereas jogging had the best reliability measures.

Other authors include O'Donoghue (2004) tests of inter-observer reliability and intra-observer reliability were conducted revealing that there was significant systematic bias between observers for the percentage time spent performing high intensity activity ($P < 0.01$) and between the first and second observations ($P < 0.05$) with higher values being recorded during the first observation. Spencer *et al.*, (2004), who also categorised movement found error measurement values of 5.9-10.2% (mean = 7.8%) were reported for the frequency of movement and 5.7-9.8% (mean 8.1%) for duration of movement when analysing half a hockey match twice. Lythe (2008) compared conditions using multiple paired T-Tests with unequal variances. Statistical significance was set at $p < 0.05$ and the reliability of the technical evaluation was assessed using pearson correlations and the typical error of measurement spreadsheets of Hopkins (www.sportsci.org). Trends were assessed using linear regression techniques. A high level of observer reliability was found when applying the technical criteria twice to the same match. A pearson correlation of $r=0.96$ and a TEM of 1.2% were found.

According to Steiner, (2003) Cronbach's Alpha is the most widely used index of reliability. He suggests this is because of its ease of use, it does not require two administrations of the scale and it does not need two or more raters. Steiner goes on to suggest flaws with Conbach's

Alpha and these are mirrored by Sijtsma, (2009) who suggests the only reason to report a Cronbach alpha is that top journals tend to accept articles that use statistical methods that have been around for a long time. Reporting alpha in addition to a greater lower bound may be a good strategy to introduce and promote a better reliability estimation practice.

In terms of inter-operator reliability tests Choi *et al.*, (2007) investigated the reliability tests used on performance analysis data. They proposed that the Pearson's r , Chi-square, % error and Kappa tests statistics were most commonly used to evaluate the reliability between independent observers. They used a peer review process of modelling different levels of reliability with synthetic data and demonstrated that kappa was the only one of the four statistics to have construct validity for the purpose of reliability assessment in performance analysis. They concluded that kappa values of 0.8 or above are interpreted as good while values of 0.6 to 0.8 are acceptable and therefore when using kappa for post hoc reliability analysis of individual event types, values of 0.5 or above can be considered as acceptable. This research was furthered by Robinson & O'Donaghue (2007) who suggested that in some areas of performance analysis are not a complete disagreement. They use the example of a netball court broken down into segments and suggest that one observer maybe report an action in one segment and another observer report the same action in another segment and indeed one could be wrong or both could be wrong. In this case the Kappa test would treat this disagreement as a total disagreement and this might not be case; they suggest the use of a weighted Kappa test. It is felt in the case of this research ambiguous key performance indicators such as areas on the tatami (judo mat) will be avoided and therefore the procedure recommended by Choi *et al.*, (2007) will suffice.

O'Donaghue (2007) describes intra-operator reliability tests as:

"Intra-operator reliability studies involve an operator analysing a performance on 2 or more occasions using the given performance analysis system. Where a good level of intra-operator agreement is achieved, it merely shows that the operator can use the system consistently. The operator's understanding of the events being counted may be different to other potential operators and, therefore, intra-operator agreement does not establish the objectivity of a system".

He proposed that improvements in reliability should be monitored during inter-operator agreement studies to ensure the operator is consistent with the analysis system.

Given the popularity of Cronbach's Alpha coupled with the criticism about its use as a reliability test, particularly in the field of performance analysis this work will conduct two reliability tests at each point to allow the reader to greater understanding of the reliability within and between operators. Both Cronbach's alpha and Cohen's Kappa will be reported. Acceptable levels of agreement for each of the tests is shown below in Tables 3.1 and 3.2.

Table 3.1: Interpreting Kappa scores

Kappa	Reliability
0 - <0.2	None/slight
0.2 - <0.4	Fair
0.4 - <0.6	Moderate
0.6 - <0.8	Good
0.8 - 1.0	Excellent

Table 3.2: Interpreting Alpha scores

Cronbach Alpha	Reliability
0 - <0.4	Poor
0.4 - <0.7	Moderate
0.7 - <0.9	Good
>0.9	Good but maybe redundant

If alpha is too high, it may suggest that some items are redundant as they are testing the same thing but in a different guise. A high value of alpha (> 0.90) may suggest redundancies and show that the test length should be shortened. In the case of this research some elements do test the same thing, for example the attacking of one *Judoka* is the defending of another.

Selecting key performance indicators

The development of performance analysis systems usually evolves around what performance indicators can be used (O'Donoghue, 2008). Hughes and Bartlett (2002) stated that a key performance indicator (KPI) is a performance variable or combination of variables that are objectively measured. O'Donoghue (2010) outlined the key purpose of performance analysis is to develop a better understanding in a particular sport or assess an athletes' execution in order to enhance performance. Many sports have a complex and dynamic nature, and therefore to cultivate an understanding of performance, observation and measurement is needed. The use of performance analysis can provide objective information to achieve this greater understanding of performance, as opposed to attaining subjective information alone. The aim of each variable is to outline some or all aspects of a performance. All movement variables can be considered as KPI's providing they contribute to the performance. Often KPI's are used to measure the performance of an individual or team, however they can be used to compare opponents, other athletes, peer groups or teams. KPI's are often selected from existing literature or based upon the needs of specific research or team coaches.

Chapter 4: Global Methodology

Outputs from this section:

Miller, G., Collins, N., Stewart, M., & **Challis, D.G.** 2015. Throw type and technique efficiency of *Nage-waza* used in the 2013 Junior and Senior British Judo Championships. *International Journal of Performance Analysis in Sport*. Volume 15, Number 1. P53-68.

Collins, N. & **Challis, D.G.** 2013. An Analysis of *Kumi Kata* at the Junior and Senior British Championships 2013. *8th International Judo Federation World Judo Research Symposium*. Rio de Janeiro, Brazil.

Chapter 4: Global Methodology

In order to address the above issues this research will consist of three research procedures that break down women's judo to develop a further understanding of its traits. This section considers the commonalities in methodology across all three studies, more detailed information specific to each study is included within the respective chapters.

Participants

In order to establish the technical, tactical and temporal components of lightweight women's judo the 2010 world championships held in Tokyo under the 2010 Olympic qualification rules were compared to the 2014 world championships held in Chelyabinsk under the 2014 Olympic qualification rules. Comparing across these two events will also develop an understanding of the effects the rule changes have had on lightweight women's judo.

Lightweight women's judo was considered as the three lightest weight groups - under 48kg, under 52kg and under 57kg. In the 2010 world championships there were 45 athletes in each of the weight groups and in 2014 there were 34 athletes in the u48kg category and 42 in each of the u52kg and u57kg giving a total number of 135 and 116 contests respectively (n=251).

Ethical approval

Ethical approval was sought and granted from the Faculty of Science and Technology "Faculty Research and Ethics Panel" (FREP) at Anglia Ruskin University in 2010 for the duration of the study.

Equipment

Throughout this study Sportscore Elite (Version 8 and Version 10, Hudl) was used to analyse the footage. Analysis was conducted using IBM SPSS statistics (Version 24 for Macintosh) and Microsoft Excel for Mac (Version 15.5 for Macintosh). Videos were recorded in the stadium on a Canon Legria HF R806 camcorder (50fps: 1920 x 1080, 35Mbps). Contests that could not be recorded in this way were downloaded from <https://www.youtube.com/user/judo>. All video was imported into Sportscore. Comparing the collected video and the results sheets from the competition all 251 fights were accessed.

Intra-operator reliability and Inter-operator reliability

Chapter 3 considers validity and reliability. In terms of reliability the conclusions of chapter 3 are to use two statistical tests where relevant - Cronbach's Alpha test and Cohen's Kappa test. For the Cronbach Alpha data was considered acceptable with a score of 0.7-0.8, good with a score of 0.8 – 0.9 and excellent with a score >0.9. For the Cohen's Kappa data was considered reliable with a score of 0.40 or higher (fair to good). More details on these are in chapter 3. The following reliability tests were conducted within this research:

Time-motion analysis –

- Intra-operator – 2 x 20-minute clips, 4 weeks apart were compared using a Cronbach alpha test, the result of this were a score of 0.81(good). This was followed by a Cohens kappa that gave a result of 0.61 (good)
- Inter-operator – 20-minute clips compared across four operators using a Cronbach alpha test and a Cohens kappa, the scores were 0.951 (excellent) and 0.41 respectively (moderate).

20-minute video clips were used because of the manageable size and the number of KPI's presented was sufficient for analysis.

Technical and tactical analysis –

Attacks/Tachi-waza

- Intra-operator – 2 x 20-minute clips, 4 weeks apart compared using Cronbach alpha test and Cohen kappa. This included techniques, laterality, handedness, and direction. The result of this was a score of 0.73 (good) for the Cronbach alpha and 0.52 (moderate) for the Cohens kappa.
- Inter-operator –20-minute clips compared using Cronbach alpha test and Cohen kappa. This included techniques, laterality, handedness, and direction. The scores were 0.975 (excellent) and 0.40 (fair) respectively

Ne-waza

- All *Ne-waza* was coded by hand by the lead researcher, two *Judoka* then also coded by hand and the results were compared. Where there were difference the video was re-watched as a group and a decision made.

Penalties

- All penalties were coded by hand by the lead researcher and then three *Judoka* also coded by hand for comparison. Where there were difference the video was re-watched as a group and a decision made

Pilot studies

Four undergraduate projects and one MSc project was conducted prior to or during this study in order to trial coding methodology and concepts. These studies were –

Collins, N and Challis, D.G. 2014. A Comparison of Kumi-Kata Across Age, Gender and Weight Categories in British Judo. Undergraduate. Anglia Ruskin University.

Stewart, M and Challis, D.G. 2014. *Notational Analysis of Ne-waza in British Judo*. Undergraduate. Anglia Ruskin University.

Miller, G and Challis, D.G. 2014. Throw type and technique efficiency of nage-waza used in the 2013 Junior and Senior British Judo Championships. Undergraduate. Anglia Ruskin University.

Fitzjohn, T. and Challis, D.G. 2015. *An Analysis of Lightweight Women's Judo and the effects of Laterality*. Undergraduate. Anglia Ruskin University.

Fitzjohn, T and Chaliis, D.G. 2016. Is profiling athletes using performance analysis a beneficial coaching tool? Postgraduate. Anglia Ruskin University

Data collection

All video was coded in “layers”. The top layer broke down the video into the main temporal components of a judo contest - *Hajime* and *Matte* (work and rest), *Hajime* was then broken down into its sub-components of *Kumi-kata*, attack/defend, transition/*Ne-waza* (Figure 4.1).

The subsequent layers come from the top layer, it was therefore possible to analyse *Kumi-kata*, attacking/defending and transition/*Ne-waza* in more detail from technical and tactical perspectives. This was conducted by a single researcher/operator and is described in more detail below.

Selection of key performance indicators

In order to select relevant key performance indicators (KPIs) a large variety of literature in the area of performance analysis in judo was assessed. There was also a series of informal discussions with national/international level coaches who were asked what they felt would be useful information from a coaching/applied perspective. Finally, the unpublished work of McDonald (2006) was also consulted as this had a series of formal interviews with high performance coaches on the subject of KPIs for judo analysis.

Once the above was collated it was split into “layers” for the practical application of coding. The top layer predominantly gave temporal data and broke the contests down into sections. The subsequent layers had separate KPIs that were predominantly technical and tactical, there are outlined below under “individual methodologies”.

Individual methodologies

Individual methodologies will be considered in the relevant sections.

The hierarchy of coding is shown in Figure 4.1, including the layers of coding and which video footage was used.

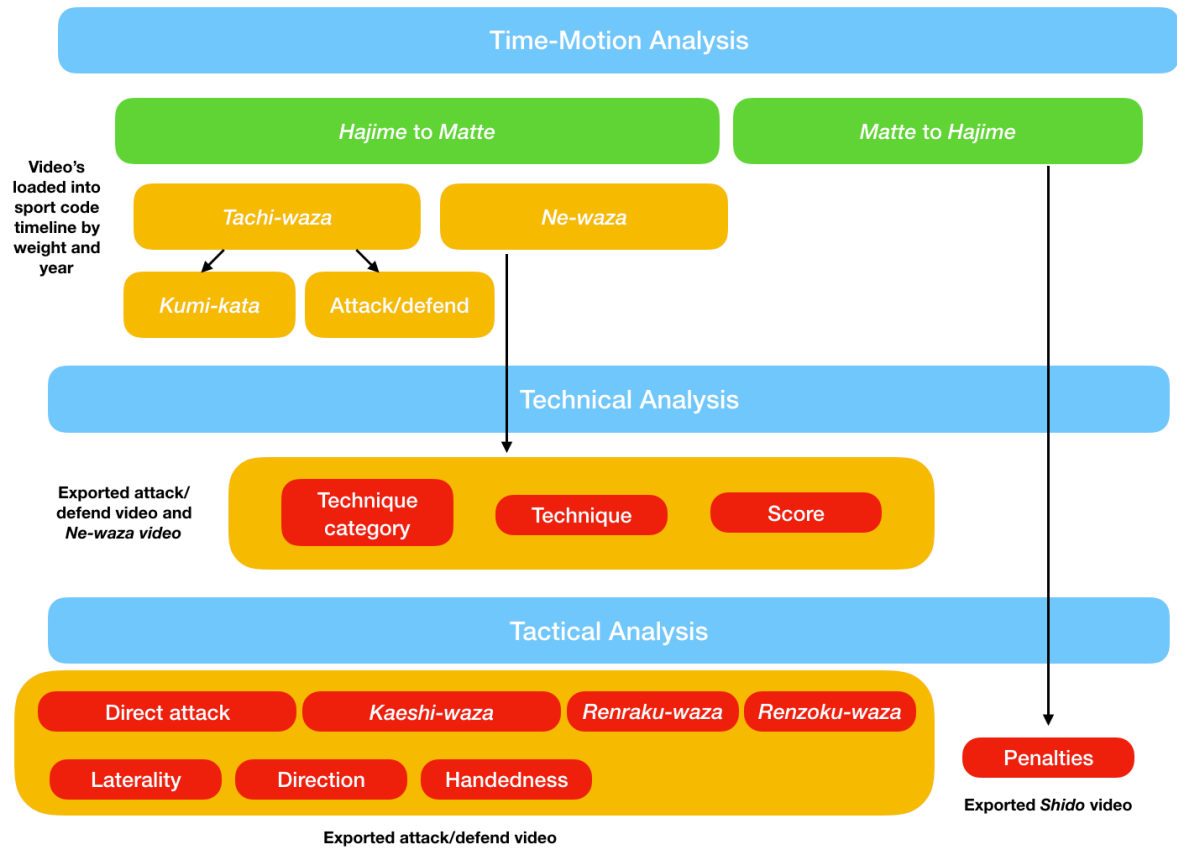


Figure 4.1: The hierarchy of coding

Chapter 5: A Time-Motion Analysis of Lightweight Women's Judo

Outputs from this section:

Challis, D.G., Scruton, A., Cole, M. and Callan, M., *In press*. A Time-Motion Analysis of Lightweight Women's Judo in the 2014 World Championships. *Journal of Combat Sports and Martial Arts*

Challis, D.G., Scruton, A., Cole, M. and Callan, M., 2015. A Time-Motion Analysis of Lightweight Women's Judo in the 2010 World Championships. *International Journal of Sports Science and Coaching*, 10(3).

Challis, D.G., 2013. A Temporal Analysis of the u52kg Women's Judo in the 2010 World Championships. *8th International Judo Federation World Judo Research Symposium*, Rio de Janeiro, Brazil.

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Chapter 5: A Time-Motion Analysis of Lightweight Women's Judo

Introduction

Dobson and Keogh (2007) suggested that time-motion analysis, which involves the study of movement patterns, can provide information such as speed, duration and distance covered by the athlete. Similarly, it can provide knowledge of the time spent in various modes of combat in a judo contest (for example the contribution of *Tachi-waza* compared to *Ne-waza*). Time-motion analysis data can be used by coaches and support staff to develop strength and conditioning programmes, periodised plans and tactical profiles for athletes (McGarry, O'Donoghue, & Sampaio, 2013; Sterkowicz-Przybycien, Miarka, & Fukuda, 2017; Miarka *et al.*, 2016).

Time-Motion Analysis (TMA) is not easy to conduct in the sport of judo because of the speed in which techniques happen. It is also not possible to use technology such as GPS and heart rate monitors as in most team sports. However, Miarka, (2011; 2012; 2014 & 2016) Sterkowicz (1999) and Marcon (2010) are examples of authors who have conducted research in this area.

Miarka (2011) compared time motion indicators across four age bands in all categories of three regional and one state championships. The performance indicators were as follows:

- Total combat time
- Pause time
- Standing combat time
- Displacement without contact
- Gripping time
- Groundwork combat time

The results showed that there was a median of 6 *Hajime* to *Matte* blocks within a contest, this is lower than other authors (Casterenas and Planas, 1997; Sikorski *et al.*, 1987; Sterkowicz, 1999) who generally found 11-12 work segments. They also showed the average duration of each block by age group, pre-juvenile (21s \pm 8s), juvenile (16s \pm 6s), junior (22s \pm 10s) and senior (30 \pm 33s).

Casterenas and Planas (1997) and Sikorski *et al.*, (1987) used time-motion analysis to assess judo contests; each contest averaged 11 bouts of 15-30 seconds work with 10 seconds rest intervals. Sterkowicz's (1999) found comparable results and suggested a contest contained 12 blocks.

Research by Franchini *et al.*, (2011) also used time-motion analysis to determine the physiological and metabolic demands of a contest via the temporal components. It was suggested an athlete will typically have 5 to 7 fights per competition in order to gain a medal. The average fight would last 3 minutes; consisting of 20-30 second bouts of activity with 5-10 seconds rest intervals. Depending on the scores achieved by the contestants a fight could last anything between a few seconds and 8 minutes.

Sikorski (2010) analysed temporal blocks at several events including the European championships (1985, 1986 and 1999), World cup (1986), Olympic Games (1988-1996 and 2008). The average time of each temporal block ranged between 18-25 seconds with 10 second rest intervals; totalling a contest length between 5-8 minutes which corresponded with the findings of Degoutte *et al.*, (2003) who used simulated judo contests.

With such variation in the the reported frequency and duration of work and rest in a judo contest Franchini *et al.*, (2013) conducted a review of the current literature on the topic. They concluded that;

- Studies have consistently shown that mean duration of judo matches is ~3min, regardless of the level of competition (Miarka *et al.*, 2012; Miarka *et al.*, 2010; Castarlenas and Planas, 1997; Sterkowicz and Maslej, 1998)
- In a typical match, athletes perform approximately 11 periods of activity (Marcon *et al.*, 2010; Castarlenas and Planas, 1997)
- It is possible to observe that periods of activity vary from 10s to 63s and pause periods vary from 1s to 22s
- The activity-pause ratio is normally 2:1 or 3:1
- The results appear to be similar between men's and women's competitions (Hernández-García and Torres-Luque, 2007; Wicks, 2006)
- Athletes seem to engage in shorter effort periods and longer intervals in the last minute compared to the previous ones (Monteiro, 1995), which can be interpreted as an effect of fatigue on technical-tactical actions.

The large variations in the observed research and the lack of data specific to “special population” coupled with a change in rules leads us to the conclusion that more research could benefit our understandings of the time-motion aspect of a judo contest.

Judo rules

Rules are regularly changing in an attempt to bring back a more traditional upright style of judo (Yeoh & Finch, 2015; Paschini, 2009), to give judo a wider audience (IJF, 2013; EJU 2013) and to differentiate it from other sports (IJF, 2016) as explained in the introduction to this thesis. The rule changes in January 2014 outlined in Ljubljana 28 October 2013 for the Rio 2016 Olympic qualification period (IJF, 2013) have major rule changes that could affect the temporal components of the contest including:

- Referees and judges:
 - One referee on the mat with a radio communication system is connected to the two referees on the table of the mat who will assist with a Computer Aided Replay (CARE) system
- Rolling Shido's:
 - A *Shido* (penalty) will be given to the fighter deserving it, in place, without having both fighters return to the formal start position (*Matte – Shido – Hajime*) except when a *Shido* is given for leaving the contest area
- Technical assessment:
 - *Ippon*: When the fall is rolled without real impact, it is not possible to consider it *Ippon*. This is to give more value and to take into account only the techniques with a real impact. .
 - *Yuko*: When a contestant throws his opponent, with control, and the opponent falls on the side of the upper body it should be *Yuko*.
 - All situations of landing in the bridge position will be considered *Ippon*.
- Penalised with *Shido*-
 - Cross gripping should be followed by an immediate attack in the same manner as for belt gripping and one side gripping

- The referees should penalise strictly the contestant who does not engage in a quick *Kumi-kata* or who tries not to be gripped by the opponent. If one of the contestants breaks the *Kumi-kata* twice in the gripping period then the third time they will receive a *Shido*
 - Breaking the grip of the opponent with two hands
 - To force the opponent with either one or both arms to take a bending position without immediate attack will be penalised by *Shido* for a blocking attitude
- Duration of Contests - No time limit for Golden Score (*Hantei* is cancelled). Contest times will be:
 - Seniors men: 5 minutes
 - Seniors women: 4 minutes

It has been shown in other sports that rule changes can affect the physiological demands of the sport. For example, Meir *et al.*, (2001) reported an even greater demand was placed on the aerobic capabilities of rugby league athletes after the 10-metre rule change was brought in. Kraak (2015) reported “*the duration of the international matches has increased owing to the increase in the number of stoppages, mainly as a result of greater use being made of the TMO, substitutions and on-field concussion tests.*” He suggested this is evident in the significant increase in total match time and ball-in-play time. Overall the results of the study show that “*the profile of international rugby has changed to a more continuous game dynamic with the increase in the number of ball carries, passes, tackle breaks and line breaks, and has led to an increase in the number of tackles.* There was also a *decrease in the number of rucks, mauls, scrums, scrum resets and line-outs.* Other sports assessed include field Hockey where Tromp and Holmes (2011) considered the new self-pass rule and concluded “*the intention of the new self-pass rule to increase the flow of the game has been met, as the average amount of time taken to engage in a free hit and thus carry on with play has been roughly halved.*”

Some authors have proposed that the temporal structure to judo contests has been altered by previous rule changes. Using rule changes from 2004, Hernandez-Garcia *et al.*, (2009) observed a contest duration of 6.15 minutes \pm 30.39 seconds. They suggest that bouts of work have increased in duration and the frequency and duration of rest periods has decreased when compared to literature produced under previous rules. Other authors, such as Miarka *et al.*, (2016) suggest the temporal components of a judo contest have been “similar and consistent” in men’s judo over the past 25 years citing the works of Castarlenas & Planas,

(1997); Marcon *et al.*, (2010); and Sikorski *et al.*, (1987). They advocate values around 15-30s: 8-15s per combat: pause cycle sequences.

The aim of this chapter of the thesis is to investigate and compare the temporal components of the lightweight women's judo contest under the 2010-2012 IJF rules and the 2014-2016 IJF rules. The KPIs that were considered included: frequency, duration and fatigue in order to establish if there is different demands placed upon this judo population and if so, allow coaches to adapt their training methods (Sterkowicz-Przybycień *et al*, 2017).

Method for time-motion analysis

Procedure

In order to break down the contests into temporal components four KPIs were selected. The KPIs were, *Hajime* to *Matte* Blocks (Work), *Matte* to *Hajime* Blocks (Rest), *Tachi-waza* Blocks (standing), and Transition/*Ne-waza* (Groundwork). Once all the data was collected a script was written by the lead researcher in a Sportscore statistics window to extract the time data, for example when the KPI was *Hajime* the script would have been:

```
$inst = length instances where row = "Hajime" limit 1  
show round($inst,2)
```

The data extracted using the script was then compared to data extracted manually, any discrepancies were then searched for in the data base and re-assessed by the operator. Common reasons for these minor errors were confusions around two KPIs being very close to each other or the referee saying *Hajime* and immediately saying *Matte* (for example if the control table stop the fight).

Reliability

This layer of coding was conducted by one operator and therefore only intra-operator reliability tests were conducted. Reliability test scores were 0.81 (good) for the Cronbach's Alpha test and 0.61 (good) for the Cohen's Kappa test.

Equipment

Time-motion analysis data was collected in a single layer of coding using Sportscore elite (V10, Hudl). This layer was considered the "top layer" for all the other layers and the code window developed for this task is shown in Figures 5.1 and 5.2.

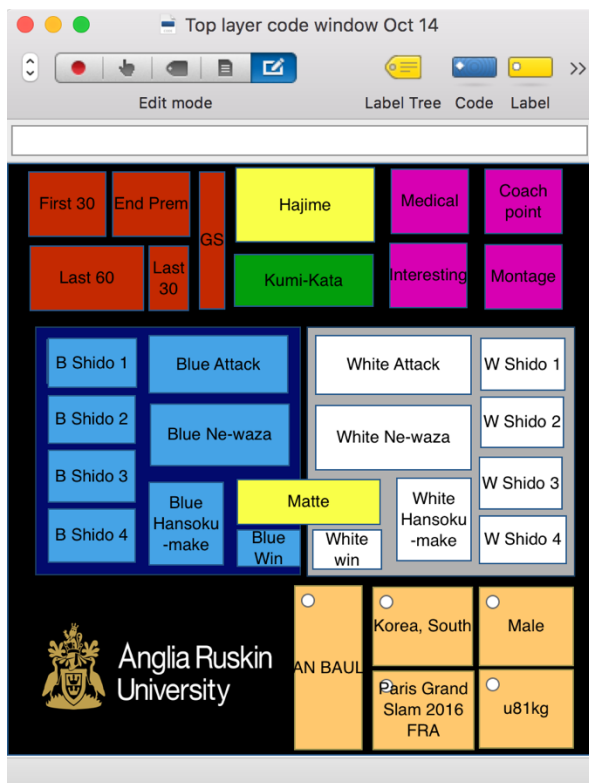


Figure 5.1: Time-Motion Analysis code window used in this study.

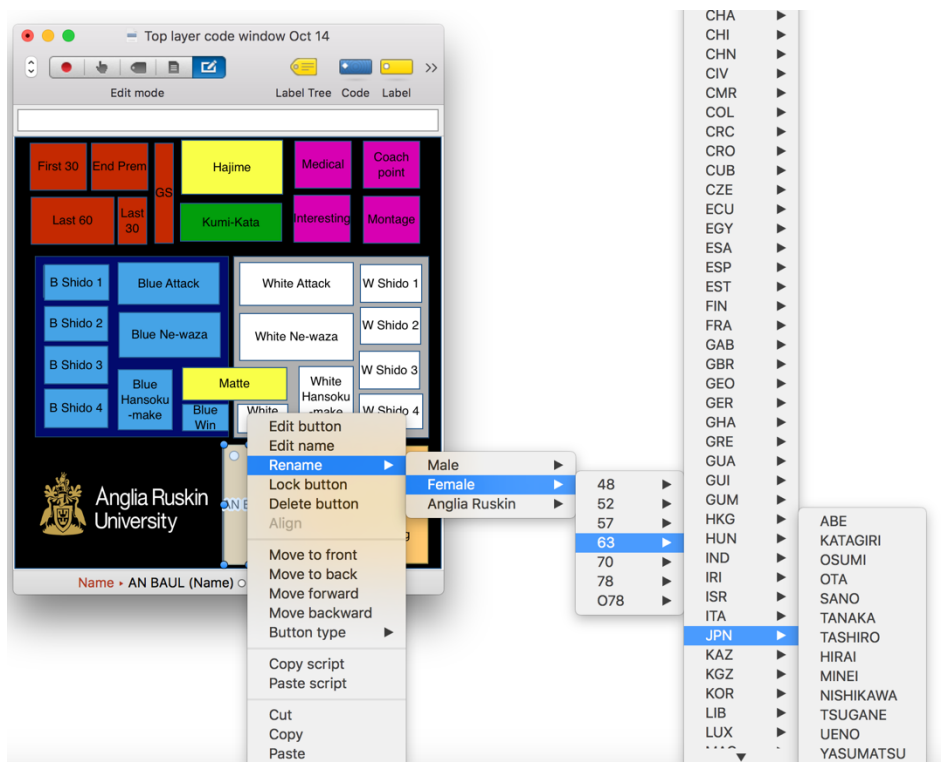


Figure 5.2: Labelling function linked to world ranking list for Time-Motion Analysis code window. The name, country, gender and weight category were changed for each fight using this method.

Data analysis

The data was finally exported into excel where descriptive statistics were developed and then into SPSS for further analysis. Tests conducted included ANOVA and independent sample T-Tests.

Key performance indicators

The key performance indicators related to this level of coding are shown below in Table 5.1. These are the same key performance indicators as cited in Miller *et al.*, 2015, Challis *et al.*, 2015, Collins & Challis, 2013 and Challis, 2013).

Table 5.1: Key Performance indicators from Miller *et al.*, (2015) that were utilized in this research.

Coding Button	Meaning	Description
Hajime	Begin	Used at the beginning of a period of combat, only stopped by <i>Matte</i> or <i>Soremade</i>
Kumi Kata	Grip Fighting	Period of combat in which gripping occurs without an attack being made
Attack/Defend	Attack made	Attack identified as 'an effort to create movement with a technique in order to throw or set up for a combination
Ne-waza	Ground work	Period of the contest that involves ground work grappling.
Matte	Stop (break)	When the referee calls for a stop in the contest
Soremade	End of Contest	When a winner has been decided
Shido	Penalty	Used for every penalty awarded
Golden Score	Extended Contest	When the initial contest time is over and the scores are level
First Aid	Injury/Medical call	Any form of time consuming injury
Interesting	Point of interest	Used to identify fights that have been placed into a different timeline, usually wrong weight category.

Results

The coding of three KPIs across the 139 contests in three weight groups in the 2010 World championships produced a total of 1756 *Hajime to Matte* blocks (work), 1422 *Matte to Hajime* blocks (rest), and 516 *Ne-waza* (ground work) sequences. The same KPIs across the three weight groups in the 2014 World championships produced a total of 1056 *Hajime to Matte* blocks (work), 923 *Matte to Hajime* blocks (rest), and 432 *Ne-waza* sequences (ground work) from 128 contests. Table 5.2 shows the volume of judo analysed and that this is similar to other research in this area.

Table 5.2: The volume of data coding to show the temporal components of lightweight women's judo across all three weight categories. Total hours footage and number of KPIs.

	<i>Total hours footage</i>	<i>Number of contests</i>	<i>Hajime to Matte (n)</i>	<i>Matte to Hajime (n)</i>	<i>Ne-waza (n)</i>
2010 WC	12hrs 47mins	139	1756	1422	516
2014 WC	9hrs 49mins	128	1056	923	432
Total	22hrs 36mins	267	2812	2345	948

Frequency

The frequency of the KPI's is expected to be lower in 2014 compared to 2010 as the duration of the contests was one minute less, from 5 minutes to 4 minutes. Table 5.2 shows the mean for each of the three comparable KPIs.

Table 5.3: The mean number of *Hajime to Matte* Blocks (Work), *Matte to Hajime* Blocks (Rest) and Transitions/*Ne-waza* (Ground Work) for Each Weight Group with the Standard Deviation.

Key Performance Indicator	2010				2014			
	48kg (n)	52kg (n)	57kg (n)	Average 2010	48kg (n)	52kg (n)	57kg (n)	Average 2014
<i>Hajime-Matte (work)</i>	12.7 ± 7.5*	10.3 ± 6.3*	10.1 ± 7.4	11.0 ± 7.2*	8.9 ± 4.8*	7.5 ± 3.9*	8.6 ± 4.6	8.3 ± 4.4*
<i>Matte-Hajime (Rest)</i>	11.5 ± 7.5*	9.3 ± 6.4*	9.0 ± 7.3	9.9 ± 7.1*	7.9 ± 4.8*	6.5 ± 3.9*	7.6 ± 4.6	7.3 ± 4.4*
<i>Transition/Ne-waza</i>	4.0 ± 2.9	3.8 ± 2.8	3.1 ± 2.8	3.6 ± 2.8	3.7 ± 2.6	3.4 ± 2.3	2.8 ± 1.6	3.2 ± 2.2

* Significant difference between 2010 and 2014 data

An independent samples T-Test showed a significant difference between the frequency of *Hajime to Matte* (work) and *Matte to Hajime* when comparing 2010 to 2014 ($p < 0.05$ level). A normality test for the above data showed a positive skew for both the 2010 and 2014 data and

this was deemed acceptable due to the volume of data (Chalmers, 1986 (p.147); Field and Miles, 2010 (p.276)).

Duration

It is possible to compare the duration of *Hajime* to *Matte* (work time), *Matte* to *Hajime* (rest time), *Tachi-waza* (standing work) transition/*Ne-waza* (ground work) and total contest duration.

Contest duration is the total combat time (*Hajime* to *Matte* + *Matte* to *Hajime*) and therefore the total amount of time the athlete is on the mat for a single contest.

Table 5.4: The mean contest duration in minutes and seconds (m.s) by weight category. A one-way ANOVA showed no significant difference across weight categories within each year ($P < 0.05$).

	48kg (m.s)	52kg (m.s)	57kg (m.s)	Average (m.s)
2010 world championships	5.47 ± 195.2	5.03 ± 173.6	5.01 ± 169.1	5.17 ± 191.2
2014 world championships	4.45 ± 116.9	4.04 ± 119.6	4.54 ± 122.8	4.34 ± 119.8

No significant differences were noted by weight groups within year using a one-way ANOVA, 2010 [$F(2, 1200) = .888$, $p = .414$] and for 2014 [$F(2, 124) = .770$, $p = .465$]. Despite changes to the regulations and the appearance of a change in duration time a one-way ANOVA showed no significant difference in contest time from 2010 to 2014. A normality test for the above data showed a positive skew and this was deemed acceptable due to the volume of data (Chalmers, 1986 (p.147); Field and Miles, 2010 (p.276)).

Table 5.5: The mean duration of *Hajime to Matte* Blocks (Work), *Matte to Hajime* Blocks (Rest), *Tachiwaza* (Standing) and Transitions/*Ne-waza* (Ground Work) for Each Weight Group with the Standard Deviation.

	2010				2014			
Key Performance Indicator	48kg (s)	52kg (s)	57kg (s)	Average (s)	48kg (s)	52kg (s)	57kg (s)	Average (s)
<i>Hajime to Matte</i> (work)	19.6 ± 10.0*	21.7 ± 10.8*	21.7 ± 11.9*	20.9 ± 10.9*	22.7 ± 12.6*	24.4 ± 12.5*	23.7 ± 14.3*	23.6 ± 13.2*
<i>Matte to Hajime</i> (Rest)	9.0 ± 9.0	9.3 ± 7.5	9.7 ± 5.8*	9.3 ± 7.7	8.3 ± 5.6	9.2 ± 9.6	8.8 ± 5.9*	8.8 ± 7.2
<i>Tachi-waza</i>	14.1 ± 7.5*	13.4 ± 8.3*	13.7 ± 9.2*	13.8 ± 8.3*	16.5 ± 8.4*	18.2 ± 9.5*	19.1 ± 11.6*	18.0 ± 10.1*
Transition/ <i>Ne-waza</i>	4.4 ± 8.3	5.4 ± 9.0	5.0 ± 9.5*	4.9 ± 8.9	5.6 ± 9.8	5.2 ± 9.5	3.6 ± 8.3*	4.7 ± 9.2

* Significant difference between 2010 and 2014 world championships

An independent samples T-Test showed a significant difference ($P < 0.05$) for *Hajime to Matte* time and *Tachi-waza* time when comparing 2010 to 2014. A normality test for the above data showed a positive skew and this was deemed acceptable due to the volume of data (Chalmers, 1986 (p.147); Field and Miles, 2010 (p.276)). It showed a significant difference between 2010 and 2014 for *Hajime to Matte* time and *Tachi-waza* time across all weight groups and within *Matte to Hajime* time and *Ne-waza* time for the u57kg. Overall the data suggests that there is a significant increase in the duration of a work block and this is due to an increase in standing combat time.

Fatigue

Fatigue was measured by assessing the lengths of the various KPIs during the first four blocks and the last four blocks of each fight. Therefore, only fights with a minimum of 8 work blocks were included. Data was considered within each year (i.e. weight group to weight group) and across years so that it could be considered where weight category affected fatigue and whether the rule changes affected fatigue. This data is shown in Table 5.5 below. For the purpose of this study, Gastins' (2001) definition of fatigue was used, "*Fatigue is the transient decrease in performance capacity of the muscles, usually seen as a failure to maintain or develop expected force or power output*".

In the 2010 data there was a significant difference ($P < 0.05$) between the duration of work (*Hajime to Matte*) blocks at the beginning and end of the contest in the u48Kg and the u57kg weight categories. The blocks towards the end of the contest were always shorter. The u57kg weight category also saw a significant difference in *Tachi-waza* time when comparing first four to last four blocks. When comparing the averages from all weight categories there was a

significant difference in both *Hajime* to *Matte* time (work) and *Tachi-waza* time (standing fighting) when comparing the first four to last four blocks.

In the 2014 data there was a significant difference in all three weight categories for both *Hajime* to *Matte* time (work) and *Tachi-waza* time (standing fighting) when comparing first four to last four blocks (Table 5.5). This was also observed when comparing the averages from all weight categories.

When comparing 2010 and 2014 it is clear that there is a significant difference ($P < 0.05$) between *Hajime* to *Matte* (work) for the first four blocks but not for the last four blocks. This is the same in *Ne-waza*. The only KPI that shows a significant difference in both the first four blocks and last four blocks when comparing 2010-2014 is *Tachi-waza* (standing fighting).

Table 5.6: Fatigue data comparing first four and last four blocks across four different KPIs. An Independent Sample T-test shows a significant difference between first four and last four blocks within years for *Hajime* to *Matte* (work) and *Tachi-waza* (standing) as well as a significant difference between years for some KPI's.

	Segment	Block	Duration 2010	Duration 2014
Under 48kg	<i>Hajime</i>	First four blocks	22.7 ± 10.8*	24.1 ± 10.1*
		Last four blocks	17.4 ± 8.4*	19.3 ± 10.5*
	<i>Matte</i>	First four blocks	7.6 ± 7.7	7.5 ± 6.1
		Last four blocks	9.3 ± 9.3	9.1 ± 5.5
	<i>Tachi-Waza</i>	First four blocks	15.7 ± 7.3*	19.1 ± 8.2*
		Last four blocks	12.9 ± 6.6*	13.4 ± 7.3*
	<i>Ne-Waza</i>	First four blocks	5.3 ± 10.0	4.2 ± 7.2
		Last four blocks	4.0 ± 7.5	4.6 ± 7.6
Under 52kg	<i>Hajime</i>	First four blocks	22.8 ± 10.1	26.1 ± 11.5*
		Last four blocks	20.4 ± 10.9	21.6 ± 11.1*
	<i>Matte</i>	First four blocks	9.1 ± 6.8	9.8 ± 12.1
		Last four blocks	8.6 ± 6.5	9.6 ± 10.3
	<i>Tachi-Waza</i>	First four blocks	14.0 ± 7.9	21.5 ± 10.1*
		Last four blocks	13.8 ± 8.9	15.8 ± 9.2*
	<i>Ne-Waza</i>	First four blocks	4.6 ± 7.9	3.6 ± 6.0
		Last four blocks	5.2 ± 8.6	4.7 ± 7.2
Under 57kg	<i>Hajime</i>	First four blocks	23.5 ± 11.6	26.8 ± 13.0*
		Last four blocks	19.3 ± 10.4	18.0 ± 11.4*
	<i>Matte</i>	First four blocks	9.1 ± 4.0	8.5 ± 5.9
		Last four blocks	9.2 ± 4.7	8.6 ± 4.7
	<i>Tachi-Waza</i>	First four blocks	17.1 ± 10.9*	22.6 ± 12.0*
		Last four blocks	12.4 ± 10.2*	14.8 ± 8.8*
	<i>Ne-Waza</i>	First four blocks	6.3 ± 13.0	3.2 ± 7.3
		Last four blocks	4.8 ± 7.7	2.2 ± 6.0
All weight categories	<i>Hajime</i>	First four blocks	23.0 ± 10.8*§	25.76 ± 11.69*§
		Last four blocks	18.9 ± 9.9*	19.63 ± 11.08*
	<i>Matte</i>	First four blocks	8.5 ± 6.5	8.62 ± 8.61
		Last four blocks	9.0 ± 7.4	9.09 ± 7.29
	<i>Tachi-Waza</i>	First four blocks	15.6 ± 8.8*§	21.17 ± 10.38*§
		Last four blocks	13.1 ± 8.5*§	14.75 ± 8.56*§
	<i>Ne-Waza</i>	First four blocks	5.4 ± 10.4§	3.62 ± 6.85§
		Last four blocks	4.6 ± 7.9	3.81 ± 6.98

* Significant difference between first and last blocks in same year comparing weight category (p <0.05)

§ Significant difference within same weight category comparing across different years (p <0.05)

Discussion on time-motion analysis in lightweight women's judo

Rule changes have been shown to change the dynamics of a judo contest (Ito *et al.*, 2014; Henandez-Garcia, 2009; Franchini *et al.*, 2013; Boguszewski, 2011; Adam *et al.*, 2012) but not all authors agree (Miarka *et al.*, 2016). The 2013-2016 rule changes (IJF, 2013a) included many elements that could greatly affect the temporal components of a contest. These include women's contests being shortened from 5 minutes to 4 minutes, direct *Hansoku-make* (disqualification) for touching the leg with the arm, rolling *Shido* (i.e. the athletes do not have to return to the middle of the mat), new rules around acceptable *Kumi-kata* and harsher controlling of the edge to avoid athletes stepping out, all of which could affect the dynamics of a contest.

Contest duration

Contest duration is the total combat time (*Hajime* to *Matte* + *Matte* to *Hajime*) and therefore the total amount of time the athlete is on the mat for a single contest. Calculating this accurately is useful for planning both in terms of physiological preparation and the management of events. Being able to accurately predict total contest time allows organisers to predict how long a judo event is likely to be and schedule appropriately. From a physiological perspective, the total duration of combat time allows physiologists, strength and conditioning coaches and other staff to plan training specific to the event.

In the 2010 World Championships the average (mean) total contest time (*Hajime* to *Matte* blocks and *Matte* to *Hajime* blocks) were shown to be 317 seconds (5 minutes 17 seconds) across all three weight categories.

The 2014-2016 rule changes changed the duration for women's contests from 5 minutes to 4 minutes and therefore it is expected to see approximately a 1-minute change in total contest time. This study has shown that the average total combat time in the 2014 World Championships is 274 seconds (4 minutes and 34 seconds) a change of 43s when compared to the 2010 World Championships.

Previous authors have reported contest times in their research including Hernández-García *et al.* (2009) 375.06 ± 30.39 seconds (simulated contests), Miarka *et al.* (2012) found contest times of 3.59 minutes (239 seconds), Miarka *et al.* (2014) 179 ± 135, Miarka (2012) 182 ± 109. It can therefore be assumed that the change of 1- minute duration for women's contests has not had a meaningful change in actual duration. This research showed the average contest

time to have shortened by only 43 seconds despite the rules changing contest time by 60 seconds. This suggests that rule changes of specific time do not change contest time by the same amount. It should also be noted that this change in contest time still fits within those times previously reported when considering their standard deviations. Changes in contest duration may have an impact on competition running time, competition organisation and the way in which judo is packaged to television companies.

A large decrease in the number of golden scores was also seen. In the 2010 World Championships there were 17 golden scores across 139 contests and in the 2014 World Championships there were only 4 golden scores across 128 contests. The reasons for this are unknown and should be investigated further.

Duration of KPI's within the contest time

Understanding the duration of various KPI's is important for both physical preparation and tactical preparation (Sterkowicz-Przybycien, Miarka, & Fukuda, 2017). For example *Tachi-waza* and *Ne-waza* would be expected to have different physiological demands although there is limited research on this with only one study found, this study compared a 5 minutes of *Tachi-waza* with 5 minutes of *Ne-waza* (Sikorski, 1985, cited in Franchini, Artioli, & Brito, 2013) and reported higher blood lactate in *Tachi-waza* ($11.3 \pm 3.6 \text{ mmol.l}^{-1}$) as compared to *Ne-waza* ($7.7 \pm 2.2 \text{ mmol.l}^{-1}$). This current research broke a judo contest down into work and rest, *Hajime* to *Matte* and *Matte* to *Hajime* respectively and then subdivided the work into *Tachi-waza* and *Ne-waza*.

Hajime to Matte (work time)

The average time for Hajime to Matte (work time) demonstrated in this study was 20.9 ± 10.9 seconds for the 2010 World Championships and 23.6 ± 13.2 seconds for 2014 World Championships. An independent paired samples t-test showed a significant difference between 2010 and 2014 ($P < 0.05$). Nonetheless, both of these fall within the same range as other studies including 15-30s (Sikoski et al., 1987; Casterenas and Planas, 1997), 18-25s (Sikoski, 2010), 20-30s (Franchini et al., 2011), 19 ± 6 (Hernandez-Garcia and Luque, 2007) and 30s (Wicks, 2006). Mean duration of Matte (rest) blocks appear to be slightly shorter in this study. This is likely to be due to the new rules on the awarding of *Shido*'s (penalties) as "rolling *Shido*'s" where the penalty is awarded in place, without having both fighters return to the formal start position (*Matte* – *Shido* – *Hajime*) except when a *Shido* is given for leaving the contest area. This would need to be confirmed with further research.

Matte to Hajime (rest)

This study showed that the average time spent in *Matte to Hajime* (rest time) was 9.3 ± 7.7 seconds for the 2010 World Championships and 8.8 ± 7.2 seconds for the 2014 World Championships. An independent samples t-test showed no significant difference ($P < 0.05$). Other studies that have considered the duration of *Matte* have all found *Matte* to be shorter in duration than *Hajime*. Authors have found mean durations of 11 ± 10 s (Miarka *et al.*, 2012) and 10s (Sikoski *et al.*, 1987; Casterenas and Planas, 1997; Wicks 2006).

The 2014 rules changed the ability of the coach to talk to the athletes during the contest, whilst coaches used to be able to talk at any time in the contest the new rules limited talking to the athlete to the *Matte* (rest) blocks. According to Castarlenas & Planas, (1997) Olympic judo players seem to use the *Matte* as a tactical way to win, as athletes use this period for recovery and for strategic development in high level combats, based on feedback from coaches and from previous actions during the tournament. This is supported by other authors such as Calmet *et al.*, (2010) and Miarka *et al.*, (2015). No studies to date have considered how these *Matte to Hajime* (rest) blocks have changed in terms of strategy, but this study does show that the duration of time for this has reduced.

An independent sample T-test showed a significant difference between 2010 and 2014 for *Hajime to Matte* time and *Tachi-waza* time across all weight groups. In the u57kg category there were also significant differences in *Matte to Hajime* time and *Ne-waza* time. Overall the data suggests that there is a significant increase in the duration of a work block and this is due to an increase in standing combat time. The exact reasons for this are unclear and further research would be needed to break down the *Tachi-waza* block to assess exactly where the increased duration comes from. It can be speculated that it could be due to rule changes in *Kumi-kata* that make athletes more tentative when initially gripping up or sometimes settle for a less preferred grip. In particular, the new rule around not being able to “break off an opponents’ grip with two hands” could affect lightweight women who have less total strength when compared to heavier weights and male competitors. Therefore, further research would address all weight categories and both genders.

Ne-waza (ground work time)

Mean time in *Ne-waza* has been previously reported by Miarka *et al.* (2012) as 15 ± 14 seconds, and Marcon (2010) as 13 seconds. This present study has a much lower duration of

4.9 ± 8.9 seconds for the 2010 world championships and 4.7 ± 9.2 seconds for the 2014 World Championships. The reasons for these are not clear and should be investigated further, it is possible that the shortening of the time required to hold for *Ippon* in *Osaekomi* partly contributes to this shorter duration. The 2014 data showed a trend for *Ne-waza* to get shorter as the weight category gets heavier, further analysis on this might show trends in *Ne-waza* that have not been explored previously, such as technical difference by weight category or gender.

Tachi-waza (standing work time)

A significant difference was seen in *Tachi-waza* time between all weight categories. The only other KPI in which a significant difference was observed was *Hajime* to *Matte* (work time) and therefore, it can be deduced that there is a significant increase in work time within blocks and this can be attributed to longer time in *Tachi-waza* (standing work). Further analysis should consider if the greater duration is due to time spent in *Kumi-kata* (whether lead grip or main grip) or time spent preparing for the throw. For lightweight women, it is possible to conclude a *Tachi-waza* to *Ne-waza* ratio of 3:1 in 2010 and 4:1 in 2014.

When considering the duration of all the KPIs it is possible to conclude that *Hajime* (work) blocks have a similar duration to those reported under the previous rules (Sikoski *et al.*, 1987; Casterenas and Planas, 1997; Sikoski, 2010; Franchini *et al.*, 2011; Hernandez-Garcia and Luque, 2007). Overall work time appears to have increased and rest time decreased with time spent in *Tachi-waza* (standing work) contributing to the increased duration as shown in Figure 5.3 below.

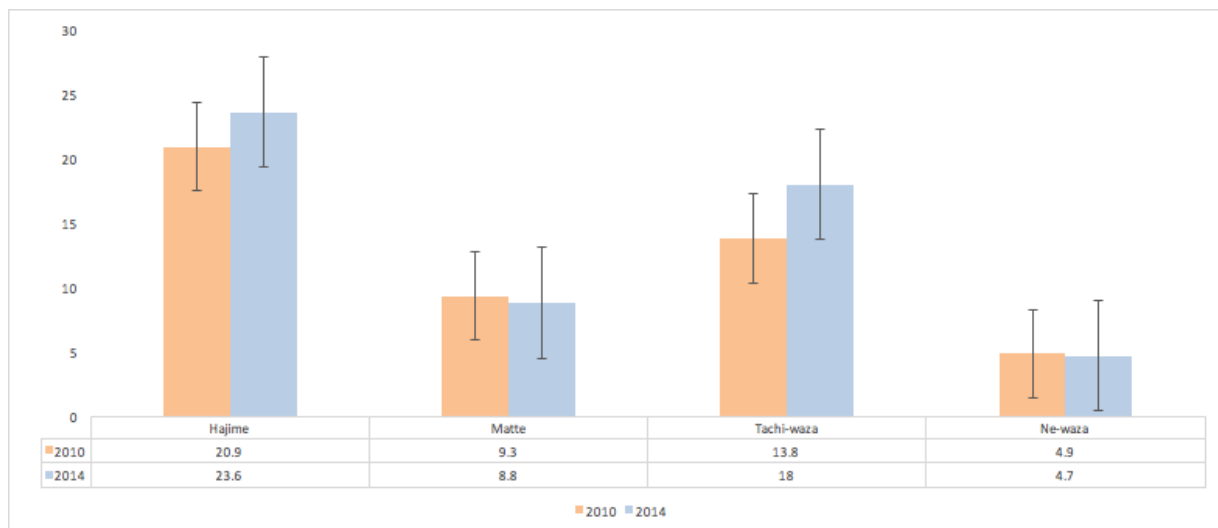


Figure 5.3: Comparison of KPIs between 2010 world championships and 2014 world championships in seconds. A paired samples t-test showed significant differences between *Hajime* to *Matte* (work) time and *Tachi-waza* (standing) time ($P<0.05$).

Work to rest ratios

A consequence of understanding these durations is that work to rest ratio's can be established. With an average *Hajime* to *Matte* time of 20.9 ± 10.9 seconds and average *Matte* to *Hajime* of $9.3s \pm 7.7$ seconds there is a work to rest ratio of 2:1 for the 2010 World Championships. This changes to a 3:1 work to rest ratio in the 2014 World Championships with work being 23.6 ± 13.2 seconds and rest being 8.8 ± 7.2 seconds. This could affect training programmes where work to recovery time is manipulate for a physiological response; further research could consider if the work to rest ratios differ across weight categories and gender to create more bespoke training programmes.

Frequency of KPIs

In the 2010 World Championships *Hajime* to *Matte* (work blocks) occur on average 11 times (± 7.2) in a contest, this is similar to Casterenas & Planas, (1997) and Sikorski, (1987) who presented 11 segments and Sterkowicz, (1999) who presented 12 work segments. *Matte* to *Hajime* (rest blocks) occurred on average $9.9 (\pm 7.1)$ times per contest. Other authors have not clearly described the frequency of *Matte* to *Hajime* segments and have focussed on duration however this is consistent with Miarka *et al.* (2014) who observed an average of 4 *Ne-waza* appearances per contest. *Ne-waza*/transition only occurred an average of 3.6 ± 2.8 times per contest.

In the 2014 world championships there was a significantly ($P < 0.05$) lower average of 8.3 ± 4.4 work blocks per contest which can be attributed to the 43s less combat time. There was also a significantly lower number of *Matte* blocks, $7.3 (\pm 4.4)$. The average number of *Ne-waza* blocks in the 2014 data $3.24 (\pm 2.17)$, this is also similar to Miarka *et al.*, (2014).

Comparing 2010 to 2014 shows that there are significantly fewer *Hajime-Matte* (work) blocks and *Matte-Hajime* (rest) block in 2014 ($P < 0.05$). This is to be expected with the shorter duration.

To summarise the frequency and duration data, the total duration of a contest has not changed significantly. There are less work blocks and they are longer in duration, less rest blocks and these are shorter in duration, there is a similar number of *Ne-waza* blocks with a much shorter duration. The increase in work time appears to come from time spent in *Tachi-waza*.

Fatigue

Using duration of temporal data to measure fatigue appears to be new to judo. This study compared the first four work blocks to the last four work blocks in all contests that met the criteria of having 8 or more work blocks. The average duration of a work block is 23.6 seconds, thus if a contest is at least 8 blocks long there would be at approximately 3 minutes or more of contest time, enough to elicit fatigue (Gastin, 2001).

When comparing all lightweight categories between 2010 and 2014 there is a significant difference between:

- *Tachi-waza* (standing) time in both the first four and last four blocks, in 2014 the duration is significantly longer
- *Hajime* to *Matte* time and *Ne-waza* time also show a significant difference for the first four blocks only
- Whilst *Hajime* to *Matte* time and *Tachi-waza* time are significantly longer *Ne-waza* time is significantly shorter in 2014

When comparing weight categories within years the 2010 data suggests there is little significant difference when comparing the first four blocks to the last four blocks with the exceptions of *Hajime* to *Matte* (work) in the 48kg and when comparing the averages of all three weight categories. Similar is seen in *Tachi-waza* (standing work) with significant differences seen in u48kg, u57kg and the averages of all weights (Table 5.5).

The 2014 data shows a great number of significant differences when comparing first four blocks to last four blocks. Significant shorter durations are seen in *Hajime* to *Matte* (work) and *Tachi-waza* (standing) for all weight categories. Interestingly, this difference appears to be in the shortening of *Tachi-waza* time and was expected to be in lengthening of *Ne-waza* time because it is commonly thought (without evidence) that athletes who are tired will try to fight in *Ne-waza* as it is perceived as less fatiguing or that you're less likely to be scored against. Conversely athletes winning the contest are likely to try and "waste time" on the floor whilst athletes losing the contest are likely to remain on their feet as it is commonly believed it is quicker to score in *Tachi-waza*, although no evidence has been produced to support this.

There was also no change in *Matte* to *Hajime* (rest) time which is also interesting because there is a perception that tired athletes will try to lengthen the time of *Matte*. Further investigation should take place in this area to establish where in the *Tachi-waza* duration is increasing, for example in the lead grip, the main grip or during the attack phase as this could help coaches develop tactical play. No existing research was found that compared the durations of *Hajime* and *Matte* blocks at the start and end of a contest.

Further research should be conducted to establish if this trend appears across all weight categories and whether this is owing to fatigue or whether other factors are contributing such a tactics.

Limitations and future recommendations

Given the novelty of understanding fatigue in judo in this way further research should be considered in this area, particularly given the specific sample in this research. Considerations would also need to be made as to whether an increased or decreased duration of work time in latter blocks is due to physical limitations or tactical play by either the winning or losing athletes. This would more than likely require a mixed methods approach.

There appears to be a lot of research conducted in this area now and there are common themes running throughout, the challenges researchers face now is bridging the gap between time-motion analysis and implementing this information into training environments with specific training programmes. For example, could automated coding now be utilised for time-motion coding?

Conclusions on time-motion analysis in lightweight women's judo

This work has considered time-motion analysis in lightweight women judo from the perspectives of total contest time, duration of key performance indicators, frequency of key performance indicators and fatigue based upon the first and last four blocks of a contest. Conclusions can be drawn in the following areas:

- Contest time has shortened by 43 seconds based on the rules changing women's contest time from 5 minutes to 4 minutes. Therefore, a one-minute change in the rules does not equate to a one minute change in actual time.
- There is a significant increase ($P < 0.05$) in *Hajime* to *Matte* (work) time and this can be attributed to more time spent in *Tachi-waza* (standing work). The reasons for this are not clear but it can be speculated that is due to athletes being more tentative around lead grip or attacking due to the new gripping rules
- There is no significant difference in *Ne-waza* (ground work) time despite efforts being made to increase time spent in *Ne-waza*
- Comparing 2010 to 2014 shows that there are significantly fewer *Hajime - Matte* (work) blocks and *Matte* to *Hajime* (rest) block in 2014 ($P < 0.05$). This is to be expected with the shorter duration
- There is noticeably more fatigue shown when comparing the first four blocks and last four blocks of a contest in 2014 than in 2010. This study considers this as fatigue but future research should consider if this is tactical
- Fatigue is clear with the 2014 data for *Hajime* to *Matte* time and *Tachi-waza* with the first four work blocks being significantly longer ($P < 0.05$) than the last four blocks. Time spent in *Ne-waza* does not change significantly with fatigue

Further analysis across all weight categories and genders would be useful for confirming whether this novel method of fatigue analysis is beneficial.

Chapter 6: An Analysis of the Technical Components of Lightweight Women's Judo

Chapter 6: An Analysis of the Technical Components of Lightweight Women's Judo

Introduction

Chapter 5 considered the time-motion characteristics of lightweight women's judo that help coaches and support staff understand the physiological demands of the sport, in relation to this special population and design conditioning programmes to prepare them for those demands. Whilst coaches feel that physical condition is an essential component of the training programme technical preparation is possibly more important. This is because technical preparation not only prepares the athlete for *Shiai* it is also the pathway to understanding the true principles of judo described in the introduction of this thesis - *Seiryoku-zenyo* ("maximum efficiency") and *Jita-kyoei* (mutual welfare and benefit) (Kodokan, 2009 p38-43; Stevens, 2013 p194). It is believed that high quality technique can overcome strength and power (Daigo, 2005; Ishikawa & Draeger, 1999; Mifune, 2004).

This chapter is split into two sections, *Tachi-waza* and *Ne-waza*. Both of these will consider their individual methodology, research specific to the area, the types of technique used, the efficiency of techniques and the categories these techniques fit into.

***Tachi-waza* in lightweight women's Judo**

Nage-waza versus Tachi-waza

Throughout this work and the analysis, the term *Tachi-waza* has been used to describe techniques used in the standing position. This is because the vast majority of literature refers to *Tachi-waza* and this is a term most readers would be more comfortable with. The *Kodokan* breaks *Tachi-waza* techniques down into five groups:

- *Ashi-waza* - Foot/ankle techniques
- *Koshi-waza* - Hip techniques
- *Te-waza* - Hand techniques
- *Ma-sutemi-waza* - Sacrifice throws
- *Yoko-sutemi-waza* - Side sacrifice throws

For accuracy, it is important to acknowledge that when referring to *Tachi-waza* we're actually discussing *Nage-waza* (throwing techniques). In it's strictest translation *Tachi-waza* is fighting in the standing position and therefore excludes *Ma-Sutemi-waza* (sacrifice throws) and *Yoko-sutemi-waza* (side sacrifice throws). It is common though when translated to the English language for both of these to be used interchangeably. Throughout this work the use of the term *Tachi-waza* will be used as this allows comparisons between the literature easier.

Tachi-waza in the literature

Tachi-waza research based upon individual profiles

Adam & Szczepańska (2011) profiled the techniques of Olympic silver and World bronze medallist Aneta Szczepańska. She won 201 contests of the 252 analysed. They considered four categories (*Ma-sutemi-waza* and *Yoko-sumtemi-waza* were combined) and concluded the most proficient category was *Ashi-waza* (51%), followed by *Te-waza* (27%), then *Sutemi-waza* (21%) and finally *Koshi-waza* (1%). Her top five dominant techniques were *Uchimata*, *Uchimata-sukashi*, *O-soto-gari*, *Tani-otoshi* and *Tai-otoshi*.

Adam, (2012) analysed a separate profile of European medallist Adriana Dadci. He analysed 123 of her contests between 2002-2004 across 33 competitions. Dadci efficiently performed 146 attacks using 20 judo techniques. Her top five most efficient *Tachi-waza* techniques were

O-uchi-gari, Uchimata, O-soto-gari, Harai-goshi and Seoi-nage. When her *Tachi-waza* was put into groups it was clear *Ashi-waza* led with 67.9% and this was followed by *Te-waza* (11.7%), *Sutemi-waza* (10.6%) and lastly *Koshi-waza* (9.8%). *Ashi-waza* was also the most efficient category.

A third profile was by Adam *et al.*, (2014) was of Waldemar Legień, winner of two Olympic gold medals. They observed contests between the period of 1991 to 1992, during which he competed in 24 tournaments performing 76 matches. He effectively executed 105 attacks, most efficient *Tachi-waza* were considered to be *Seoi-nage, Uchimata, O-soto-gari, Ko-uchi-gari* and *Morote-gari* (now a banned technique). Legień also presented the same order of efficiency in terms of the order of the category as both Adriana Dadci and Aneta Szczepańska - *Ashi-waza* (47.5%), then *Te-waza* (36.6%), *Sutemi-waza* (14.5%) and lastly *Koshi-waza* (1.5%). These individual profiles suggest there is no difference in terms of the efficiency of *Tachi-waza* categories for males and females.

Adam & Majdan, (2011) completed a profile of world bronze medallist Joanna Majdan, between 1988-1993 she took part in 55 competitions domestically and internationally; in total she fought 206 contests, winning 167 of them, being defeated in 36 and ending 3 in a draw. Majdan effectively used 22 judo techniques With *Seoi-nage* being the most prominent. The other top four *Tachi-waza* techniques were *Ko-uchi-gari, Tai-otoshi, De-ashi-harai* and *Ko-uchi-makkikomi*. The leading category was *Te-waza* (70.2%), *Ashi-waza* (19.8%), *Sutemi-waza* (9.6%) and *Koshi-waza* (0.4%). *Te-waza* was also the most efficient category.

Tachi-waza research by team/nationality

Adam *et al.*, (2015) considered Japanese athletes competing in the open weight category between 2003 and 2012. They observed 252 *Tachi-waza* attacks across 278 contests and noted 37 different techniques. They categorised techniques differently to other research, making comparisons difficult, rather than using traditional classifications proposed by the *Kodokan* they split techniques into the following criteria:

1. *UCHI* (throws performed by reaping/hooks opponent's legs from inside): *Uchimata, Ouchi-gari, Kouchi-gari*
2. *SOTO* (throws performed by reaping/hooks opponent's legs from outside): *O-soto-gari, Kosoto-gake, Kosoto-gari*

3. OTOSHI (throws performed by body dropping): *Tai-otoshi*, *Tani-otoshi*, *Sumi-otoshi* and *Uki-otoshi*
4. GAESHI/SUKASHI (throws performed by responding to an opponent's attack – counter- attacks or counter throws): *Osoto-gaeshi*, *Uchimata-gaeshi*, *Ouchi-gaeshi*, *Uchimata-sukashi*, *Ko-uchi-gaeshi*, *Harai-goshi-gaeshi*, *Sumi-gaeshi*
5. TSURIKOMI (throws performed by pulling-lifting action with hands): *Sasae-tsurikomi-ashi*, *Tsurikomi-goshi*, *Harai-tsurikomi-ashi*
6. HARAI (throws performed by sweeping action with leg or hip): *Harai-goshi*, *De-ashi-harai*
7. MAKIKOMI (throws performed by winding an opponent's body): *Harai-makikomi*, *Uchimata- makikomi*, *O-soto-makikomi*, *Soto-makikomi*

They concluded *Ashi-waza* were the dominant throws, performed by reaping an opponent's leg from the inside (*UCHI*) and outside (*SOTO*) such as *Uchimata*, *Ouchi-gari*, *O-soto-gari*. Adam *et al.*, (2013) analysed the Russian teams' performance in the London 2012 Olympic Games. They suggested the top five *Tachi-waza* techniques ranked by efficiency used by the Russian team were *Harai-goshi*, *Ko-soto-gari*, *Tani-otoshi*, *Uchimata* and *Seoi-nage*. Their opponents favoured *Tai-otoshi*, *Seoi-nage*, *O-uchi-gari*, *Tani-otoshi* and *Ko-uchi-gari*. When broken down into categories it was noted that *Ashi-waza* made up 67%, *Te-waza* (19%), *Sutemi-waza* (9%) and *Koshi-waza* (6%).

Adam *et al.*, (2011a) analysed the Japanese teams' performance in the 2010 World Championships, Tokyo. They suggested the top five techniques in terms of efficiency were *Uchimata*, *O-soto-gari*, *Seoi-nage*, *Ko-uchi-gari* and *Harai-goshi*. The most often performance techniques were *Uchimata*, *Seoi-nage*, *De-ashi-barai*, *Ko-uchi-gari* and *O-uchi-gari*.

Carratala Deval *et al.*, (2010) observed Spanish cadet (under 17yo) *Judoka* at their national championships to assess the diversity of the techniques used by category. Across all weight categories analysed they suggested the most seen category was *Sutemi-waza* (17.8%), *Ashi-waza* (16.6%), *Te-waza* (16.3%) and *Koshi-waza* (14.2%), the other 35% of score were made up by *Ne-waza* and penalties. They also suggested *Judokas* of this population are characterised by the frequent use of the following techniques: *Seoi-nage*, *Kouchi-gari*, *Ouchi-gari*, *Kosoto-gari*, *Kosoto-gake*, *Harai-goshi* and *Tani-otoshi*.

Sertić & Segedi, (2012) compared juniors to seniors in terms of technical diversity. The categories of techniques used was evenly spread and in the same order with *Ashi-waza* top followed by *Koshi-waza*, *Te-waza* and *Sutemi-waza* respectively. The top two techniques seen were also the same in both groups, *Ippon-seoi-nage* and *Morote-seoi-nage*. 3rd, 4th and 5th places differed with *O-uchi-gari*, *Uchimata* and *Ko-uchi-gari* for juniors and *Uchimata*, *Ko-uchi-gari* and *Tai-otoshi* for seniors.

Kajmovic *et al.*, (2011) compared the techniques of athletes from Bosnia and Herzegovina to athletes from other Balkans countries. Analysing 188 contests they considered *Te-waza* to be the most prolific category (32%) across both groups, followed by *Ashi-waza* (30%), *Sutemi-waza* (14%) and *Koshi-waza* (11%), the other categories were *Ne-waza*. When broken down into athletes from Bosnia and Herzegovina *Te-waza* remained at the top (38%), however when considering athletes from the Balkans *Ashi-waza* was most prolific (37%). When comparing techniques athletes from Bosnia and Herzegovina saw *Ippon-seoi-nage*, *Tani-otoshi*, *Harai-goshi*, *De-ashi-barai* and *Uchimata* in their top five *Tachi-waza* whilst athletes from the Balkans saw *Uchimata*, *Sukui-nage*, *Ippon-seoi-nage*, *O-soto-gari* and *O-soto-gari* as their most prolific.

Tachi-waza research with general samples

Kajmovic & Radjo, (2014a) considered the throws used in relation to whether the athletes were in *Ai-yotsu* (left against left or right against right) or *Kenka-yotsu* (left against right). Female athletes were considered to have the highest efficiency with *Harai-goshi*, *Ippon-seoi-nage*, *Uchimata*, *O-uchi-gari* and *Tani-otoshi* when in *Ai-yotsu*. When in *Kenka-yotsu* similar techniques were seen, *Uchimata*, *Ippon-seoi-nage*, *Tani-otoshi*, *O-uchi-gari* and *O-soto-gari* were observed. A similar study by the same authors Kajmovic & Radjo, (2016) considered only female athletes and found almost identical results suggesting rule changes had not changed the types of techniques favoured. They concluded that female seniors dominate in throwing techniques from *Kenka-yotsu* (62.7%) compared to throws from *Ai-yotsu* (37.3%) at the National championships of Bosnia and Herzegovina. Another very similar study was by Kajmovic *et al.*, (2014b) which also studied grip configurations in male and female *Judoka* in relation to attacks in *Ai-yotsu* and *Kenka-yotsu*, this research however considered cadet athletes (u17yo). The research considers video recordings 390 contests and observed 470 throwing techniques of male cadets and 350 throwing techniques of female cadets at the European Judo Championship for U-17 Cadets, held in Sarajevo (Bosnia and Herzegovina)

in 2008. They found that in *Ai-yotsu* females preferred *Sukui-nage*, *O-soto-gari*, *O-uchi-gari*, *Tani-Otoshi* and *Uchimata*, three of the same techniques as their senior counterparts. In *Kenka-yotsu* the same techniques were observed but in a different order of frequency - *O-uchi-gari*, *Tani-Otoshi*, *Uchimata*, *Sukui-nage*, and *O-soto-gari* which is also similar.

Sterkowicz, & Maslej, (1999) analysed 92 seniors matches from the Polish Senior National Championship and the Ladder Tournament in 1996. Among the attempted techniques, *Te-waza* (44%) dominated followed by *Ashi-waza* (41%). Among the most popular techniques are *Seoi-nage* (18% of all attacks), and *Uchimata* (15%).

Witkowski *et al.*, (2012) studied 303 contests from the men's judo tournament in Beijing as published on the official website of the 2008 Olympic Games. The indirect observation method was applied, using computerised and publicly available information concerning each combat. There were 228 competitors participating. When considering the number of effectively applied techniques and breaking it down into groups, the highest number of effective attacks were made using *Te-waza* (27.06%) and then *Ashi-waza* (23.43%), *Sutemi-waza* made up 13.2% and *Koshi-waza* was considered 3%, the remainder of scoring techniques were *Ne-waza* or penalties. They listed techniques by the number attempted, the top five techniques seen were *Seoi-nage*, *Kata-guruma*, *Kuchiki-taoshi*, *Uchimata* and *Sumi-gaeshi*. This is the only research that lists *Kuchiki-taoshi* in the top five and this technique would now be banned because of the need to grasp the leg.

Pimenovs & Fonarjova, (2012) research registered 379 successful throws executed in the 2003 and 2005 world championships, they analysed the finals, semi-finals and bronze medal matches (a total of 62 fights). It is not easy to compare their data to others as they used the Kawaishi classification of throws (Kawaishi, 1955) rather than the *Kodokan* classification (Kodokan, 2011). The most often used throws were from the leg techniques (15%), arm techniques (49%) and shoulder techniques groups (22%), correspondingly in 2003. In 2005 there was leg techniques (24%), arm technique (44%) and shoulder technique groups (18%). Whilst not easy to compare the category closest to the *Kodokan's* "*Ashi-waza*" group was still most prolific supporting other research.

Sterkowicz, (1998) considered the groups of *Tachi-waza* techniques, he found a similar order to other authors cited - *Ashi-waza*, *Te-waza*, *Sutemi-waza* and lastly *Koshi-waza* at the 1996 Olympic Games, Atlanta. He found the most common techniques used by women *Judoka* were, *Seoi-nage*, *O-uchi-gari*, *Uchimata*, *Harai-goshi* and *O-soto-gari*. He suggested the

manner of winning was indicative of the women's inferiority in maximal anaerobic power in comparison with the men, which was borne out by fewer victories before time by *Ippon* achieved by the female *Judoka*.

Adam *et al.*, (2016) compared the 2014 and 2015 World championships. When breaking techniques down in category they suggested *Tachi-waza* was 76% of all combat. *Ashi-waza* (36%), *Te-waza* (29%), *Yoko-sutemi-waza* (14%), *Koshi-waza* (11%), and *Ma-sutemi-waza* (10%). Efficiency by group was listed in the same order. The top five most efficient techniques were considered as *Uchimata*, *Seoi-nage*, *Ko-uchi-Gari*, *Ippon-seoi-nage* and *Ura-nage*.

Abdel-Raouf, & Abdelhalem, (2011) analysed mens judo at the 2010 World Championships. They considered the techniques used and ordered them as *Morote-seoi-nage*, *De-ashi-barai*, *Uchimata-gaeshi*, *Harai-makkikomi* and *O-soto-makikomi*. In terms of *Kodokan* category *Ashi-waza* and *Sutemi-waza* were joint top with 33.3%, this was followed by *Te-waza* with 13.3% and lastly *Koshi-waza* with 6.6%. The remaining 14% was from *Ne-waza*.

Sertić & Segedi continued their analysis of judo in 2016 with a technical analysis of the Croatian national championships for seniors (Sertić, Centić & Segedi, 2016). Using footage from the CARE system they analysed 143 males and 30 females. The top five most used techniques by men were *Ippon-seoi-nage*, *Uchimata*, *Soto-makikomi*, *O-uchi-gari* and *Harai-goshi*. However, when considering efficiency, the list was very different, *Uchimata-sukashi*, *Ko-soto-gari*, *Tani-otoshi*, *Ura-nage* and *Yoko-guruma* were considered top. For women, the top 5 techniques were *O-uchi-gari*, *Uchimata*, *Soto-makikomi*, *Ippon-seoi-nage* and *Harai-goshi*. Similarly, the techniques listed as most efficient were different - *Ko-uchi-gari*, *Tai-otoshi*, *Eri-seoi-nage*, *Morote-seoi-nage* and *Koshi-guruma*. All of the top techniques for efficiency in both men and women were attempted very few times.

Adam *et al.*, (2011b) compared the 2009 and 2010 World championships. They showed efficiency by *Tachi-waza* group campaign both World Championships. Their data is reproduced below in Figure 6.1. They also listed the most efficient techniques, *Seoi-nage* and *Uchimata* were the most efficient in both years, in 2009 these were followed by *Kuchiki-taoshi*, *Ko-soto-gari* and *Sumi-gaeshi* and in 2010 by *O-soto-gari*, *Ko-uchi-gari* and *O-uchi-gari*. The sharp increase in *Ashi-waza* and the decrease in *Te-waza* is similar to findings by Miller *et al.*, (2015) who considered techniques used in the British Championships, they found that *Te-waza* was diminishing in relation to *Ashi-waza* and suggested the rules changes affect this group more than other with techniques such as *Kata-guruma* and *Kuchiki-taoshi* now banned.

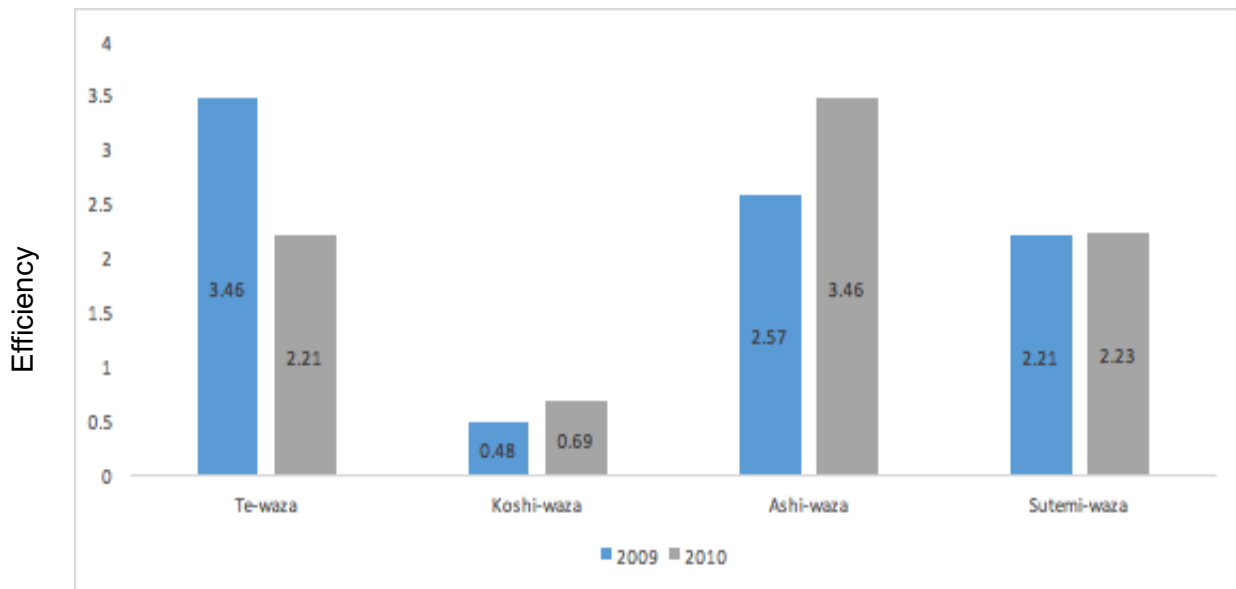


Figure 6.1: Data showing the results of Adam *et al.*, (2011b) for efficiency of *Tachi-waza* categories.

Adam *et al.*, (2012) reviewed the Olympic games of 2008 and 2012 as well as the World Championships of 2009, 2010, 2011. The research material consisted of 1854 recorded fights. Table 6.1 below shows the top five *Tachi-waza* techniques for each of the five competitions. They also listed the efficiency by categories of technique, in order of highest efficiency it was *Te-waza*, *Ashi-waza*, *Sutemi-waza* and *Koshi-waza*.

Table 6.1: The top five *Tachi-waza* techniques according to efficiency for each of the five competitions.

Rank	2008 OG	2009 WC	2010 WC	2011 WC	2012 OG
1	<i>Sumi-Gaeshi</i>	<i>Seoi-nage</i>	<i>Seoi-nage</i>	<i>Seoi-nage</i>	<i>Seoi-nage</i>
2	<i>Sukui-Nage</i>	<i>Uchimata</i>	<i>Uchimata</i>	<i>Uchimata</i>	<i>Tai-otoshi</i>
3	<i>Seoi-nage</i>	<i>Kuchiki-taoshi</i>	<i>O-soto-gari</i>	<i>Sode-tsurikomi-goshi</i>	<i>Uchimata</i>
4	<i>Uchimata</i>	<i>Ko-soto-gari</i>	<i>Ko-uchi-gari</i>	<i>O-uchi-gari</i>	<i>Sukui-nage</i>
5	<i>Kata-Guruma</i>	<i>Sumi-gaeshi</i>	<i>O-uchi-gari</i>	<i>O-soto-gari</i>	<i>Sode-tsurikomi-goshi</i>

Method for Tachi-waza analysis

Procedure

Following the Time-motion Analysis at level one where the contests were broken down in *Hajime to Matte*, *Matte to Hajime*, *Attacks*, *Shido's etc* the footage of “attacks/defend” were exported into six video's, one per weight category. Coded labels stayed in place but differed from the 2010 data and 2014 data. For example, the 2014 data include the name of the athletes and the country. This gave 6.5 hours of *Tachi-waza* video with 2284 attacks.

Key performance indicators

Technical elements of the study were coded with a new code window (Figure 6.2, 6.3 and 6.4.). This code window allowed the analysis of technique name, technique category, direction, score, laterality, and handedness, all of these are defined in Table 6.2 below.

Table 6.2: Definitions of the KPIs in the technical code window.

Key Performance Indicator	Definition
Technique name	The name of the technique based upon the <i>Kodokan</i> definition where possible
Technique category	The category of the techniques based upon the <i>Kodokan</i> definition where possible
Direction	Direction <i>Uke</i> is thrown in - front left, front right, left, right, rear right, rear left
Score	The score awarded but the referee including ‘no score’
Laterality	Whether the athletes were in <i>Ai-yotsu</i> or <i>Kenka-yotsu</i> or if this is ‘unkown’.
Handedness	The directions the athlete turns in for the attack regardless of whether the grip is left or right handed. For example, an athlete can attack with a left sided <i>Ippon-seoi-nage</i> with a right-handed lapel grip.

Reliability

Coding for *Tachi-waza* was conducted by two researchers, the lead researcher developed the KPIs and then provided training and discussion for the second coder as suggested by O'Donaghue (2007). Two reliability tests were conducted, a Cronbach Alpha (0.975 - very

reliable) and a Cohen's Kappa (0.400 - fair to good). Post coding the data was exported in excel for analysis and where necessary into SPSS.

Equipment

Videos were recorded in the stadium on a Canon Legria HF R806 camcorder (50fps: 1920 x 1080, 35Mbps). Contests that could not be recorded in this way were downloaded from <https://www.youtube.com/user/judo>. These videos were then imported into Sportcode elite (V10, Hudl) for coding before being exported into Excel for Macintosh (version 15.5) and IBM SPSS for Mac (version 24).

Efficiency

To calculate the efficiency formula described by Adam, Klimowicz, & Pujszo, (2016) was used. The efficiency of attacks index (Ea) was determined on the basis of the following formula:

Equation 6.1 - Efficiency

$$Ea = (n \times I + n \times W + n \times Y) / N$$

where:

Ea – efficiency of attacks index

n – the number of attacks

I – assessed as *Ippon* (10 pts.)

W – assessed as *Waza-ari* (7 pts.)

Y – assessed as *Yuko* (5 pts)

N – the number of analysed bouts

This formula has been used by Kajmovic, & Radjo, (2014); Adam, (2011); Adam, *et al.*, (2013) and Miller *et al.*, (2015). This equation gives the efficiency of a given technique or category of techniques based upon the number of times it was attempted and the number of times it scores across a weight category, year or the whole sample.

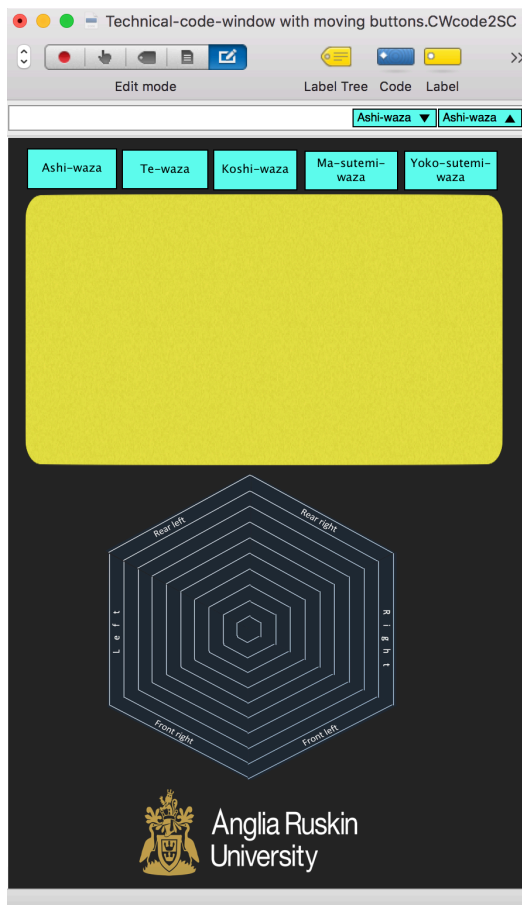


Figure 6.2: The technical code window in static state.



Figure 6.3: The technical code window in showing the techniques when a category is pressed, this means the coder cannot forget the category.

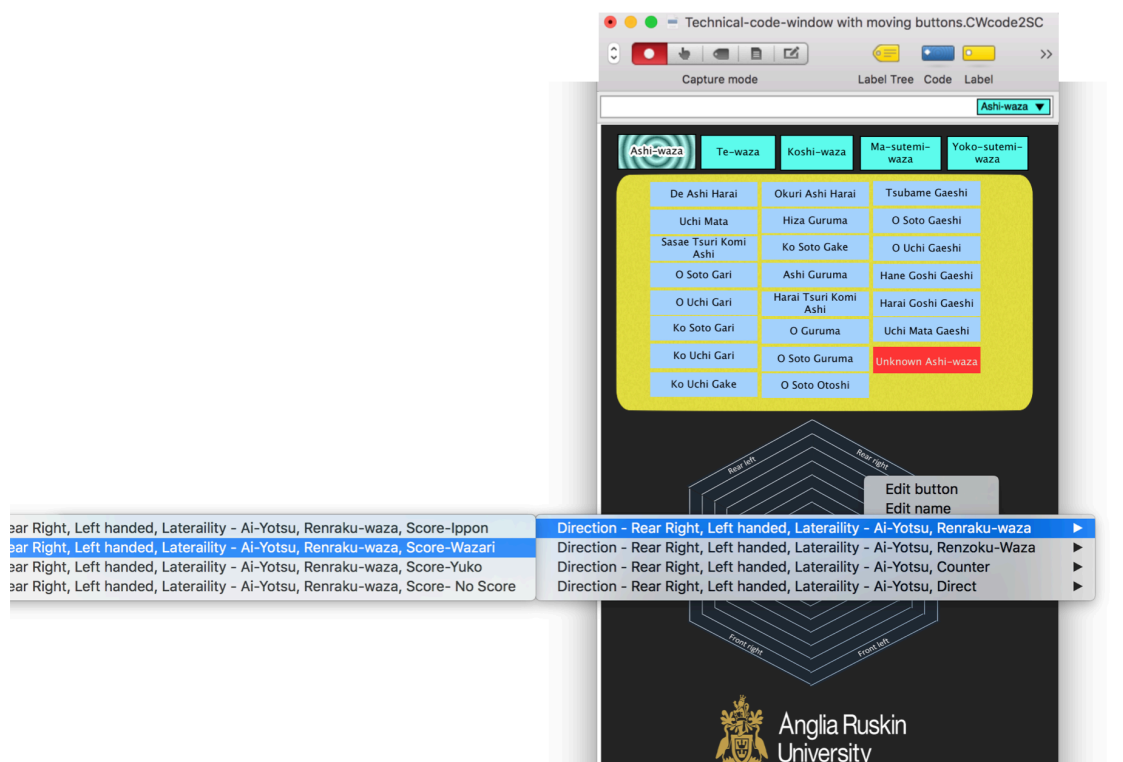


Figure 6.4: The technical code window showing the labelling system using the 'rename' function.

Tachi-waza results

This section considers the techniques used in *Tachi-waza* by lightweight women *Judoka*. It is broken down into total attacks, most prolific techniques used, efficiently and the groups of *Tachi-waza*.

Table 6.3: Variety of *Tachi-waza* techniques used, scores, no scores and total number of attacks shown alongside the “success rate” for *Tachiwaza*.

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	sum 2010 & 2014
Number of different techniques	37	40	39	48	28	36	37	42	52*
Number of throws for <i>Ippon</i>	19	16	15	50	5	9	9	23	73
Number of throws for <i>Wazari</i>	13	14	16	43	12	12	17	41	84
Number of throws for <i>Yuko</i>	26	12	13	51	14	15	13	42	93
Number of throws for no score	443	370	359	1172	272	275	315	862	2034
Total number of attacks	501	412	403	1316	303	311	354	968	2284
Success rate (% of total attempts that yielded a score)	11.5	10.2	10.9	10.9**	10.2	11.6	11.0	11.0**	11.0**

*In 2014 four techniques were seen that were not seen in 2010 - *Tsuri-komi-goshi*, *Ura-nage*, *uki-waza*, *Yoko-wakare* ** Average not SUM

The most prolific throw seen throughout this analysis is *Ippon-seoi-nage* which topped the table in the 2010 u48kg and u52kg as well as the 2014 u52kg and 2014 u57kg. The only other two techniques to top the table in terms of numbers seen was *Uchimata* and *Sode-tsuru-komi-goshi* in the 2010 u57kg and 2014 u48kg respectively (Table 6.4). There was slightly more diversity in the most efficient techniques. *Uchimata-gaeshi* was top of the table for U48kg in both year groups, *Sumi-Otoshi* and *O-guruma* were top of the table for the 2010 u52kg and 2014 257kg. Interestingly *Tsubame-gaeshi* was top of the table in two weight categories, the 2010 u57kg and the 2014 U52kg.

Table 6.4: Most prolific throws - taken from the top 5 most prolific throws in each weight i.e attempted the most times. An empty cell shows that technique was not top 5 in that weight/year.

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
<i>Ippon-seoi-nage</i>	63	73	37	173	56	61	62	179	352
<i>Uchimata</i>	53	41	63	157	34	43	44	121	278
<i>Sode-tsuru-komi-goshi</i>	56	24	56	136	60	23	32	115	251
<i>O-uchi-gari</i>	39	21		60	26	26	19	71	131
<i>Morote-seoi-nage</i>	48	26		74			20	20	94
<i>Yoko-otoshi</i>				0	19	17		36	36
<i>O-soto-gari</i>			30	30				0	30
<i>Tai-otoshi</i>			23	23				0	23

Table 6.5: Efficiency of the top 5 most prolific throws in each weight category. An empty cell shows that technique was not top 5 in that weight/year

	2010 u48kg	2010 u52kg	2010 u57kg	2014 u48kg	2014 u52kg	2014 u57kg
<i>O-soto-gari</i>			1.17			
<i>Morote-seoi-nage</i>	0.94	0.54				1.45
<i>O-uchi-gari</i>	0.69	1.05		0.65	0.92	1.32
<i>Uchimata</i>	0.70	0.37	0.51	0.94	1.60	0.55
<i>Yoko-otoshi</i>				1.11	0.41	
<i>Sode-tsuru-komi-goshi</i>	0.27	0.83	0.91	0.82	0.30	1.00
<i>Ippon-seoi-nage</i>	0.19	0.33	0.84	0.21	0.33	0.77
<i>Tai-otoshi</i>			0.00			

Breaking the results down into *Tachi-waza* category (Table 6.6) demonstrated a clear leader, *Ashi-waza*, across all weight categories and years. *Te-waza* was in second place for all years and weight categories.

Table 6.6: Number of throws by *Tachi-waza* category.

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
<i>Ashi-waza</i>	179	130	175	484	95	119	137	351	835
<i>Koshi-waza</i>	66	43	72	181	68	35	47	150	331
<i>Ma-sutemi-waza</i>	20	18	17	55	2	13	15	30	85
<i>Te-waza</i>	164	138	89	391	87	86	105	278	669
<i>Yoko-sutemi-waza</i>	71	83	50	204	51	58	50	159	363
Sum	501*	412	403	1315	303	311	354	968	2283

* including 1 unknown technique

In terms of efficiency the results were slightly different. *Ashi-waza* and *Koshi-waza* were considered most efficient with an average efficiency of 1.32. The third most efficient category was *Te-waza*.

Ne-waza in lightweight women's judo

Katame-waza versus Ne-waza

Katame-waza is the term used to describe “grappling techniques” such as joint locks, strangles, chokes and pins. Possibly a suitable term would be “immobilisation techniques”. *Katame-waza* includes these techniques in both a standing position and on the ground, often described as the horizontal position (Boguszewski, 2010; Carratala Deval, 2010; Witkowski et al., 2012).

Ne-waza is the term used to describe techniques that are contested in the “horizontal position”. It is predominantly *Katame-waza* techniques but does also include the often-complex techniques used to manoeuvre an opponent into the correct position to apply *Katame-waza*.

Ne-waza is split into three subcategories, *Osaekomi-waza* (Holds/pins), *Shime-waza* (strangles and chokes), *Kansetsu-waza* (joint locks) (Daigo, 2005; Ishikawa & Draeger, 1999; Mifune, 2004). Miarka et al., 2016b). Article 13 of the IJF refereeing rules 2011- 2012 explains how scores from *Osaekomi-waza* are distributed -

- A. *Ippon*: Total of 20 seconds.
- B. *Waza-ari*: 15 seconds or more but less than 20 seconds.
- C. *Yuko*: 10 seconds or more but less than 15 seconds.

Kansetsu-waza and *Shime-waza* are decided by submission or an inability to continue the fight.

For sportification it is important that the rules clearly describe when *Ne-waza* starts and ends. The IJF rules describe this in Article 16 of the 2011-2012 refereeing rules shown in Figure 6.5 (IJF, 2011).

For the purpose of this research the IJF definition of *Ne-waza* was used. Furthermore, our definition of *Ne-waza* included “transition” which is a colloquial term used to describe the small temporal gap between *Tachi-waza* (standing fighting) and *Ne-waza* (fighting in the horizontal position or ‘on the floor’). Defining this gap is important in research as it is often credited with being responsible for not capitalising on *Ne-waza* opportunities (Gordon, 2017; Burton, 2017; Bischof, 2016; Pierontozzi, et al., 2016).

ARTICLE 16 - Entry into *Ne-waza*

1. The contestants shall be able change from *Tachi-waza* to *Newaza* as far as it is done by one of the cases referred to in this Article. However, if the technique used is not continuous, the Referee shall announce *Mate* and order both contestants to resume the fight from the standing position.

2. Situations that allow the passage from *Tachi-waza* to *Ne-waza*

a) When a contestant, after obtaining some result by a throwing technique changes without interruption into *Ne-waza* and takes the offensive.

b) When one of the contestants falls to the ground, following the unsuccessful application of a throwing technique the other may take advantage of his opponent's position to take him to the ground.

c) When one contestant obtains some considerable effect by applying a *Shime-waza* or *Kansetsu-waza* in the standing position and then changes without interruption to *Ne-waza*.

d) When one contestant takes his opponent down into *Ne-waza* by the particularly skilful application of a movement which does not qualify as a throwing technique.

e) In any other case where one contestant falls down or is about to fall down, not covered by the preceding sub-sections of this article, the other contestant may take advantage of his opponent's unbalanced position to go into *Ne-waza*.

3. Exceptions

When one contestant pulls his opponent down into *Ne-waza* not in accordance with Article 16 paragraph 2 and his opponent does not take advantage of this to continue into *Ne-waza*, the Referee shall announce *Mate*, and penalise with *Shido* the contestant who has infringed Article 25.7.

Figure 6.5: Article 16 of the International Judo Federations Refereeing Rules (IJF, 2011).

Ne-waza in the literature

Research in this area includes the frequency of *Ne-waza*, time spent in *Ne-waza*, types of techniques used in *Ne-waza*, the efficiency of *Ne-waza* and a variety of comparisons across age, gender and performance level.

The time spent and frequency of attacks in *Ne-waza* was the subject of earlier chapters in this work. However, it is important to highlight this area again to allow the contextualisation of the data presented here within the great picture of the overall contest.

Chapter 5 considered *Ne-waza* as a part of the whole contest, it was concluded that the mean duration of *Ne-waza* was 4.8 ± 9.2 s and the mean frequency per contest was 3.4 ± 2.8 . With an average *Hajime-Matte* (work) time of 22.3 ± 13.2 s and *Matte-Hajime* time of 9.1 ± 7.7 s the contribution of *Ne-waza* within the work time was 23% (Figure 6.6).

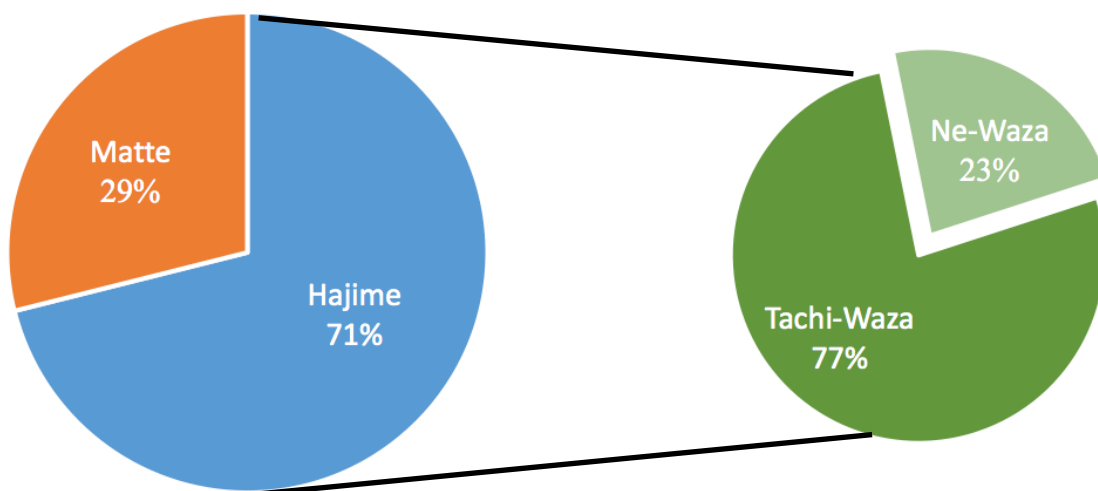


Figure 6.6: Work to rest time and the contribution of *Tachi-waza* to *Ne-waza* as previously reported in chapter 5.

Franchini & Sterkowicz, (2000) studied male *Judoka* at World and Olympic tournaments from 1995 - 1999, the mean time per contest in *Ne-waza* was 54 sec \pm 38 sec. These equated to an average of 18 seconds per block in *Ne-waza*. In percent, 56% of the total time was spent in *Tachi-waza* and 18% was spent in *Ne-waza*, the other 26% in *Matte - Hajime* blocks.

Sterkowicz-Przybycien, *et al.*, (2017) analysed 8700 instances of *Ne-waza* from a total of 1,411 judo matches contested by 147 senior-level men (21 from each weight category) and

98 senior level women (14 from each weight category) that qualified for the 2012 Olympic Games, London.

They concluded that the lightest and heaviest judo athletes displayed unique characteristics compared to athletes in the other weight categories, particularly in the attack, defence, *Ne-waza*, and *Matte-Hajime* phases. The female extra lightweight category had longer *Ne-waza* times than the light and middle weight categories. They suggested the average time for *Ne-waza* was across all weight categories was 2.8s and that for lightweight women the average was higher at 5.9s.

Miarka *et al.*, (2016c) considered female *Judoka* in Olympic versus non-Olympic events and considered *Ne-waza* to be 9% of a contest and occur on average of 6.1(\pm 4.7) times per contest.

Adam and Majdan, (2011) examined the career of world bronze medallist Joanna Majdan who fought in the under 52kg category. Results suggested that 83.78% of Majdan's judo was *Tachi-waza* and 16.22% was *Ne-waza*. Her opponents showed similar results with 76.61% of their contests in *Tachi-waza* and 23.39% in *Ne-waza*. Majdan showed much great efficiency in *Tachi-waza* when compare to her opponents and when compared to the *Ne-waza* of both parties. Interestingly 100% of Majdan's success in *Ne-waza* was *Osaekomi-waza*.

The final article evaluated in relation to frequency and time spent in *Ne-waza* is Sterkowicz, & Maslej, (1999). Based on the analysis of 92 seniors matches recorded at the 1996 Polish Senior National Championship and the 1996 Ladder Tournament held in Bytom they identified that the players attempted a total of 819 attacks, 97% of which were done in *Tachi-waza* and just 21 (<3%) in *Ne-waza* (17 *Osaekomi-waza*, 2 *Shime-waza*, and 2 *Kansetsu-waza*). Despite this much lesser activity in *Ne-waza*, the attacks were very effective. From the 21 observed attempts, only one *Osaekomi-waza* did not end the match.

When considering the type of techniques used in *Ne-waza* the research is sparse, some literature breaks down into the three categories: *Osaekomi-waza*, *Kansetsu-waza* and *Shime-waza* but little research considers the actual techniques used. Segedi *et al.*, (2014) is an example of research that breaks *Ne-waza* down into its three categories. Their study considered *Ne-waza* from the elimination rounds of the 2013 Grand Prix Tournament (Rijeka, Croatia), their sample was 193 matches (n= 125 men's contests, 68 women's contests) and they observed 2 *Kansetsu-waza*, 4 *Shime-waza* and 7 *Osaekomi-waza* across all seven weight categories for women and 5, 4, 18 for men respectively. They suggest that in the men's

weight categories *Ne-waza* gradually becomes more frequent as the weight categories get heavier but this is not seen in women's judo. They propose the larger frequency of *Osaekomi-waza* is because the simplicity in the execution. On the other hand, *Kansetsu-waza* and *Shime-waza* demand more precise movement and greater *Ne-waza* knowledge. They suggest it is easier to defend one part of body (elbow or neck) than the whole body and that it is enough to learn some quality defence and the probability of application of arm locks and strangulations will be diminished.

Witkowski *et al.*, (2012) agree with the research cited previously that victories were most often awarded in consequence of the *Nage-waza* (throwing techniques) rather than the *Katame-waza* (grappling techniques). The *Katame-waza* ended 15.51% of all combats. Out of all 47 combats that ended in a horizontal position, 36 (11.88%) ended by *Osaekomi-waza*, 9 (2.97%) by *Kansetsu-waza* and 2 (0.66%) by *Shime-waza*. Their analysis of 296 fights in the men's weight categories of the 2008 Beijing Olympic Games concluded that *Tate-shiho-gatame* and *Kesa-gatame* were the most prolific *Osaekomi-waza* ending 8 combats (2.64% of all contests). Witkowski *et al.*, speculate that the application of efficient *Katame-waza* techniques requires more time for preparation and this is the reason underlying the limited popularity of this way of combat settlement. Another reason may be the growing sport level among contestants and the perfection of defence in *ne-waza*. The argument of defensive action is similar to Segedi *et al.*, (2014) above and interestingly there is no form of *Shido* in *Ne-waza* for defensive actions like in *Tachi-waza*.

Ne-waza techniques were considered in the context of their efficiency by Bocioaca, (2014) who analysed 150 contests by the Romanian judo team. Footage from 2010-2012 of the European Championships, World Championships and the Olympic Games. Table 6.7 shows the final ranking of the *Ne-waza* techniques by Bocioaca (2014) with the frequency and their effectiveness based upon percentage scoring.

Table 6.7: Taken from Bocioaca (2014) showing the frequency of techniques and their effectiveness.

No.	The name of the technique, according to the international classification	The total number of attack	Effective percentage of shares (with score)
1	KESA - GATAME	49	18
2	KATA - GATAME	38	14
3	KAMI - SHIHO - GATAME	21	7.7
4	YOKO - SHIHO -GATAME	12	4.4
5	TATE – SHIHO - GATAME	8	3
6	NAMI - JUJI - JIME	15	5.5
7	GYAKU - JUJI - JIME	9	3.3
8	KATA - JUJI - JIME	12	4.4
9	OKURI - ERI - JIME	36	13.7
10	TSUKIKOMI - JIME	25	9
11	UDE - HISHIGI - JUJI - GATAME	32	11.5
12	UDE - HISHIGI - WAKI - GATAME	5	2.5
13	UDE - HISHIGI - SANKAKU - GATAME	3	1
25	OTHER	5	2
26	TOTAL	270	100

The top five efficient techniques listed in Table 6.7 are all *Osaekomi-waza* agreeing with Boguszewski (2010), who also found *Kesa-gatame* to be the most prolific *Ne-waza* technique followed by *Kami-shiho-gatame* that was third in the study by Bocioaca (2014).

Efficiency of *Ne-waza* is generally considered against the efficiency of *Tachi-waza* rather than by technique. For example, Abdel-Raouf, & Abdelhalem, (2011) considered the efficiency of all techniques across specific men's categories in the 2010 World Championships. The only *Ne-waza* technique cited in the top 15 most efficient techniques was "*Yoko-shiho-gatame* of *Ude-garami*" but with only 15 matches analysed and a sample of only men this validity of this research should be questioned.

Other researchers such as Boguszewski (2010) suggests the effectiveness of *Ne-waza* is several times higher than that of throws (18% in women and 27% in men). This research analysed recordings of finals in the 2008 Olympic games (Beijing), the 2005 World Championships in Cairo and World Cup tournaments in Warsaw (2005 - 2008). The actions of the male and female competitors were analysed across 54 contests totalling 628 actions (throws or holds). This included 58 (9.23%) successful actions. *Katame-waza* and *Ne-waza*

were rarely used (5.72% of all noted attacks) but were more effectively performed, with almost 1 in 4 (23.53%) actions scored, while only 8.42% of *Tachi-waza* techniques scored. Although *Ne-waza* was rare its effectiveness was higher (statistically significant differences were noted between the frequency of throws and grapples at $p < 0.001$ and between the effectiveness of throws and grapples at $p < 0.001$). When breaking down the *Ne-waza*, *Osaekomi-waza* proved most effective both for the male and female *Judokas*. No significant differences were noted between the male and female competitors as for the effectiveness of their actions.

A much broader study that considered both the frequency and efficiency of techniques was Adam *et al.*, (2016). The researchers observed 846 contests from the 2014 World Championship in Chelyabinsk (Russia) and the 2015 World Championships in Astana (Kazakhstan). The analysis included only the men's individual competitions in which 812 *Judoka* from 130 national teams participated. Analysis suggested the competitors used throwing techniques more than three times more efficiently (77%) than *Ne-waza* (23%). In *Ne-waza*, athletes most efficiently performed *Osaekomi-waza* (65%) and then, with similar efficiency, *Kansetsu-waza* (18%) and *Shime-waza* (17%) agreeing with Boguszewski (2010) and Bocioaca (2014) that *Osaekomi-waza* was more prevalent and efficient. *Osaekomi-waza* contributed to about 60-70% efficiency, while *Kansetsu-waza* and *Shime-waza* accounted for 30–40% of the efficiency.

When considering *Tachi-waza* and *Ne-waza* in their traditional classifications there was a visible advantage of efficiency in *Ashi-waza* (foot techniques) and *Te-waza* (hand techniques). The next most efficient techniques were *Osaekomi-waza* (pinning techniques), conversely the lowest values of efficiency were obtained with *Kansetsu-waza* (joint locks) and *Shime-waza* (strangles and chokes). Therefore, the inefficiency of *Ne-waza* may be caused from *Kansetsu-waza* and *Shime-waza* attempts rather than all *Ne-waza* suggesting all analysis in this area should be broken down to provide clarity and prevent misinformation.

Adam, (2011) conducted a profile of World and Olympic medallist Aneta Szczepańska's. Her *Nage-waza* was 88.47% of the contest whilst *Ne-waza* was 11.53%. *Osaekomi-waza* was 73.15%, *Kansetsu-waza* was 26.85% and *Shime-waza* was 0%. Only one *Ne-waza* appeared in her top 10 techniques, *Juji-gatame*, despite this overall *Osaekomi-waza* was found to be more efficient than *Kansetsu-waza* this score of 0.856 and 0.317 respectively.

Similarly, Adam, (2012) studied 2002 European champion Adriana Dadci from 2002 - 2004. He noted that she was exceptionally efficient in *Ne-waza* with 4 *Ne-waza* techniques in her

top 10. Most effective was *Juji-gatame* the other three techniques were all *Osaekomi-waza*, *Kesa-gatame*, *Tatae-shiho-gatame* and *Kata-gatame*.

The London 2012 Olympic Games was the first Olympic Games that Japan had not been top of the medal table for judo since its inclusion in 1964. The Russian team topped the medal table with three gold's, one silver and one bronze compared to one gold, three silvers and three bronzes from the Japanese team. The techniques and tactics of the Russian team in this Olympic Games were the subject of research from Adam *et al.*, (2013). They considered the techniques used, their efficiency and penalties awarded. The efficiency of *Katame-waza* among Russian athletes was high, while their opponents could not efficiently perform any technique from this group. Unlike in other studies *Osaekomi-waza*, *Kansetsu-waza* and *Shime-waza* were performed by Russian athletes with similar efficiency. The conclusions were that they were far superior to other participants in the 2012 Olympic Games in the efficiency of particularly *Kansetsu-waza* and *Koshi-waza* (hip throws).

Other comparative research includes comparisons of gender, for example Sterkowicz, (1998) considered differences in the frequencies of techniques between men and women in the 1996 Atlanta Olympic Games. *Nage-waza* (throwing techniques) lead to more victories in both women and men (59.6% and 65.9% respectively). The second decisive factor in victory were penalties (27.7% and 22.2%) while the third important techniques were *Osaekomi-waza*. It was observed that only that only throws *Harai-goshi* (5.2%) and holds *Tate-shiho-gatame* (2.4%) noticeably more often ($p < 0.05$) determined victories in the case of the female than male contestants.

Finally, two pieces of research consider defensive actions used in judo, Boguszewski, (2009 & 2011). Both of these articles consider the same 12 defensive actions. In 2009 the defensive actions were considered at the Polish national championships and in 2011 at international competition. Of the 12 defensive actions two were in *Ne-waza*, "twisting onto the belly" and "standing to avoid *Ne-waza*". The relevance of this is that "twisting onto the belly" was common and inefficient in both studies. This may have relevance because of the overwhelming proficiency of *Osaekomi-waza* described above.

In summarising the current literature on *Ne-waza* there appears to be little *Ne-waza* in a judo contest compared to *Tachi-waza*. When *Ne-waza* is performed it can be highly efficient. Of the three groups of *Ne-waza* it is *Osaekomi-waza* that appears to be most effective and efficient. There also appears to be little research that identifies which techniques within the groups are most effective across a large number of contests.

Method for Ne-waza analysis

Procedure

Transition and *Ne-waza* was extracted from the the level 1 coding in Sportscore elite (V10, Hudl) and put into separate video files for analysis. All the *Ne-waza* was coded by the lead researcher manually on paper and then recoded by three *Judoka* all of whom were 1st dan and above and national level competitors to assess the reliability of the coding.

Reliability

Training was given before; difficult or ambiguous scores were discussed, and this resulted in the scores from all four analysts being identical. This was predicted as the referee gives a score and it can normally also be seen on the scoreboard.

Efficiency

To calculate the efficiency formula described by Adam, Klimowicz, & Pujszo, (2016) was used. The efficiency of attacks index (Ea) was determined on the basis of the following formula:

Equation 6.2 - Efficiency

$$Ea = (n \times I + n \times W + n \times Y) / N$$

where:

Ea – efficiency of attacks index

n – the number of attacks

I – assessed as *Ippon* (10 pts.)

W – assessed as *Waza-ari* (7 pts.)

Y – assessed as *Yuko* (5 pts)

N – the number of analysed bouts

This formula has been used by Kajmovic, & Radjo, (2014); Adam, (2011); Adam, *et al.*, (2013) and Miller *et al.*, (2015). This equation gives the efficiency of a given technique or category of techniques based upon the number of times it was attempted and the number of times it scores across a weight category, year or the whole sample.

Ne-waza results

This research considers the results of the *Ne-waza* analysis in *Osaekomi-waza* separately to *Kansetsu-waza* and *Shime-waza* so that efficiency can be considered. It allows comparisons across the three weight categories of lightweight women's judo and the 2010 World Championships versus the 2014 World Championships.

Osaekomi-waza

Osaekomi-waza was seen 58 times, of these 58, 13 resulted in *Toketa* (hold broken) before a score, 2 achieved *Yuko*, 0 achieved *Wazari*, and 43 achieved *Ippon*.

Table 6.8: Shows all the *Osaekomi-waza* used sorted by the efficiency.

	Sum of 2010 & 2014	Average Ea	Sum Ea
<i>Mune-Gatame</i>	16	8.3	41.7
<i>Kuzure-kesa-gatame</i>	5	10	40
<i>Sangaku-Osaekomi</i>	9	8.4	33.5
<i>Kesa-gatame</i>	4	7.5	30
<i>Tate-shiho-gatame</i>	5	7.5	30
Other	4	8.3	25
<i>Yoko-shiho-gatame</i>	4	6.7	20
<i>Ura-gatame</i>	4	8.3	16.7
<i>Kami-shiho-gatame</i>	5	7.5	15
<i>Kuzure-kami-shiho-gatame</i>	2	2.5	5
Sum of <i>Osaekomi-waza</i>			58

In Table 6.8 “other” refers to techniques not list on the official *Kodokan* website. These included *Makura-kesa-gatame* (pillow scarf hold), two occurrences of a hold that appears to be a variation of *Mune-gatame* or *Kuzure-yoko-shiho-gatame* (see Figure 6.8) and *Kuzure-kata-gatame* (Figure 6.7).



Figure 6.7: *Kuzure-kesa-gatame* variant.



Figure 6.8: *Mune-gatame* or *Kuzure-yoko-shiho-gatame* variant.

The following *Osaekomi-waza* were observed for but not seen - *Ushiro-kesa-gatame*, *Kata-gatame* and *Uki-gatame*.

Submissions - Kansetsu-waza and Shime-waza

Kansetsu-waza scored *Ippon* 9 times across all weights and both years but was more prolific in 2014 as shown in Table 6.9. The only *Kansetsu-waza* observed were *Juji-gatame* (7) and *Hiza-gatame* (2). Both instances of *Hiza-gatame* were from *Kesa-gatame* as shown in Figure 6.9 There was also one instance of a submission during a *Tate-shiho-gatame* and it is not known if the opponent submitted from a *Ude-garami*, a *Sode-guruma-jime* or from the pressure of the *Tate-shiho-gatame*, this instance was recorded as *Tate-shiho-gatame*.



Figure 6.9: *Hiza-gatame* from *Kesa gatame*.

Table 6.9: Frequency of *Kansetsu-waza* and *Shime-waza* by weight category and year.

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
<i>Kansetsu-waza</i>									
<i>Juji-gatame</i>	0	0	2	2	1	1	3	5	7
<i>Hiza-gatame</i>	1	0	0	1	0	1	0	1	2
<i>Shime-waza</i>									
<i>Okuri-eri-jime</i>	0	0	1	1	0	0	0	0	1
<i>Sankaku-jime</i>	0	0	0	0	0	0	2	2	2
<i>Koshi-jime</i>	0	1	1	2	0	1	0	1	3
Other	0	1	1	2	0	0	0	0	2

A large number of *Kansetsu-waza* were not observed - *Ude-garami*, *Juji-gatame*, *Ude-gatame*, *Hiza-gatame*, *Waki-gatame*, *Hara-gatame*, *Ashi-gatame*, *Te-gatame*, and *Sankaku-gatame*.

Shime-waza was also lacking diversity (Table 6.9), just four types of *Shime-waza* scored *Ippon* - *Okuri-eri-jime* (1), *Sankaku-jime* (2), *Koshi-jime* (3) and “Other” (2). Both instances of “other” were the same technique that is shown in Figure 6.10.

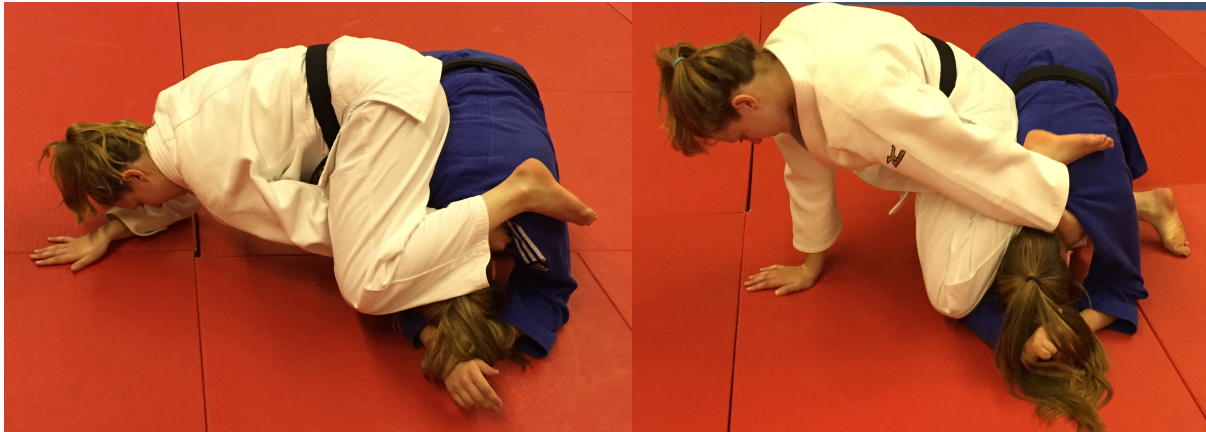


Figure 6.10: Two variants of the same strangle described as “other”

In order to establish the efficiency of *Ne-waza* as a whole this research recorded all instances of *Ne-waza*, how many instances ended with *Matte* and how many resulted in a score. This data is shown in Table 6.10, there was a high number of *Ne-waza* attempts recorded (795) across 267 fights but only 63 (10.2%) of these yielded a score. In this research, there was 2284 *Tachi-waza* attacks, 250 of which yielded a score, this is a success rate of 11%. Therefore, in this research the success rates of *Ne-waza* and *Tachi-waza* were very similar.

Table 6.10: Variety of *Ne-waza* techniques used, scores, no scores and total number of attacks shown alongside the “success rate” for *Ne-waza*

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
Ne-waza initiated but Matte called	170	166	129	465	129	136	119	255	720
Attempts equalling a score	13	10	13	36	11	18	10	39	75
Total Ne-waza Attempts	183	176	142	501	140	154	129	294	795
Success rate (% of total attempts that yielded a score)	7.1	5.7	9.2	7.2	7.9	11.7	7.8	13.3	10.2*

* = average (mean)

Overall there were 58 attempts at *Osaekomi-waza*, 9 *Kansetsu-waza* and 8 *Shime-waza*. It should be noted that only scoring attempts of *Kansetsu-waza* and *Shime-waza* were analysed whereas 12 of the 58 *Osaekomi-waza* attempts were no score.

Discussion on technical components of lightweight women judo

This work has considered 267 fights that consisted of 2284 *Tachi-waza* exchanges and 795 *Ne-waza* exchanges. Both of these were broken down to establish the total number of attacks, their efficiency and their success rate. It was established that the success rate (percentage of attacks that yielded a score) was 10% for *Ne-waza* and 11% for *Tachi-waza* but the latter had far more overall attempts and therefore had a lower efficiency using the equation of Adam, Klimowicz, & Pujszo, (2016).

Types of techniques used

Comparing the literature cited earlier in this chapter, it was possible to consider techniques previously cited as prevalent in the literature (Table 6.11). The most commonly presented techniques in *Tachi-waza* were *Uchimata*, *Seoi-nage* and *O-uchi-gari*, *Ippon-Seoi-nage* and *O-soto-gari*. A large number of research articles placed *Ippon-seoi-nage*, *Morote-Seoi-nage* and *Eri-seoi-nage* into one group - *Seoi-nage* and if in Table 6.4 we combined the results of these three distinctions with that of “*Seoi-nage*” then this would by far be the most prevalent technique. It is therefore possible that the prevalence of *Seoi-nage* in the literature is due to this combining of techniques, nonetheless *Seoi-nage* variants appear to be very popular. Almansba *et al.*, (2008) suggest *Seoi-nage* is the fastest technique to do based on a series of *Nage-komi* drills (throwing drills) in their study, this could provide another reason for the wide spread presence of this technique. The the most popular technique was *Uchimata* though, shown to be a ‘slower’ techniques by Almansba *et al.*, (2008) but possibly more prominent because of it’s diversity in methods of entry (*Tsukuri*) and the number of techniques it can be combined with (Sugai, 1991). Table 6.11 shows the techniques cited in the literature ranked based upon equation 6.3 below. The data used to establish where the techniques sit in the top 5 in each study is shown in Table 6.12

Equation 6.3.

Number of times cited 1st x 5

Number of times cited 2nd x 4

Number of times cited 3rd x 3

Number of times cited 4th x 2

Number of times cited 5th x 1

= “Score”

Table 6.11: Top 5 most frequent techniques as cited in the literature.

Technique	1st	2nd	3rd	4th	5th	score
<i>Uchimata</i>	20	24	8	4	2	58
<i>Seoi-nage</i>	35	8			1	44
<i>O-uchi-gari</i>	15		12	2	2	31
<i>Ippon-Seoi-nage</i>	20		3	4		27
<i>O-soto-gari</i>		4	12	2	2	20
<i>Ko-uchi-gari</i>		8	3	6	1	18
<i>Morote-Seoi-nage</i>	5	8			1	14
<i>De-Ashi-Harai</i>		4	4	4		12
<i>Sukui-nage</i>	5	4		2		11
<i>Tani-Otoshi</i>		8		2		10
<i>Harai-goshi</i>			3	2	2	7
<i>Soto-makikomi</i>			6		1	7
<i>Tai-otoshi</i>			4		2	6
<i>Kuchiki-taoshi</i>			6			6
<i>Uchimata-sukashi</i>		4				4
<i>Kata-guruma</i>		4				4
<i>Ko-soto-gari</i>				4		4
<i>Uchimata-gaeshi</i>			3			3
<i>Harai-makikomi</i>				2		2
<i>Sumi-gaeshi</i>					2	2
<i>Ko-uchi-makikomi</i>					1	1
<i>Ko-soto-gake</i>					1	1
<i>Ura-nage</i>					1	1

Table 6.12: Frequency ranked as 5 techniques by author.

Author	1st	2nd	3rd	4th	5th
Adam & Szczepańska (2011)	<i>Uchimata</i> ,	<i>Uchimata-sukashi</i>	<i>O-soto-gari</i>	<i>Tani-otoshi</i>	<i>Tai-otoshi</i>
Adam, (2012)	<i>O-uchi-gari</i>	<i>Uchimata</i>	<i>O-soto-gari</i>	<i>Harai-goshi</i>	<i>Seoi-nage</i>
Adam <i>et al.</i> , (2014)	<i>Seoi-nage</i>	<i>Uchimata</i>	<i>O-soto-gari</i>	<i>Ko-uchi-gari</i>	<i>Morote-gari</i>
Adam & Majdan, (2011)	<i>Seoi-nage</i>	<i>Ko-uchi-gari</i>	<i>Tai-otoshi</i>	<i>De-ashi-harai</i>	<i>Ko-uchi-makkikomi</i>
Adam <i>et al.</i> , (2011a)	<i>Uchimata</i>	<i>Seoi-nage</i>	<i>De-ashi-barai</i>	<i>Ko-uchi-gari</i>	<i>O-uchi-gari</i>
Carratala Deval <i>et al.</i> , (2010)	<i>Seoi-nage</i>	<i>Kouchi-gari</i>	<i>Ouchi-gari</i>	<i>Kosoto-gari</i>	<i>Kosoto-gake</i>
Sertić & Segedi, (2012)	<i>Ippon-Seoi-nage</i>	<i>Morote-seoi-nage</i>	<i>Ouchi-gari</i>	<i>Uchimata</i>	<i>Ko-uchi-gari</i>
Sertić & Segedi, (2012)	<i>Ippon-Seoi-nage</i>	<i>Morote-seoi-nage</i>	<i>Uchimata</i>	<i>Ko-uchi-gari</i>	<i>Tai-otoshi</i>
Kajmovic <i>et al.</i> , (2011)	<i>Ippon-seoi-nage</i>	<i>Tani-othoshi</i>	<i>Harai-goshi</i> ,	<i>De-ashi-barai</i>	<i>Uchimata</i>
Kajmovic <i>et al.</i> , (2011)	<i>Uchimata</i>	<i>Sukui-nage</i>	<i>Ippon-seoi-nage</i>	<i>O-soto-gari</i>	<i>O-soto-gari</i>
Kajmovic <i>et al.</i> , (2014b)	<i>Sukui-nage</i>	<i>O-soto-gari</i>	<i>O-uchi-gari</i>	<i>Tani-Otoshi</i>	<i>Uchimata</i>
Kajmovic <i>et al.</i> , (2014b)	<i>O-uchi-gari</i>	<i>Tani-Otoshi</i>	<i>Uchimata</i>	<i>Sukui-nage</i>	<i>O-soto-gari</i>
Witkowski <i>et al.</i> , (2012)	<i>Seoi-nage</i>	<i>Kata-guruma</i>	<i>Kuchiki-taoshi</i>	<i>Uchimata</i>	<i>Sumi-gaeshi</i>
Adams <i>et al.</i> , (2016)	<i>Uchimata</i>	<i>Seoi-nage</i>	<i>Ko-uchi-Gari</i>	<i>Ippon-seoi-nage</i>	<i>Ura-nage</i>
Abdel-Raouf, & Abdelhalem, (2011)	<i>Morote-seoi-nage</i>	<i>De-ashi-barai</i>	<i>Uchimata-gaeshi</i>	<i>Harai-makkikomi</i>	<i>O-soto-makikommi</i>
Sertić, Centić & Segedi, (2016)	<i>Ippon-seoi-nage</i>	<i>Uchimata</i>	<i>Soto-makikomi</i>	<i>O-uchi-gari</i>	<i>Harai-goshi</i>
Sertić, Centić & Segedi, (2016)	<i>O-uchi-gari</i>	<i>Uchimata</i>	<i>Soto-makikomi</i>	<i>Ippon-seoi-nage</i>	<i>Harai-goshi</i>
Adam <i>et al.</i> , (2011b)	<i>Seoi-nage</i>	<i>Uchimata</i>	<i>Kuchiki-taoshi</i>	<i>Ko-soto-gari</i>	<i>Sumi-gaeshi</i>
Adam <i>et al.</i> , (2011b)	<i>Seoi-nage</i>	<i>Uchimata</i>	<i>O-soto-gari</i>	<i>Ko-uchi-gari</i>	<i>O-uchi-gari</i>

This study has shown *Ippon-seoi-nage*, *Uchimata*, *Sode-tsurikomi-goshi*, *O-uchi-gari* and *Morote-seoi-nage* as the highest presented techniques. There is commonality with previous research in *Uchimata*, *Ippon-Seoi-nage*, *Ouchi-gari* and potentially *Morote-seoi-nage*. The outlier in lightweight women's judo in terms of frequency of attempts appears to be *Sode-tsurikomi-goshi*.

Techniques used in *Ne-waza* were less frequent possibly because, as discussed in chapter 5, the time spent in *Ne-waza* is considerably shorter than that spent in *Tachi-waza*. This study suggests it is approximately 23% of work time and has an average duration of 4.8 ± 9.2 s and the mean frequency per contest was 3.4 ± 2.8 suggesting approximately a 3:1 ratio of *Tachi-waza* to *Ne-waza*. This agrees with previous research in the area (Sikoski *et al.*, 1987; Casterenas and Planas, 1997; Sikoski, 2010; Franchini *et al.*, 2011; Hernandez-Garcia and Luque, 2007). There were two main differences between *Ne-waza* in 2010 and 2014. Firstly, substantially more attempts at *Ne-waza* were seen in the 2010 World Championships than the 2014 World Championships, secondly *Ne-waza* was much more efficient in 2014 (success percentage was 7.2% and 13.3% respectively). One reason for this might be the rule changes around the area where in 2010 if being held by *Osaekomi-waza* you could move out of the area to force *Matte*. The new rules mean once *Osaekomi-waza* is applied the opponent must physically escape or control and leg with their which is much harder.

Techniques used in *Ne-waza* most frequently were *Mune-gatame*, *Sangaku-gatame*, *Juji-gatame*, with *Kuzure-kesa-gatame*, *Tate-shiho-gatame*, and *Kami-shiho-gatame* all in 4th place with 5 instances. These results are consistent with the research cited above.

Efficiency of techniques used

Many authors used a similar equation for efficiency as this work that was developed from Adam (2012). Because of the similarities in the equation it was possible to construct tables similar to Table 6.11 and 6.12 but for efficiency. These are shown below (Tables 6.13 and 6.14).

Table 6.13: Efficiency of techniques ranked within top 5 by the authors.

Author	1st	2nd	3rd	4th	5th
Adam <i>et al.</i> , (2013)	<i>Harai-goshi</i>	<i>Ko-soto-gari</i>	<i>Tani-otoshi</i>	<i>Uchimata</i>	<i>Seoi-nage</i>
Adam <i>et al.</i> , (2013)	<i>Tai-otoshi</i>	<i>Seoi-nage</i>	<i>O-uchi-gari</i>	<i>Tani-otoshi</i>	<i>Ko-uchi-gari</i>
Adam <i>et al.</i> , (2011a)	<i>Uchimata</i>	<i>O-soto-gari,</i>	<i>Seoi-nage</i>	<i>Ko-uchi-gari</i>	<i>Harai-goshi</i>
Kajmovic & Radjo, (2014a)	<i>Harai-goshi</i>	<i>Ippon-seoi-nage</i>	<i>Uchimata</i>	<i>O-uchi-gari</i>	<i>Tani-otoshi</i>
Kajmovic & Radjo, (2014a)	<i>Uchimata</i>	<i>Ippon-seoi-nage</i>	<i>Tani-otoshi</i>	<i>O-uchi-gari</i>	<i>O-soto-gari</i>
Sertić, Centić & Segedi, (2016)	<i>Uchimata-sukashi</i>	<i>Ko-soto-gari</i>	<i>Tani-otoshi</i>	<i>Ura-nage</i>	<i>Yoko-gurma</i>
Sertić, Centić & Segedi, (2016)	<i>Ko-uchi-gari</i>	<i>Tai-otoshi</i>	<i>Eri-seoi-nage</i>	<i>Morote-seoi-nage</i>	<i>Koshi-guruma</i>
Adam <i>et al.</i> , (2011b)	<i>Sumi-Gaeshi</i>	<i>Sukui-Nage</i>	<i>Seoi-nage,</i>	<i>Uchimata</i>	<i>Kata-guruma</i>
Adam <i>et al.</i> , (2011b)	<i>Seoi-nage</i>	<i>Uchimata</i>	<i>Kuchiki-Taoshi</i>	<i>Ko-soto-gari</i>	<i>Sumi-gaeshi</i>
Adam <i>et al.</i> , (2011b)	<i>Seoi-nage</i>	<i>Uchimata</i>	<i>O-Soto-gari</i>	<i>Ko-uchi-gari</i>	<i>O-uchi-gari</i>
Adam <i>et al.</i> , (2011b)	<i>Seoi-nage</i>	<i>Uchimata</i>	<i>Sode-tsuri-komi-goshi</i>	<i>O-uchi-gari</i>	<i>O-soto-gari</i>
Adam <i>et al.</i> , (2011b)	<i>Seoi-nage</i>	<i>Tai-otoshi</i>	<i>Uchimata</i>	<i>Sukui-nage</i>	<i>Sode-tsuri-komi-goshi</i>

Table 6.14: Top 5 most efficient techniques as cited in the literature.

Technique	1st	2nd	3rd	4th	5th	score
<i>Uchimata</i>	10	12	6	4		32
<i>Seoi-nage</i>	20	4	6		1	31
<i>Tai-otoshi</i>	5	8				13
<i>Tani-Otoshi</i>			9	2	1	12
<i>Ko-soto-gari</i>		8		4		12
<i>Harai-goshi</i>	10				1	11
<i>O-uchi-gari</i>			3	6	1	10
<i>Ko-uchi-gari</i>	5			4	1	10
<i>Ippon-Seoi-nage</i>		8				8
<i>Sukui-nage</i>		4		2		6
<i>Sumi-gaeshi</i>	5				1	6
<i>Uchimata-sukashi</i>	5					5
<i>O-soto-gari</i>			3		2	5
<i>Sode-tsuru-komi-goshi</i>			3		1	4
<i>Kuchiki-taoshi</i>			3			3
<i>Eri-seoi-nage,</i>			3			3
<i>Morote-Seoi-nage</i>				2		2
<i>Ura-nage</i>				2		2
<i>Kata-guruma</i>					1	1
<i>Yoko-gurma</i>					1	1
<i>Koshi-guruma</i>					1	1
<i>Uchimata-gaeshi</i>						0
<i>Soto-makikomi</i>						0

Within *Tachi-waza*, using the same method as above (equation 6.2), *Uchimata* was considered the most efficient technique in judo. This was followed by *Seoi-nage*, *Tai-otoshi*, *Tani-otoshi* and *Ko-soto-gari* respectively. The results of this research are quite different, taking the top 5 most prolific techniques from each weight category and both World Championships suggests that the top five most efficient techniques *Uchimata* is considered top, which is in line with previous research (Taking the top five from each category removes techniques that are attempted just once and score *Ippon*). Following *Uchimata*, *O-uchi-gari* and *Sode-tsuru-komi-goshi* are considered 3rd and 4th respectively. Only Adam et al., (2013)

and Kajmovic & Radjo (2014a) consider *O-uchi-gari* in their top 5 and *Sode-tsurikomi-goshi* is only considered top 5 by Adam et al., (2011b).

Within *Ne-waza* efficiency can be calculated the same for *Osaekomi-waza* but not for *Kansetsu-waza* and *Shime-waza*. This is because in the latter scores are graded *Ippon* or no score, it is not possible to score *Yuko* or *Wazari*.

Categories of techniques used

Last to be considered was the prevalence of a category in both *Tachi-waza* and *Ne-waza*. In the latter, it was clear the leading category of techniques was *Osaekomi-waza* and this agreed with almost all of the previous literature with the exception of Adams' research of the Russian team in the 2012 Olympic games (Adam, 2012). Considering his research was solely on male *Judoka* and of only the Russian team this is not surprising, particularly as they have a tradition of joint locking techniques from their native combat sport Sambo (Moshanov, 2004).

Osaekomi-waza has been shown to be the most prolific category of *Ne-waza* (Adam & Majden, 2011; Bocioaca, 2014) and the most efficient (Sterkowicz & Maslej, 1999; Adam et al., 2016; Boguszewski, 2010). This study supports that view in relation to lightweight women's judo and also shows that *Osaekomi-waza* is the most diverse group with observation of 10 varieties of *Osaekomi-waza*, 2 *Kansetsu-waza* and 4 *Shime-waza*. Some authors have proposed that this could be due to athletes becoming more skilled in *Ne-waza* defence and with *Kansetsu-waza* and *Shime-waza* you only have to defence the arms and neck respectively (Segedi et al., 2014)

Table 6.15: Category of *Tachi-waza* techniques ranked by the author.

Author	1st	2nd	3rd	4th
Adam & Szczepańska (2011)	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Adam, (2012)	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Adam <i>et al.</i> , (2014)	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Adam <i>et al.</i> , (2013)	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Carratala Deval <i>et al.</i> , (2010)	<i>Sutemi-waza</i>	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Koshi-waza</i>
Sertić & Segedi, (2012)	<i>Ashi-waza</i>	<i>Koshi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>
Kajmovic <i>et al.</i> , (2011)	<i>Te-waza</i>	<i>Ashi-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Witkowski <i>et al.</i> , (2012)	<i>Te-waza</i>	<i>Ashi-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Sterkowicz, (1998)	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>
Adam <i>et al.</i> , (2016)	<i>Ashi-waza</i>	<i>Te-waza</i>	<i>Sutemi-waza</i>	<i>Koshi-waza</i>

Table 6.16: Ranking of *Tachi-waza* groups based upon relevant literature.

Category	1st	2nd	3rd	4th	Score
<i>Ashi-waza</i>	28	9	0	0	37
<i>Te-waza</i>	8	18	4	0	30
<i>Sutemi-waza</i>	4	0	16	1	21
<i>Koshi-waza</i>	0	3	0	9	12

Limitations and future recommendations

Technical analysis is presented in an abundance throughout the literature. It has been common practice to consider techniques across an entire population, i.e. all weight categories, both genders, age, or by team for example the Russian national team, Polish National team or Japanese national team. The limitations within this research is there is yet to be enough studies across these two rule sets to make comparisons to other weight categories. Some research even compares weight categories, genders *etc.* Little research has focussed upon comparing the technical aspects by nation or by continent and it is therefore recommended that future research considers this.

Conclusions on the technical analysis of lightweight women's judo

In *Tachi-waza* lightweight women show a similar profile of throwing techniques as previously shown in the literature across all weight categories and both genders with the exception of a high frequency of *Sode-tsuri-komi-goshi* and a high efficiency of both *Sode-tsuri-komi-goshi* and *O-uchi-gari*. Coaches working with lightweight female *Judoka* should be mindful of developing these techniques and strategies to avoid or block them and should consider adding these as core techniques withing and individual repertoire. It is possible that rule changes have forced this trend and therefore coaches should be midful of *Sode-tsuri-komi-goshi* becoming more frequent across all weight categories and both genders.

In *Ne-waza* there is little difference seen in lightweight woman *Judoka* to the rest of the judo population with *Osakomi-waza* being exceptionally prevalent with 46 scoring attempts compared to 9 and 7 for *Kansetsu-waza* and *Shime-waza*. With shorter time required to score *Ippon* from *Osaekomi-waza* coaches may need to spend less time considering escaping from these techniques and more time focussing on not allowing them to be applied.

Chapter 7: An Analysis of the Tactical Component of Lightweight Women's Judo

Chapter 7: Analysis of the Tactical components of Lightweight Women's Judo

Tactical analysis considers both tactics and strategy. During competition in any sport tactics are not directly observable; yet an indication of what strategy and tactics are being applied can be seen through the different skills performed, and the location and timing of these skills (O'Donoghue, 2010). A simple tactic, for example, might be the use of combination techniques (*Renraku-waza* & *Renzoku-waza*) to create instability through action-reaction or possibly the use the edge of the combat area to elicit a penalty for the opponent (stepping out can be punishable by *Shido*).

If *Ippon* or decisive advantage ends the match, the uncertainty resides in the actions and behaviours of the other combatant. In *Tachi-waza*, the mastery of several throws in different directions is then necessary to create and direct this uncertainty and to succeed in with throws (Calmet & Ahmaidi, 2004, Calmet & Ahmaidi, 2006).

This section will consider combinations (*Renraku-waza* and *Renzoku-waza*), *Kaeshi-waza* (counter techniques), direction of throw, laterality, penalties and handedness as predictors of tactics.

Method for tactical analysis study

Analysis of direction, laterality and combinations and counters was completed at the same time as the technical analysis on the videos exported of “attack/defend”. The code window for this is shown in Figure 6.2, 6.3 and 6.4. Reliability testing was also conducted at the same time and was 0.975 (very reliable) for the Cronbach’s Alpha test and 0.40 (fair to good) for Cohen’s Kappa as reported in chapter 6.

Direction

Direction was broken down into six directions, front left, front right, right, left rear right and rear left. The direction is the direction that *Uke* (the person being thrown) is thrown in relation to their original orientation. The majority of research uses two directions, forwards and backwards, some uses four directions, forwards, backwards, left and right but these tend to have small angles for left and right and large angles for forward and back. Kuzushi is often described as eight directions, *Happo-no-kuzushi* but this is very complicated to analyse on video because you rarely have an angle from above. After trialling coding in 2, 4, 6 and 8 directions it was concluded that 6 was the manageable maximum and 8 resulted in too many errors. This is similar to findings in team sports where the pitch is coded. it is often found that less detail provides more accurate results (Hughes & Franks, 2008).

Handedness

Handedness is often reported as whether the athlete is left or right handed. In the case of judo this is very challenging because athletes often swap or have a grip that is neither. In this study Handedness was coded as the direction they attacked ie a left-handed athlete turns right and the right-handed athletes turns left.

Laterality

Laterality was coded as to whether the athletes were left against left, right against right (*Ai-yotsu*) or whether they were right vs left (*Kenka-yotsu*). Clear definitions of these are in Table 7.1.

Combinations and counters

The use of *Renraku-waza* (combinations with techniques in the opposite directions), *Renzoku-waza* (combinations with techniques in the same direction), *Kaeshi-waza* (counter attacks) and direct attacks were all recorded as part of the technical analysis described above. Clear definitions of these are below in Table 7.1.

Penalties

Using the data collected for chapter 5 videos were exported from the Sportscodes software of just the penalties being awarded. The researcher then watched each weight category and manually recorded what each *Shido* and *Hansoku-make* was awarded for. Three *Judoka*, all 1st dan and above, one a qualified referee then watched the same videos and manually recorded their answers to establish if the researcher was reliable. The data was almost identical and therefore no statistical reliability test was conducted. The final reliability test was to compare the penalties observed in this research to the official International Judo Federation websites.

Table 7.1: Key performance indicator definitions for laterality and handedness

Group	Key Performance Indicator	Definition
Laterality	Ai-yotsu	The athletes have a same sided grip, left vs left or right vs right. The feet are toe to toe as right to right or left to left. Figure 7.1 shows this position in more detail
	Kenka-yotsu	The athletes have opposing grips, left vs right. The feet are toe to toe as left to right. Figure 7.1 shows this position in more detail
	Unknown	Not possible to determine if in <i>Ai-yotsu</i> or <i>Kenka-yotsu</i> , often caused by double sleeve grip, double lapel or a poor view
Handedness	Right attack	Regardless of hand position the athlete rotates left in the case of a forward attack or in the case of a rear attack the right side of their body is next to the opponent
	Left Attack	Regardless of hand position the athlete rotates right in the case of a forward attack or in the case of a rear attack the left side of their body is next to the opponent
	Unknown	Sometimes it is not possible to determine direction because of over rotation, a reverse <i>Seoi-nage</i> would be an example of this

Laterality and Handedness

Literature considering laterality and handedness

Laterality

The disproportionately high percentage of left-handed players amongst elite athletes in interactive sports has been noted by many researchers (Loffing *et al.*, 2010; Holtzen 2000; Annett 1985; Azemar *et al.*, 1983; McLean & Ciurczak 1982). Around 10% of the general population are left-handed (Raymond *et al.*, 1996; Rigal, 1994; Gilbert & Wysocki, 1992).

There are three prominent theories as to why left-handed advantage may exist:

- The Innate Superiority Hypothesis - proposes a physical advantage due to the difference in the dominant brain hemisphere (Loffing, 2012; Annett, 1985, Geshwind & Galaburda, 1985; Gursoy, 2009, Bisiacchi, 1985; Annet, 1996)
- The Tactical Advantage Hypothesis - proposes that the types of techniques used against a left-handed opponent differs (Loffing *et al.*, 2009; Tirp *et al.*, 2014)
- The Negative Perceptual Frequency Effect Hypothesis - proposes that players are less familiar with left handed opponents and therefore are less able to play against them (Hagemann, 2009; Giese & Poggio, 2003; Jacobs, Pinto & Shiffrar, 2004; Loffing *et al.*, 2012; Goulet *et al.*, 1989; Wood & Aggleton, 1989; Neumaier, 1983; Grouios *et al.*, 2000; Grouios *et al.*, 2004)

However, there is evidence that the left-handed advantage has decreased over time (O'Donoghue, 2009; Loffing *et al.*, 2012), largely due to improved training at elite levels and the increased familiarity with playing left handed athletes. By studying the difference in impact of the left-hander advantage between team and single matches Loffing *et al.*, (2012) conclude that the change in the percentage of left-handers at the elite levels in tennis “*stem from basic processes related to learning and potential adaptation to left-handed opponents*”

Dopico, *et al.*, (2014) suggests laterality can be defined in two ways, motoric and functional. The motoric dominance is defined as the preferential use of an upper or lower limb in a variety of common tasks, this includes concepts such as handwriting and painting. Whereas functional dominance refers to the laterality evidenced by performing different specialised sport techniques, thus sporting preferences of laterality can be adapted away from a players' preferred handedness through training. This poses an interesting point as players in judo tend

to learn techniques right handed first to then learn the left-handed techniques later. Minority coaches try to encourage adolescents into using both sides (Healey 2002).

Judoka define laterality in terms of *Ai-yotsu* (same sided grips) and *Kenka-yotsu* (opposite sided grips). This is important because the laterality is about more than just which hands the athletes are holding with, the whole shape created by the stances differs and presents different challenges in terms of attacking an opponent. Figure 7.1 shows an *Ai-yotsu* and a *Kenka-yotsu* stance. It should be noted that in both stances the athletes are stood dominant foot to dominant foot, however in *Ai-yotsu* the athletes are right side to right side (or left to left) meaning that the majority of the time the attacking player has to “square up” her opponent in order to attack. Conversely in *Kenka-yotsu* athletes are right side to left side meaning the attacking player has to cross in front of their opponent to attack.



Figure 7.1: On the left *Ai-yotsu*, in this case both athletes are right handed in a sleeve lapel grip. Notice they are right foot to right foot. On the right *Kenk-yotsu*, notice in this stance the lapel arms are against eachother and the athletes are left foot to right foot.

By studying laterality in elite men and women *Judokas* during the final and semi-final matches at 12 IJF tournament for all weight categories, Courel *et al.*, (2014) have come to a conclusion that *Kenka-yotsu* was the one most frequently performed with both men and women across all weight categories. However, when considering the efficiency of the throwing techniques performed, the *Ai-yotsu* is more efficient. The research also showed the *Kenka-yotsu* was the best way to achieve a grip to increase the probability of attack success, especially for judo athletes in the lightest weight categories as reported in this study. Their sample was composed of 1462 throw attempts (male = 722; female = 690) from 242 combats (male = 121; female = 121) of finals and semi-finals of 12 tournaments including all weight categories. The analysis included both attacks that referee declared valid and ineffective actions in which a contestant clearly unbalanced his/her opponent.

They went on to cite support from Weers (1997) who, analysing the Atlanta Olympic Games and determined *Kenka-yotsu* was the most prevalent form of *Kumi-kata*. Weers suggested that this is probably related to the fact that a *Kenka-yotsu* stance increases the distance between opponents and decreases the chance of being attacked. Thus, it seems that judo athletes adopt a more defensive posture to combat, as almost half of the situations analysed were in this specific configuration.

Fitzjohn and Challis (2015) considered left and right-handed athletes in *Ai-yotsu* and *Kenka-yotsu*. They suggested that when considering left handed athletes' successful attacks in *Ai-yotsu* contributed only 12% compared to 88% in *Kenka-yotsu* suggesting the left-handed athletes are more successful when competing against right handed athletes. Conversely right-handed athletes saw an almost even split in *Ai-yotsu* and *Kenka-yotsu* with 47% and 53% respectively.

Kajmovic & Radjo (2014) compared male and female athletes in *Ai-yotsu* and *Kenka-yotsu* a total of 446 fights were analysed (280 male and 166 female). 211 contests were fought in *Ai-yotsu* and 235 *Kenka-yotsu*. Females were considered more efficient in *Kenka-yotsu* when compared to their male counterparts and when compared to themselves in *Ai-yotsu*. They also considered the types of throw utilised in *Ai-yotsu* and *Kenka-yotsu*. In females, the most common throws in *Ai-yotsu* were *Harai-goshi*, *Ippon-seoi-nage* and *Uchimata*; in males, the most common throws were *Ippon-seoi-nage*, *O-uchi-gari* and *O-soto-gari*. In *Kenka-yotsu* the top two most efficient techniques were *Uchimata* and *Ippon-seoi-nage* for both genders, the third most efficient for males was *O-soto-gari* again and for females *Tani-otoshi*.

Tirp *et al.*, (2014) examined a total of 840 male athletes at Olympic Games, German national championships and the German University Championships and considered laterality of combat stance. They determined 63.3% preferred right combat stance and 36.7% used a left combat stance. For the *Judoka* who made up the normative sample (athletes ranked seventh or below), 79.2% athletes used a right combat stance and 20.8% used a left combat stance.

Kajmović & Rađo, (2016) presented a comparison of different grip configurations for female seniors at the Bosnia and Herzegovina national championships. Based on video analysis of 83 grip configurations and throwing techniques *Ai-yotsu* and *Kenka-yotsu* were considered. The results showed that the female seniors preferred *Kenka-yotsu*, when compared to *Ai-yotsu*. Results of this research showed that female seniors dominate in throwing techniques from *Kenka-yotsu* (62,7%) compared to *Ai-yotsu* (37,3%). These results are similar to previous findings by the same authors when comparing males to females (Kajmović and Rađo, 2014) who found female's dominant in throwing in *Kenka-yotsu* (63,9%), while male seniors dominate in *Ai-yotsu* (53,9%).

A further similar study (Kajmovic *et al.*, 2014) considered *Kumi-kata* in cadet aged athletes (u17yo) and identified statistically significant differences in males and females. Male cadets dominate in *Ai-yotsu*, whereas female cadets dominate *Kenka-yotsu*. These authors also found *Ippon-seoi-nage* to prevalent for females in *Kenka-yotsu*. They suggested 49.4% of male fights were in *Ai-yotsu*, 38.9 in *Kenka-yotsu* and 11.7% in "other". For females this was 42.6%, 48.8% and 8.6% respectively across a total of 820 contests. They also considered types of attack and concluded the most prevalent throws for males was *Sukui-nage* in both *Ai-yotsu* and *Kenka-yotsu*, for females it was *Sukui-nage* in *Ai-yotsu* and *O-uchi-gari* in *Kenka-yotsu*.

Lastly, Stankovic *et al.*, (2015) is the only research to compare *Ai-yotsu* and *Kenka-yotsu* across weight categories (light, middle, heavy). Overall, they considered *Ai-yotsu* as 24.11%, *Kenka-yotsu* as 37.94% and "other" as 37.94% across 759 contests. Their results broken down into light, middle and heavy are shown below in Table 7.2.

Table 7.2: Adapted from Stankovic *et al.*, (2015), grip configuration broken down into light, middle and heavy weight

	<i>Ai-yotsu</i>	<i>Kenka-yotsu</i>	Other
Lightweight	22.76%	30.89%	46.35%
Middleweight	26.43%	39.81%	33.76%
Heavyweight	22.11%	43.72%	34.17%

Tirp *et al* (2014) defined laterality of combat stance as:

- A right-oriented combat stance was identified when the *Judoka* had his right leg forward, grasping the opponent with his right hand around the neck and with his left hand on the right arm. Thus, a right- oriented *Judoka* will be standing with his body (slightly) turned to the left.
- A left-oriented combat stance was identified when the *Judoka* had his left leg forward, grasping the opponent with his left hand around the neck and with his right hand on the left arm.

Handedness

Defining laterality in terms of stance and therefore *Ai-yotsu* and *Kenka-yostu* is relatively simple, however, it can be argued that handedness is more complex than this. According to Dopico *et al.*, (2014) handedness is a specific term, and typically refers to the hand preferentially used for a simple (e.g. pointing) or a complex (e.g. writing) motoric activity, or to the hand that is more skilful at performing a task. In contrast, the term *functional dominance* refers to laterality demonstrated by the preference with which the athlete executes different sport skills

This work does not consider if the athletes were left or right handed, it considers handedness by the direction the athletes turns in order to throw, thus “*functional dominance*” is what is really measured according to Dopico *et al.*, (2014). This is an important distinction because it is possible for athletes to grip as a right-handed athlete but throw in the direction of a left-handed athletes and *vice versa*. Figures 7.2 and 7.3 show this phenomenon using *Ippon-seoi-nage* as an example. Indeed, in judo Mikheev *et al.*, (2002) found that, compared to a control

group, *Judoka* preferred using the left-oriented combat stance, even when they were right-handed.



Figure 7.2: *Ippon-seoi-nage* by a right-handed athlete conducted traditionally from the sleeve grip. The athlete turns in the direction a right-handed athlete is expected too (left rotation/anti-clockwise)



Figure 7.3: *Ippon-seoi-nage* by a right-handed athlete who is attacking off the lapel grip and therefore turns the opposite way (right/clockwise).

Defining handedness in this manner links handedness more clearly to laterality and direction. The pilot study for this work, Collins and Challis (2014) demonstrated that measuring handedness through a preference of left or right handed *Kumi-kata* was an exceptionally challenging task because of the multitude of *Kumi-kata* configurations available and the often-counterintuitive direction derived from these.

Results

When consider laterality this study analysed the number of techniques in *Ai-yotsu* and *Kenka-yotsu*. Table 7.3 below shows the number of techniques broken down by weight category and year for *Ai-yotsu*, *Kenka-yotsu* and “unknown”. This last category is made up of grip configurations where it is not possible to tell whether one athlete or both athletes are left or right handed or have a left or right stance, for example a double sleeve grip, a double lapel grip or if the referee is blocking the view.

Table 7.3: Number of techniques used in *Ai-yotsu* and *Kenka-yotsu* split by weight and year.

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
Number of techniques in <i>Ai-yotsu</i>	446	204	234	884	339	234	372	945	1829
Number of techniques in <i>Kenka-yotsu</i>	537	616	562	1715	265	362	320	947	2662
Number of techniques unknown laterality	8	0	0	8	12	22	12	46	54
Sum	991	820	796	2607	616	618	704	1938	4545

Following the analysis of the number of techniques seen in each grip configuration the type of technique seen and the *Tachi-waza* group seen was considered. Table 7.4 shows that the most common techniques seen in *Ai-yotsu* were *Ippon Seoi-nage* and *Sode-tsuru-komi-goshi* whereas the most popular techniques in *Kenka-yotsu* were *Uchimata* and *Ippon-seoi-nage*. In terms of categories *Ashi-waza* was most prevalent throughout.

Table7.4: List of prevalent techniques in *Ai-yotsu* and *Kenka-yotsu* as well as *Tachi-waza* category

Most common technique in ..	2010 u48kg	2010 u52kg	2010 u57kg	2014 u48kg	2014 u52kg	2014 u57kg	Most common
<i>Ai-yotsu</i>	STG	ISN	STG	STG	ISN	ISN	ISN & STG
<i>Kenka-yotsu</i>	ISN	ISN	STG	UMA	UMA	UMA	UMA
<i>Ai-yotsu</i> by category	<i>Ashi-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>	<i>Koshi-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>
<i>Kenka-yotsu</i> by category	<i>Te-waza</i>	<i>Te-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>	<i>Ashi-waza</i>

Abbreviations: ISN – Ippon-seoi-nage, STG – Sode-tsuru-komi-goshi, UMA - Uchimata

Handedness or functional dominance is shown in Table 7.5 and demonstrates and even split between left and right-handed attacks.

Table 7.5: Handedness by weight category and year.

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
Left handed	459	576	339	1374	282	347	282	911	2285
Right handed	537	246	470	1253	334	278	418	1030	2283
Unknown	0	0	0	0	2	2	8	12	12
Total attacks	996	822	809	2627	618	627	708	1953	4580

The most common techniques presented by left dominant athletes was *Ippon-Seoi-nage* followed by *Sode-tsuru-komi-goshi*. For right-side-dominant athletes jointly top of the rankings was *Ippon-seoi-nage* and *Uchimata* followed by *Sode-tsuru-komi-goshi*. The most prolific *Tachi-waza* category was *Ashi-waza* on both the left and the right.

Most significant is whether competing in *Ai-yotsu* or *Kenka-yotsu* gives an advantage to an athlete who is functionally left or right dominant. Table 7.6 presents laterality data and handedness data alongside score data from chapter 6 to provide efficiency score for left and right attacks in both *Ai-yotsu* and *Kenka-yotsu* using equation 6.1 from chapter 6. The data suggests that there is little difference in scores and efficiency when comparing *Ai-yotsu* and *Kenka-yotsu*.

Table 7.6: Combining data from laterality, handedness, and scores to demonstrate efficiency of left and right attacks in *Ai-yotsu* and *Kenka-yotsu*

	U48kg 2010				U52kg 2010				U457g 2010				Total 2010			
	Ai-yotsu		Kenka-yotsu		Ai-yotsu		Kenka-yotsu		Ai-yotsu		Kenka-yotsu		Ai-yotsu		Kenka-yotsu	
	223		269		104		308		117		281		444		858	
Attacking direction	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Total attacks	130	91	137	132	22	79	101	206	86	32	145	136	238	202	383	474
Ippon	5	3	9	1	3	6	3	4	7	1	4	3	15	10	16	8
Wazari	3	2	5	2	0	1	4	9	6	0	7	3	9	3	16	14
Yuko	11	5	4	5	0	2	4	6	2	1	5	5	13	8	13	16
No score	111	81	119	124	19	70	90	186	71	30	129	125	201	181	338	435
Efficiency	0.97	0.76	1.06	0.37	1.36	0.97	0.77	0.65	1.42	0.47	0.79	0.56	1.17	0.80	0.88	0.54
Efficiency by stance	0.86	0.71	1.17	0.71	0.94	0.67	0.98	0.71								
																0.71

	U48kg 2014				U52kg 2014				U57g 2014				Total 2014				Total 2010 & 2014			
	<i>Ai-yotsu</i>		<i>Kenka-yotsu</i>		<i>Ai-yotsu</i>		<i>Kenka-yotsu</i>		<i>Ai-yotsu</i>		<i>Kenka-yotsu</i>		<i>Ai-yotsu</i>		<i>Kenka-yotsu</i>		<i>Ai-yotsu</i>		<i>Kenka-yotsu</i>	
	169	132	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Attacking direction	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Total attacks	91	78	70	62	112	122	154	211	220	150	190	130	423	350	414	403	552	797	877	
<i>Ippon</i>	1	0	4	0	2	2	4	10	10	0	6	2	13	2	14	12	28	12	30	20
<i>Wazari</i>	3	4	2	3	2	0	6	12	10	12	6	6	15	16	14	21	24	19	30	35
<i>Yuko</i>	4	4	5	1	10	2	6	13	12	0	4	8	26	6	15	22	39	14	28	38
No score	82	70	59	58	98	118	137	176	186	138	174	114	366	326	370	348	567	507	708	783
Efficiency	0.56	0.62	1.13	0.42	0.75	0.25	0.73	1.18	1.05	0.56	0.64	0.78	0.86	0.46	0.76	0.94	0.97	0.59	0.82	0.72
Efficiency by stance	0.59	0.77	0.50	0.95	0.80	0.71	0.66	0.85	0.78	0.71	0.66	0.85	0.78	0.59	0.82	0.72	0.77			

Discussion on laterality and handedness

The literature suggests that there is an advantage to being a left-handed competitor and that there are more male left-handed people than female (Dopico-Calvo *et al.*, 2016; Dopico *et al.*, 2014). They go on to suggest that because of this the percentage of left handed athletes across sports is much higher than the general population. The concept of left or right handedness is not as simple as which hand the athletes grasps with in judo however, and therefore this research considered handedness in the context of functional dominance. This considers whether the athlete attacks to the left or right rather than just the position of their grasps. Results of this study suggest there is an even split between athletes who attack to the left and the right. No left-handed advantage was presented in lightweight women's judo.

Alongside handedness is laterality, this is also an often-confused topic with researchers interchanging the meanings of laterality and handedness. For the purpose of this research laterality was the stance configuration of the two athletes, *Ai-yotsu* (left vs left stance or right vs right stance) and *Kenka-yotsu* (left vs right). These two positions create a unique dynamic in judo as described above. Athletes observed in this research were twice as likely to attack in *Kenka-yotsu* in the 2010 data but evenly spread between *Ai-yotsu* and *Kenka-yotsu* in 2014. The reasons for there being less prominence of *Kenka-yotsu* in 2014 is unknown, it could be, as suggested by O'Donaghue, (2009) that left-handed advantage is decreasing over time or that lightweight women have less preference of *Kenka-yotsu*. Regardless of the laterality the top three most common techniques remained *Ippon-Seoi-nage*, *Uchimata* and *Sode-tsuri-komi-goshi*. This dominance of *Kenka-yotsu* appears to be prevalent throughout the literature (Kajmović and Rađo, 2014; Kajmović and Rađo, 2016; Kajmović *et al.*, 2014; Stankovic *et al.*, 2015).

Limitations and future research

Building on previous judo research can be challenging with regards to laterality and handedness as there appears to be a variety of definitions and understandings presented. The vast majority of work appears to support efficiency and prominence in *Kenka-yotsu* and for left handed athletes but neither of these have been found in this population. Further research should consider the work of Dopico-Calvo *et al.*, (2016) and Dopico *et al.*, (2014) with regards to defining this area and then expand upon the sample in this research to establish patterns.

Conclusions on laterality and handedness

Undoubtedly the stance a *Judoka* takes when engaging with an opponent affects the dynamics of the contest including the techniques used, the directions of attack. This research has reinforced the literature demonstrating the *Kenka-yotsu* stance as having the most attacking opportunities however no clear advantage has been identified for attacking left or right in either stance and there is no clear indication of differing techniques have prevalence in either stance.

Direction

Literature considering direction of throw

When analysing judo direction is normally broken down into forward and backwards throws, or forwards, backwards, left and right. Sometimes direction is broken down into front left, front right, left, right, rear left and rear right. This study is broken down into the latter classifications.

Adam & Szczepańska, (2011) profiles *Judoka* Aneta Szczepańska and consider forward and rearward attacks concluding that 53.05% of her attacks were to the front and 47.95% to the rear. The most efficient direction was to the front left.

Adam *et al.*, (2014) also considered forward and rearward attacks as a percentage (55.35% and 44.65% respectively) in a male double Olympic champion. They then further broke this down into right front (21.03%), left front (36.69%), right back (19.46%) and left back 22.82%). The most efficient of these was left front but no statistical differences were observed. They concluded the greatest challenge for his opponents was his ability to attack in all four directions, making him tactically very difficult to predict. This theory was supported by a study by Franchini *et al.*, (2008) that showed super elite *Judokas* had a greater diversity in their throwing techniques resulting in more scores than elite *Judokas*. Also, the number of different throwing techniques and the variability of directions in which techniques were executed, were correlated with the number of wins and scores. Thus, this greater number of throwing techniques and use of a variety of directions for attack seem to be important in increasing unpredictability during judo matches. Another profiling study was conducted by Adam and Majdan, (2011), they found similar results and suggested 76.47% of throws were forward and 23.53% were backwards, they also considered forward techniques more efficient and forward left the most prevalent and efficient.

In their study of the Russian team at the 2012 Olympic Games Adam *et al.*, (2013) considered the throwing directions of both the Russian team and their opponents. The Russian team threw more to the front than the rear whilst their opponents had a fairly even split. In a similar study Adam *et al.*, (2011a) reviewed the Japanese men's team in the 2010 World Championships. They found the same trend with forward techniques prevailing.

Pujso, Adam, Kuźmińska, & Błach, (2014) observed the +100kg category at the 2012 London Olympic Games, they broke throwing direction down further and considered "the numbers of fights with attack forwards" (91.2%), "the number of fights with attacks backwards" (97.1%),

“the number of fights finished before time by forwards attacks” (20.6%) and “the number of fights finished before time by backwards attacks” (17.6%). They suggested as the duration of the fight got longer there was a clear downwards trend in the number of backwards attacks.

Sertić, Centić, & Segedi, (2016) compared directions of attack to gender, they suggested men attacked to the forward right 41.7%, forward left 38.3%, backward left 10.8% and backward right 9.3%, women attacked forward right 41.6%, forward left 25.5%, backward left 18.2% and backward right 14.6%. This supports Calmet & Ahmaidi (2004) who suggest senior athletes used on average 3 to 4 directions of attack (3.25 ± 0.86).

Pujso, Pujso, Stępnia & Adam (2016) reviewed all backwards throws in the +100kg based upon 87 contests across two world championships, Rotterdam 2009 and Paris 2011. They suggest that according to the authors, experienced coaches and judo practitioners, the ban on attacking opponents' legs with a hand limits the players to the greatest degree of his/her backward techniques, versatility of movements and in future even the defence character of judo training. Across the 87 fights 86.2% in 2009 (before the rule change) and 86.8% (after the rule change) had backwards throws. The percentage of the fights with backward attacks were similar and despite the difference in the number of fights there were no statistically relevant differences, even is the number of scores or contests ended by backwards throws. The only statistical difference was seen in efficiency leading them to suggest the fall of both effectiveness and efficiency of backward attacks was the consequence of lower dynamics. They argued this concurred with the low level of efficiency indicator (E_a) in all weights category in World Championship in 2011 confirmed by other authors (Stanković *et al.*, 2015).

Adam *et al.*, (2012c) studied the individual profiles of 12 athletes (6 males and 6 females) across 1968 contests. While performing throws into 4 directions, 5 competitors (2 women and 3 men) scored more points than they lost. Three competitors (1 female and 2 males) scored more points than they lost in 3 directions, and in one direction they lost more than they scored. The competitors performing attacks along the forward right and left backwards lines or left front and right backwards lost most points along the opposing line. Significant dependencies were seen between the left backwards direction of executing throws and the right backwards directions of executing throws by their opponents. A significant correlation exists between the throwing direction left backwards and direction left forward of throws executed by their opponents.

Results

This study considered direction in six directions - front left, front right, left, right, rear left and rear right shown in Figure 7.4.

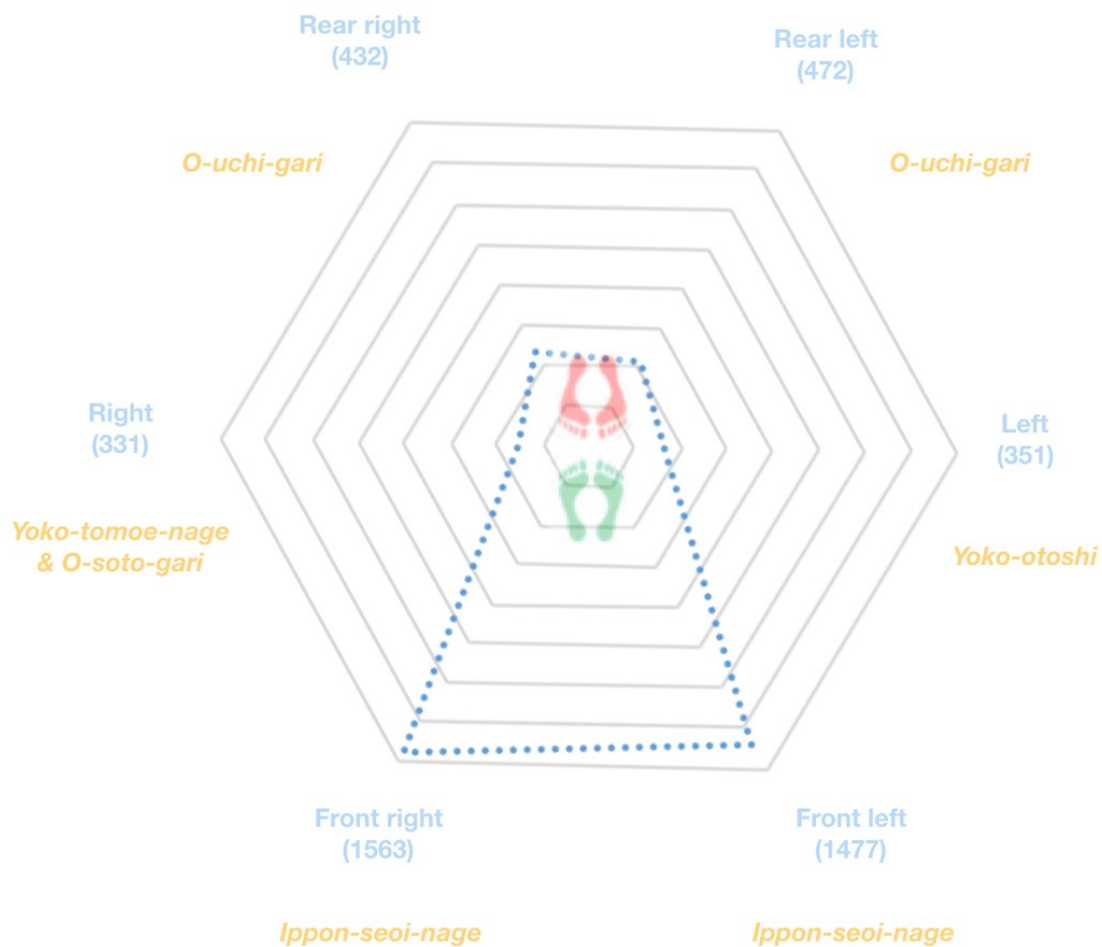


Figure 7.4: Directions most commonly seen in lightweight women's judo with number of attacks and most prevalent throw in that direction. Green feet represent *Tori* and red feet *Uke*.

The sum of throws in the forward direction was 3040 (65.9%) and in the rearwards direction was 904 (19.96%) showing a clear dominance of forward attacks. This study suggests front right has a slight dominance over front left. The dominance in forward throws is attributed to *Ippon-seoi-nage* but in actual fact four of the top five throws cited in chapter 6 of this study are forward throws.

Discussion on direction of throw

The numbers of direction an athlete can throw in has been said to contribute to successful performance, research generally suggests a range of 3-4 directions for elite level athletes (Franchini *et al.*, 2008). This research considered the directions that athletes most frequently

throw in and what techniques are most common in these directions. Previous research has suggested that the most common direction to throw in is forward (Adam & Majdan, 2001; Adam *et al.*, 2014; Sertic, Certic & Sedegi, 2016) and more specifically forward left (Adam & Majdan, 2001; Adam *et al.*, 2014). This research agrees with forward throws being the most prolific (65.9%) but found a slight advantage to front right (33.9%) rather than front left (32.0%). Only one study cited in this research suggested rearward throws were most prolific (Pujso, Adam, Kuźmińska, & Błach, 2014).

Limitations and future research

There is a balance between the number of direction analysed and the accuracy of the coding, despite these six directions were coded and data has been presented that agrees with previous data. The challenge researchers face now is presenting this data in a meaningful fashion, in a context that coaches can relate to that shows data that generalises across competitions, weight categories and ages as well as profiles of individuals. This will allow coaches to develop athletes' repertoires based upon most efficient directions of attack, based upon elite athletes or directions most likely needed to defend in.

Conclusions on directions of throw

It can be concluded that there are no differences in the range or directions or the most common direction in lightweight women's judo when compared to the data presented in the literature for a range of weight categories, ages and both genders. There is a large dominance towards forward throws (65.9%) with a much smaller number of throws in the backwards direction (19.6%) and even less to the sides (14.8%). Future research should consider why the forward direction is so dominant and why the backwards direction is so challenging to athletes.

Combinations & counters

Literature considering the use of combinations and counters

According to Boguszewski and Boguszewska, (2006) and Boguszewski, (2011) defensively males most often applied *Te-waza* (*Sukui-nage*) counter attacking techniques, whereas females used *Ashi-waza* (*Ko-soto gari*) more regularly. Frequency aside, *Sutemi-waza* proved to be the most effective, scoring more points than any other type of *Kaeshi-waza* (counter technique). *Sumi-gaeshi* and *Tani-otoshi* were the main counters used by men and women respectively. Counter attacks within champion fighters (gold medallists) were highly efficient, with up to 66% of all attempted counters producing a score.

Boguszewski, (2009) also considered counter attacks and suggested the effectiveness of counter-attacks (as a scoring technique) is quite high (29%). *Ashi-waza* were most often applied by female contestants (0.36 per fight). In the group of men *Sutemi-waza* were dominant (0.29 per fight). Hip throws were the most effective (50% of effectiveness) in the group of women and sacrifice throws in the group of men. Overall, *Sutemi-waza* were the most effective (44%) when combining both men and women.

Sterkowicz & Maslej (1998) investigated the importance of counterattacks and combinations. In the 92 contests analyzed the athletes executed total of 43 counterattacks. This constituting 5% of all *Tachi-waza* attempts. Effectiveness was high however, over 46% (in 20 cases points were awarded for the attempted counters). The most frequently attempted counter was *Tani-otoshi*. They observed 35 combinations of which 10 resulted in scores (29%). The majority of the attempted combinations involved *Uchimata* and *Ko-uchi-gari*. This is understandable as these two throws constitute a large percentage of all throw attempts (156 out of 798). They measured the most effective counter-attacks were performed by female contestants in heavyweight categories (66% effectiveness) and male *Judokas* in middleweight categories (50%). Throws most often countered by female were *Ashi-waza* (11%). Most effectively countered throws belonged to the *Te-waza* group of throwing techniques (3%). For male athletes *Ashi-waza* were also most frequent (13%). They concluded “*the high effectiveness of counter-attacks (29%) should be a tip for coaches and judo players, to make professional training follow (and not the other way around as it used to be) judo rules set forth by professor Jigoro Kano (among others “give up in order to win”)*”.

In their research of the changes to skills and tactics due to rule changes Abdel-Raouf and Abdelhalem (2011) studied direct attacks, combinations and action-reaction strategy. These were defined as:

Direct Attack: An attack in *Tachi-waza* with no leap up, ruse, deception, or link to another technique. An attack solely attempted on its own, for example: *Uchimata*.

Combination: A series of attacks in *Tachi-waza*, of two or more, with the aim of enhancing the effectiveness of the techniques attempted. For example, *Kouchi-gari* followed by *Ouchi-gari* then *Tai-otoshi*.

Action-Reaction Strategies: Actions in *Tachi-waza* that attempt to create a reaction or movement from an opponent in order to enhance the effectiveness of an attack. For example, a ruse, a deceptive movement, a dummy action that elicits a reaction or movement from the opponent that can be capitalised upon to aid the execution of a throw.

They considered *Uchimata-gaeshi*, *Ko-soto-gake*, *De-ashi-barai* and counter *Ushiro-goshi* as the most prolific counter techniques. Overall direct attacks were 66.6% of all scoring attacks in *Tachi-waza*, combinations were 8.3% and counter attacks were 33.3%.

Results

This study considered combinations in terms of *Renraku-waza* (combinations in opposite directions), *Renzoku-waza* (combinations in the same directions), direct attacks (as defined by Abdel-Raouf and Abdelhalem, 2011), and *Kaeshi-waza* (counter techniques). Direct attacks accounted for the vast majority of attacks in this section (73.4%) as shown in Table 7.7

Table 7.7 Number of counter techniques, direct attacks, *Renraku-waza* and *Renzoku-waza* broken down into weight category and year.

Most common....	2010 u48kg	2010 u52kg	2010 u57kg	2014 u48kg	2014 u52kg	2014 u57kg	Most common
Counter	UTW	UMS	UMS	KSG & STG	DAB	UMS	UMS
Direct	ISN & STG	ISN	STG	ISN	ISN	ISN	ISN
<i>Renraku-waza</i>	UMA	ISN	ISN	OUG	UMA	UMA	UMA
<i>Renzoku-waza</i>	TNO	ISN	UMA	UMA	UMA	UMA	UMA

Abbreviations: ISN – Ippon-seoi-nage, UMA – Uchimata, UMS – Uchimata-sukashi, UTW – Unknown Te-waza, STG – Sode-tsuri-komi-goshi, TNO – Tani-otoshi, OUG - O-uchi-gari, KSG- Ko-soto-gari, DAB - De-ashi-barai.

When considering the actual techniques most commonly presented (Table 7.8) in each group *Uchimata-sukashi* was the most prevalent counter whilst *Uchimata* was the most commonly seen technique used as a combination. *Ippon-seoi-nage* was the most seen direct attack.

Table 7.8: Most commonly presented techniques as *Kaeshi-waza*, direct attacks, *Renraku-waza* and

	2010 u48kg	2010 u52kg	2010 u57kg	2010 total	2014 u48kg	2014 u52kg	2014 u57kg	2014 total	Sum 2010 & 2014
Counter	79	86	40	205	20	42	34	96	301
Direct	723	482	654	1859	472	487	534	1493	3352
<i>Renraku-waza</i>	182	210	110	502	107	76	118	301	803
<i>Renzoku-waza</i>	10	42	2	54	18	16	22	56	110
Sum	994	820	806	2620	617	621	708	1946	4566

Efficiency was calculated using equation 6.1. Considering all weight categories and both years counters showed an efficiency score of 4.65, direct attacks 0.63, *Renraku-waza* 1.02 and *Renzoku-waza* 0.38.

Discussion on combinations and counters

Probably due to its very complex nature there is a dearth of literature that considers combinations in any detail, particularly that consider the actual attacks being used. Whilst there is research on *Kaeshi-waza* (counter techniques) this is also fairly limited in nature.

This study considered the frequency of *Renraku-waza*, *Renzoku-waza*, *Kaeshi-waza* and direct attacks as well as the most prolific technique in each of these. *Uchimata-sukashi* was the most dominant counter with 31 *Ippons* and a total of 119 scoring attempts, counters still only made up 6.6% of the overall attacks though, this is similar to other reports (Sterkowicz & Maslej, 1998) but still less than most (Abdel-Raouf and Abdelhalem, 2011; Boguszewski, 2009). *Ranraku-waza* (combinations with techniques in opposing directions) was seen more than *Renzoku-waza* (combinations with techniques in similar directions), nonetheless, *Uchimata* was the most prevalent technique seen in both. In total, these two types of combinations were seen in only 20% of all attacks. By far the most prevalent of this group was direct attacks (73.45%), this agrees with the current literature (Abdel-Raouf and Abdelhalem, 2011). Why this is the case is unknown, are *Judoka* waiting for opportunity? Is it because the way in which the data is collected? For example, if someone attacks with *Ko-soto-gari* and does not score this would be counted as a “direct attack, no score” but potentially the intention was a combination and they did not get the reaction expected. Without communication with the athletes about their intentions this is not possible to analyse.

When considering efficiency, the results appear completely different. *Renzoku-waza* with the least attempts showed the worst score 0.38, just 5.5% of attempts scoring. Direct attacks, that are so prolific are the next least efficient with an efficiency score of 0.63, 8.2% of attempts scoring. *Ranraku-waza* had an efficiency score of 1.02, 12.2% of attempted attacks score. Leading in efficiency was *Kaeshi-waza* with an efficiency score of 4.56, 39.4% of all attacking attempts were successful. This suggests that counter attacks are more efficient than any single throw and all *Ne-waza*.

Limitations and future research

Future research in this area should consider the used of combination in the context of the techniques used, to the authors knowledge no research to date has considered which techniques are combined together and in which order over a large volume of data on elite level athletes. Understanding this would allow coaches to develop combinations more efficiently

and would also allows researchers to start to understand why there is still such a prevalence of direct attacks. Possibly more research into what happens preceding direct attacks, for example feints, movement, edge play *etc.* would also allow research to develop more understanding in this area.

Conclusions on combinations and counters

Direct attacks appear to be most popular for lightweight women *Judoka* (73.4%), this theme is seen throughout the literature and across weight categories and genders. There appears to be little difference in this population to the general judo population when comparing the use of combinations and *Kaeshi-waza*, the efficiency of *Kaeshi-waza* is noteworthy however.

Penalties in lightweight women's judo

During a contest, an individual can receive up to three *Shidos*, and the fourth will be *Hansoku-make* (3 warnings and then disqualification). *Shidos* do not give points to the opponent, only technical scores can give points on the scoreboard. At the end of the fight, if scoring is equal on the scoreboard, the one with less *Shidos* wins. If the fight continues to golden score, the first receiving a *Shido* loses, or the first technical score will win.

To 'award' a *Shido* the referee will stop the contest, gesture the reason for the *Shido* and point to the athlete or athletes being awarded the *Shido*, without having both fighters return to the formal start position (*Matte – Shido – Hajime*) except when a *Shido* is given for leaving the contest area.

There are three categories of *Hansoku-make*:

- Accumulation of four *Shido*'s
- Direct *Hansoku-make* for grave infringement that is technical in nature i.e. To "dive" head first onto the tatami by bending forward and downward while attempting to perform techniques such as *Uchimata*, *Harai-goshi*, etc
- Direct *Hansoku-make* for something that is against the spirit of judo

The two former *Hansoku-make* result in the contest being awarded to the opponent whilst the latter can result in disqualification from the tournament.

This research spans two sets of rules:

- the International Judo Federation (2009) for the period from 1/01/2010 until 31/12/2012
- the International Judo Federation (2013) for the period from 1/01/2014 until 31/12/2016

The differences in these rules relating to *Shido* and *Hansoku-make* was solely around "leg grabs" and is outlined below:

2010-2012

- All direct attacks or blocking by gripping the leg (below the belt) with one or two hands are prohibited. The punishment after the first attack is *hansokumake* (disqualification)

- Grips of the legs are authorised in sequence of a technique or a counterattack if it's real and well-differentiated in time. A real technique is the opposite of a false attack, it is a technique with an intention to make the opponent fall
- Gripping the leg is also authorised when the opponent takes a cross guard grip; however, if the cross guard has occurred by the *Judoka* ducking their head under the opponent's arm, they are not authorised to grip the leg, if they do so the punishment would be *Hansoku-make*

2014-2016

- All attacks or blocking with one or two hands or with one or two arms below the belt in *Tachi-waza* will be penalised by *Hansoku-make*. It is possible to grip the leg only when the two opponents are in a clear *Ne-waza* position and the *Tachi-waza* action has stopped

The aim of this rule change was to make it easier for referees to determine what was a “leg grab” and what was not.

Current research on penalties in judo

Previous research has considered the awarding of *Shido* in a judo contest but rarely is an analysis of *Shido*'s the main aim of the research. *Shido* is often considered within a greater remit such as a technical and tactical analysis of judo.

One research article that considers *Shido* as a stand-alone topic is Escobar-Molina et al., (2014) who consider “The impact of penalties on subsequent attack effectiveness and combat outcome among high elite judo competitors.” Their sample included 242 combatants (male = 121; female = 121) across all weight categories, selected randomly from participants in the finals and semi-finals of 12 tournaments valid to the IJF 2013 World Ranking List. These participants generated a total of 293 *Shido*'s (male = 141; female = 152). They recorded penalties, throw attempts performed after a penalty, and effective attacks after a penalty. Analyses also included categorical variables related to gender (male and female), attack effectiveness (scored and not-scored throw attempts), and combat result (win and defeat), as well as continuous variables referring to combat minute (moment when the throw attempt or penalty occurred) and weight category. On average, 6 out of 10 fights included penalties (male = 62.0%; female = 58.9%). Of these 20.7% of the sample (males = 26 fights; females = 24

fight) penalties were the deciding factor of the contest, predominately in the heavier weight categories. In seven cases (2.9%), indirect Hansoku-make was observed for accumulating 4 Shido. Main findings revealed that receiving a Shido was associated with increasing the likelihood of being defeated. Importantly, winners were more effective in attacking after receiving a Shido compared to combatants who ultimately lost the match.

All other research considers *Shido* as part of a wider agenda. This is further complicated by the manner in which the *Shido*'s are analysed. Common themes appear to be "*where in the contest*" *Shido*'s occur, the number of *Shido*'s that occur, and comparing the number of *Shido*'s across rule sets.

Miarka *et al.*, (2014) noted the frequency of *Shido*'s awarded across four age bands - Pre-cadet, Cadet, Junior and Senior. They found that penalties occurred 0.21 ± 0.52 , 0.14 ± 0.43 , 0.06 ± 0.23 and 0.31 ± 0.67 respectively per combat and concluded there was no significant difference in the number of penalties awarded when comparing age group.

Sterkowicz & Maslej, (1998) considered when in the contest *Shido*'s were awarded as part of a larger study into the technical and tactical aspects of senior judo. They analysed 92 matches from the Polish national championships and observed 70 *Shido*'s. They concluded that "*relatively high number of penalties during the first two minutes of match is a result of low activity (passivity) as the players try to figure out their opponent. The high number of penalties in the last minute is probably caused by many "faked" attacks, fatigue, and passive defence by players trying to maintain advantages score*" Their study also considered when in the contest *Shido*'s were most likely to be awarded and showed the 1st and 2nd minute were most prolific, the 5th minute was also high and the 3rd and 4th minutes had the lowest number of *Shido*'s awarded.

Adam *et al.*, (2013) analysed the Russian teams' performance in the 2012 Olympic Games. He concluded that although Russian athletes did receive penalties they were exceptional good at forcing their opponents to receive penalties, especially for passivity. Other authors to consider *Shido* by nationality are Kajmovic *et al.*, (2011) who considered male competitors and Kajmovic *et al.*, (2012) who considered female competitors, both considered athletes from Bosnia and Herzegovina against other Balkan nations. They concluded that male competitors from Bosnia and Herzegovina received more *Shido*'s and more *Hansoku-make* than their counterparts from other Balkan countries. Female competitors from Bosnia and Herzegovina were more likely to receive a first *Shido* but less likely to receive subsequent *Shido*'s than their counterparts.

Franchini *et al.*, (2013) considered the awarding of *Shido* and *Hansoku-make* at two European championships before and after the rule changes of 2013 and is therefore considered similar to this work. They observed a total of 513 *Shido*'s in 2012 and 869 in 2013 concluding there was a significant increase in the number of *Shido*'s awarded.

They also broke the awarding of *Shido* down into male and female. In the men's judo, they observed 348 *Shido*'s in 2012 and 569 in 2013 with 1 and 9 direct *Hansoku-make* respectively. For women, a total of 165 *Shido*'s in 2012 and 300 in 2013 with 1 and 3 direct *Hansoku-make* respectively. Further analysis broke these down into 1st, 2nd, 3rd and 4th *Shido*. This breakdown showed 20 *Hansoku-make* for receiving a fourth *Shido* in 2012 and 96 *Hansoku-make* for receiving a fourth *Shido* in 2013. Franchini *et al.*, concluded that the rules had the opposite affect to that desired and actually increased the number of *Shido*'s and *Hansoku-make*.

Previous analysis that considered males and females separately was conducted on the 1996 Olympic games by Sterkowicz, (1998). He recorded a total 8 *Hansoku-make* and 636 *Shido*'s. He found that men received a total of 7 *Hansoku-make* and 464 *Shido*'s whilst women only received 1 *Hansoku-make* and 172 *Shido*'s. This concurs with Franchini *et al.*, (2013) that males receive more *Shido*'s than females.

In summary, the current research on *Shido*'s in judo is often embedded with literature considering a wider agenda such as technical and tactical elements. Of the research, the is available it appears to be clear that males receive more *Shido*'s than females, heavier weight categories receive more penalties than lighter weight categories and that recent rule changes appear to have increase the number of penalties awarded.

Results

This research considered all penalties for the under 48kg, under 52kg and under 57kg weight categories in the 2010 World Championships (Tokyo) and the 2014 World Championships (Chelyabinsk). The results are broken down so that weight category and year can be evaluated. There were 8 penalties that were not categorised due to the position of the referee on the video.

Table 7.8 shows the results of the analysis and is broken down into weight category and year. To our knowledge this is the only research that breaks down every *Shido* by classification in the English language. The most prolific reason for a *Shido* across both years was for passivity or “In a standing position, before or after *Kumi-kata* has been established, not to make any attacking moves”. This yielded three times the number of *Shido*’s than any other penalty. The other high scoring reasons for a *Shido* were to intentionally avoid *Kumi-kata*, excessively defensive posture (*Jigotai*), False attack/pull down into *Ne-waza*, and going outside the contest area.

Table 7.8: Shows the number of penalties by classification, weight category and year

Reason for shido/Hansokumake	2010					2014				
	U48kg	U52kg	U57kg	Total 2010		U48kg	U52kg	U57kg	Total 2014	sum
To intentionally avoid taking Kumikata	2	4	2	8		16	11	17	44	52
To adopt in a standing position, after Kumikata, an excessively defensive posture.	6	2	9	17		5	9	5	19	36
To make an action designed to give the impression of an attack but which clearly shows that there was no intent to throw the opponent. (False attack) OR To pull the opponent down in order to start <i>Ne-waza</i> unless in accordance with Article 16	8	4	2	14		13	10	11	34	48
In a standing position, to continually hold the opponent's sleeve end(s) for a defensive purpose or to grasp by "screwing up" the sleeve end(s).	0	1	0	1		1	4	5	10	11
In a standing position, to continually keep the opponent's fingers of one or both hands interlocked	1	1	0	2		0	0	0	0	2
To insert a finger or fingers inside the opponent's sleeve or bottom of his trousers	0	0	0	0		1	0	0	1	1
In a standing position to take any grip other than a "normal" grip without attacking	2	0	0	2		2	3	4	9	11
In a standing position, before or after Kumikata has been established, not to make any attacking moves	23	34	26	83		22	21	30	73	156
To hold the opponent's sleeve end(s) between the thumb and the fingers ("Pistol" grip).	0	0	0	0		2	0	0	2	2
To put a hand, arm, foot or leg directly on the opponent's face.	0	0	1	1		0	0	0	0	1
To go outside the contest area or intentionally force the opponent to go outside the contest area either in standing position or in <i>Newaza</i>	10	5	4	19		9	8	10	27	46
To kick with the knee or foot, the hand or arm of the opponent, in order to make him release his grip or to kick the opponent's leg or ankle without applying any technique	0	0	0	0		0	0	1	1	1
Cover the upper part of the lapel of the Judogi jacket to prevent the grip.	0	0	0	0		0	2	0	2	2
Don't know (video issue)	0	0	4	4		2	2	0	4	8
All attacks or blocking with one or two hands or with one or two arms below the belt in <i>Tachi-Waza</i> will be penalized by Hansokumake.	1	0	0	1		1	1	1	3	4
As result of 4 x Shido	0	0	1	1		1	1	4	6	7
Sum of all shido's in category	52	51	48	151		73	70	83	226	377
IJF data – taken from www.ippon.org and www.judobase.org	52	52	44	148		27	31	48	106	254

The follow categories for *Shido* were not seen in the three weight categories analysed in either 2010 or 2014

- To intentionally disarrange his own *Judogi* or to untie or retie the belt or the trousers without the Referee's permission.
- To hold the opponent's sleeve end(s) by folding it over ("Pocket" grip).
- To hug directly the opponent for a throw (Bear hug).
- To encircle the end of the belt or jacket around any part of the opponent's body.
- To take the *Judogi* in the mouth (either his own or his opponent's *Judogi*)
- To apply leg scissors to the opponent's trunk (*Dojime*), neck or head
- To bend back the opponent's finger(s) in order to break his grip
- Breaking the grip of the opponent with 2 hands
- To force the opponent with either one or both arms to take a bending position without immediate attack will be penalised by *Shido* for a blocking attitude

The following categories of *Hansoku-make* were also not observed during the analysis:

- To apply *Kawazu-gake*
- To apply *Kansetsu-waza* anywhere other than to the elbow joint
- To lift off the *Tatami* the opponent who is lying on the *Tatami* and to drive him back into the *Tatami*.
- To reap the opponents supporting leg from the inside when the opponent is applying a technique such as *Harai-goshi* etc.
- To disregard the Referee's instructions
- To make unnecessary calls, remarks or gestures derogatory to the opponent or Referee during the contest.
- To make any action this may endanger or injure the opponent especially the opponent's neck or spinal vertebrae, or may be against the spirit of judo
- To fall directly to the *Tatami* (mat) while applying or attempting to apply techniques such as *Ude-Hishigi-Waki-Gatame*.
- To "dive" head first, onto the *Tatami* by bending forward and downward while performing or attempting to perform techniques such as *Uchimata*, *Harai-goshi*, etc. or to fall directly backwards while performing or attempting a technique.
- To intentionally fall backwards when the other contestant is clinging to his back and when either contestant has control of the other's movement
- To wear a hard or metallic object (covered or not)

Only two categories for *Hansoku-make* were observed:

- All attacks or blocking with one or two hands or with one or two arms below the belt in *Tachi-Waza* will be penalised by *Hansoku-make*.
- As result of 4 x *Shido*

There were only seven instances where *Hansoku-make* was awarded for receiving four *Shido*'s. There were four different reasons for the seven occurrences of a 4th *Shido*:

3 x "In a standing position, before or after *Kumi-kata* has been established, not to make any attacking moves (passivity)"

2 x "To make an action designed to give the impression of an attack but which clearly shows that there was no intent to throw the opponent. (False attack)"

1 x "To adopt in a standing position, after *Kumi-kata*, an excessively defensive posture"

1 x "To go outside the contest area or intentionally force the opponent to go outside the contest area either in standing position or in *Ne-waza*"

In order to check the reliability of the data the results were compared to the International Judo Federation official statistics at www.judobase.org and www.ippon.org. Despite disclaimers about the possibility of inaccuracies the data on these websites are considered valid and reliable as it is taken directly from the scoreboards in the arena. The data for 2010 was similar to that shown on the official websites (see Table 7.8) given the volume of data and possible operator error within either system. However, the data for 2014 was clearly different (see Table 7.8) with 27 *Shido*'s presented by the International Judo Federation and 73 *Shido*'s presented in this work. There is also a discrepancy with *Hansoku-make*, this work showing 9 and the IJF showing 1. Further investigation suggests the IJF data is not recording the penalties award to the *Judoka* in blue for that particular event.

Discussion on penalties

Analysing penalties in judo is relatively simple in comparison to analysing other aspects such as techniques, tactics and *Kumi-kata* because the referee gives a signal that allows the observer to understand what the *Shido* or *Hansoku-make* was awarded for. However,

complication do arise, such as not being able to view the referee very well on the video, and penalties being changed or “waved off”.

To our knowledge this is the first research that has broken down *Shido*’s and *Hansoku-make*’s by category so that it can be observed which is more prolific. This has generated four themes for discussion which will be discussed in turn:

- The abundance of some category of *Shido*
- The non-use of certain category of *Shido*
- The use of *Hansoku-make*
- The inaccuracies of the IJF databases

Prevailing shido’s

The highest number of *Shido*’s awarded from one classification was for “passivity” with 156 awarded across all categories and both years. There was an even split between weights and years. Given the rule changes were designed to make judo more dynamic and better for spectators this is a worrying statistic. The IJF should consider why this is so prevalent, for example is it easy to force a passivity penalty on an opponent? Is it because without “two handed grip breaking” athletes cannot move into a more offensive position once a grip has been established? Is it as prolific across all weight categories or just lightweight women?

It is clear that there is a “next category” of *Shido in terms of prevalence*. To intentionally avoid gripping up in *Kumi-kata*, to be overly defensive, to step out of the area and false attacks all had a similar frequency. It could be argued that all of these *Shido*’s and passivity are related to an inability to attack, probably through superior *Kumi-kata*. The IJF rules to date favour the *Judoka* with the dominant *Kumi-kata*, if *Judoka A* is outgripped and cannot remove the grip with one hand (this potentially already presents a bias) then she has limited options. She could try to work into a more favourable position but this takes time and there is likely to be a penalty for passivity, she could wait for player B to attack and counter but this is risky because they may not attack and because if they do they have dominant grip, she could step out of the area, she could present a defensive posture and or she could attack and hope “it is good enough” to not warrant a false attack. On the other hand, *Judoka B*, with the dominant grip either waits for the correct time to attack, sets up the attack or waits for *Judoka A* to “make a mistake”. In essence, if you win the *Kumi-kata* the rules are in your favour. This is essentially what is described by Adam *et al.*, (2013) where the Russian team received far less penalties than

their opponents. They do not go on to describe in detail the reason for this but the Russians are renowned for strong and unorthodox *Kumi-kata* (Iatskevitch, 1999; Adams, 1992).

To change this bias would be difficult, for example giving the player with the more dominant grip less time than the player out gripped would be difficult to referee. One option is the return of two handed grip breaking, another might be the removal of the *Shido* for “intentionally avoiding the grip” as this would allow athletes to engage more cautiously.

Shido's not observed in this study

There are a large number of *Shido*'s not used at all in either 2010 or 2014. This would need to be checked against all weight categories and a larger number of competitions before it can be suggested that changes should be made. In contrast to the infringements cited above the *Shido*'s not used were often from gripping infringements, taking the *Judogi* in the mouth and some dangerous techniques. This is not surprising as infringements of this type should not happen at an elite level.

The use of Hansoku-make

Hansoku-make not seen included going on the mat with a metallic object, spine locks, being rude to the referee, against the spirit of judo. It is justified to say that these rules are in place for the safety of the athletes involved and as these rules are fixed across all ages and abilities it is likely some of these rules would be seen at a lower performance level.

Inaccuracies of the IJF databases

To ensure the reliability of the data in this study there were three reliability checks in place for this data. The “top layer” of coding had an intra-operator reliability test for the one operator that coded all three weight categories across both year groups. The results of the Cronbach's Alpha test were 0.975 (very reliable) and a Cohen's Kappa score of 0.40 (fair – good). This level was about coding all the *Shido*'s awarded. This was then reconfirmed by checking the data against the IJF databases on www.judobase.org and www.ippon.org.

The third reliability was in the “2nd layer of coding” where all the *Shido*'s were analysed and put into the category. This was completed by the lead researcher and then reassessed by three *Judoka* all of 1st Dan or above.

An issue occurred with the second reliability test against the IJF database where they cited far fewer *Shido*'s than that recorded in this study for the 2014 World Championships. The IJF data is recorded directly from the IJF scoreboard and therefore initial assumptions were that the data from this study was incorrect but once re-checked it was not. This was a large error, for example in the under 48kg for 2014 the IJF had recorded 27 *Shido*'s and this research 73 *Shido*'s. Eventually it was noted that the IJF data was not recording the penalties for the competitor wearing a blue *Judogi*. This discovery has a potentially huge impact for three main reasons:

1. Various studies (published, peer reviewed) have used this data
2. The IJF have published a number of press articles about the positive changes their new rules have had on the sport
3. Subsequent rule changes were more than likely based upon the successes of these rule changes

The current IJF data suggests that the number of *Shido*'s has decreases from 148 - 106 with the rule changes when comparing 2010 World Championships to the 2014 World Championships. However, in reality they increased from 151 - 256, approximately a 65% increase. It is not clear how many competitions are affected or if the 2014 World Championships is the only competiion affected. Collaboraitons between the IJF and researchers may alleviate these issues.

Limitations and future research

This work is limited to lightweight women and is conducted on a previous set of rules, as a matter of urgency researchers should consider this area so that future rule changes can be based upon peer reviewed, objective and reliable data. Data should be collected over a whole Olympic qualification period and compared to previous Olympic cycles where possible.

Conclusions of penalties

Overall there seems to be a larger number of penalties awarded for passivity and 'negative judo'. For example, 46 *Shido*'s awarded for 'stepping out of the area' yet not one for 'pushing out of the area'. An 'overly defensive posture' was penalised 36 times yet not one penalty for 'forcing the opponent to into a bending position'. Considerations should be made as to how rules can be applied to ensure the original philosophies presented by Kano are present in the sportified version of judo.

Chapter 8: Conclusions, Implications and Recommendations

Chapter 8: Conclusions, Implications and Recommendations

Research context and questions

As a sport judo has fourteen weight categories, seven men and seven women. Whilst the literature review above has identified a growing body of research into this combat sport, there is little that focusses solely on women in particular. With seven Olympic medals available from women's judo, and Great Britain investing over £5m per Olympic medal, it can be justified to consider them separately.

The aims of this research were threefold:

1. To develop an understanding of the technical demands of lightweight women's judo
2. To develop an understanding of the tactical demands of lightweight women's judo
3. To develop an understanding of the temporal components of lightweight women's judo

The work has been split into two sections that analyses the three aims above under the 2010-2013 rules and the 2014-2016 rules in order to establish if the rule changes have also affect women's judo.

Findings from the literature

Authors have confirmed *Te-waza* as either the most dominant or second most dominant category of techniques in international judo (Sterkowicz, 1998; Franchini and Sterkowicz, 2000; Boguszewski, 2010 and 2011; Sertic, Segedi and Vucak, 2009a & 2009b; Witkowski *et al.*, 2012 and Adam *et al.*, 2012), including studies that considered lightweight women (Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; and Boguszewski, 2010). The issue with this is that 5/15 *Te-waza* techniques require the attacker to grasp the leg and would therefore now lead to a *Hansoku-make* (Direct disqualification).

Various authors have considered techniques based upon weight category and found technical differences between weight category and some between gender as well as weight category (Franchini and Sterkowicz, 2000; Franchini and Sterkowicz, 2003; Sertic, Segedi and Sterkowicz, 2007; Kruszewski *et al.*, 2008; Carratala, Garcia and Fernandez, 2009;

Boguszewski, 2010; and Witkowski *et al.*, 2012). Few of these have considered females only and no research to date appears to have focussed upon differences in time-motion data or focussed solely on *Ne-waza* differences.

According to the literature (see Table 6.11) the most commonly seen techniques in judo, across gender, age and weight categories are *Uchimata*, *Seoi-nage*, *O-uchi-gari*, and *Ippon-seoi-nage*. In terms of efficiency the top 5 are *Uchimata*, *Seoi-nage*, *Tai-otoshi*, *Tani-otoshi* and *Ko-soto-gari*.

Empirical findings

Findings are presented in relation to time-motion analysis, technical analysis and tactical analysis.

Time-motion analysis

The vast majority of time-motion data agrees with data previously presented and supports the notions of 10-12 work blocks within a contest that have an average duration of 20.9 seconds (± 10.9) for 2010. However, following the rule changes of 2013 there appears to be less work blocks (8.3 ± 4.4) of a slightly longer duration (23.6 seconds, ± 13.2). Work to rest ratios change from 3:1 to 2:1. The following points can be considered 'new knowledge' in this area:

- Contest time has shortened by 43 seconds based on the rules changing women's contest time from 5 minutes to 4 minutes
- There is a significant increase ($P < 0.05$) in *Hajime* to *Matte* (work) time and this can be attributed to more time spent in *Tachi-waza* (standing work). The reasons for this are not clear but it can be speculated that it is due to athletes being more tentative around lead grip or attacking due to the new gripping rules
- There is noticeably more fatigue shown when comparing the first four blocks and last four blocks of a contest in 2014 than in 2010. This is counterintuitive as contest duration is shorter but maybe related to the longer duration of *Tach-waza*.
- Fatigue is clear with the 2014 data for *Hajime* to *Matte* time and *Tachi-waza* with the first four work blocks being significantly longer ($P < 0.05$) than the last four blocks. Time spent in *Ne-waza* does not change significantly with fatigue
- Time in *Ne-waza* in this study is approximately 1/3 of that presented in previous literature

There was also a large decrease in the number of contests that went into golden score, in the 2010 world championships there were 17 and in the 2014 world championships there was only 4. The reason for this is unknown although it maybe due to the increased number of *Hansoku-make* awarded, 2 and 9 respectively.

Technical analysis

In *Tachi-waza* there was a total of 2284 attacks of which 10.9% scored. The *Tachi-waza* analysis demonstrated a variety of 52 techniques and the most frequently seen techniques are similar to those reported in the literature – *Ippon-Seoi-nage*, *Uchimata*, *O-uchi-gari*, *Morote-seoi-nage* for example. An exception to this is the popularity of *Sode-tsurikomi-goshi* that appears both frequently and is efficient. This technique appears to be prevalent within this population, coaches working with lightweight female *Judoka* should be mindful of developing these techniques and strategies to avoid or block them. The top three techniques were the same in both world championships and presented in the same order suggesting the rules have not affected these, therefore coaches should focus attention on *Ippon-seoi-nage*, *Uchimata* and *Sode-tsurikomi-goshi*.

Previous literature presented *Te-waza* as either the most dominant category of throwing techniques or the second most dominant. With the new rules removing 5 out of the 15 *Te-waza* techniques this research considered if this was the case in modern lightweight women's judo. In this research *Ashi-waza* was by far the most dominant category of throws, it is not yet known whether this is across all weight categories because of the rule changes or if this is specific to this group. Figure 8.1 summarises the data on *Tachi-waza* including frequency of techniques, efficiency of techniques and category.

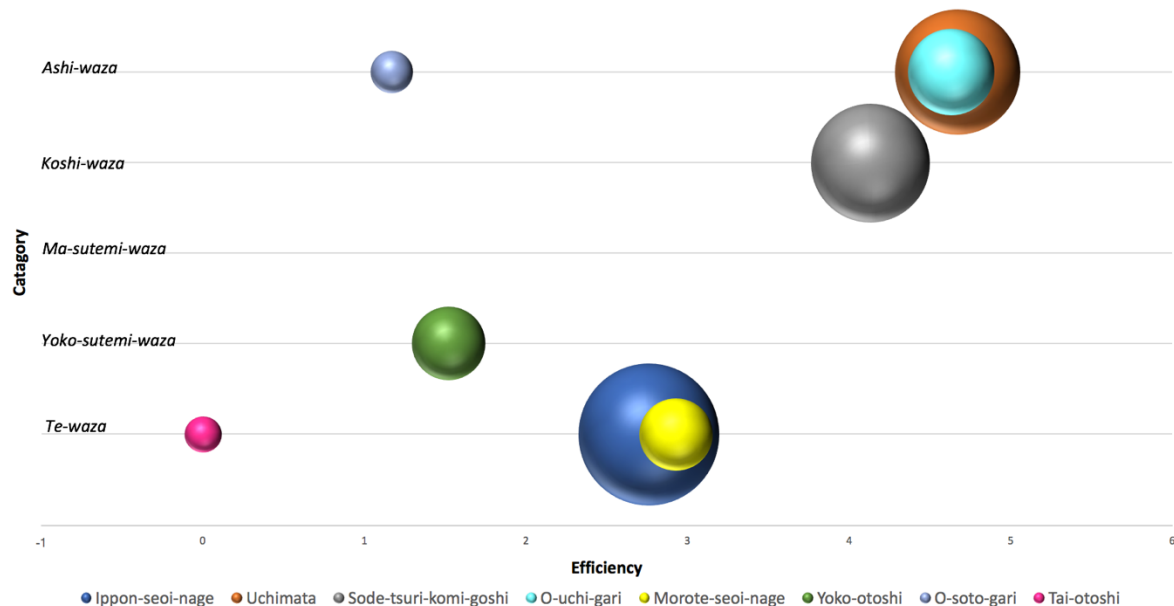


Figure 8.1: Technique efficiency, frequency and category based upon the results of this study. The further right a bubble is the more efficient it was and the larger the bubble more frequent it was.

In *Ne-waza*, *Osaekomi-waza* continues to lead as the most frequently used category with 46 scoring attempts compared to 9 and 7 for *Kansetsu-waza* and *Shime-waza*. *Mune-gatame* being the most prolific and efficient of the *Osaekomi-waza*, it was seen more than 3 times more than the second most seen technique, *Kuzure-kesa-gatame*. There appears to be a lack of variety in the *Kansetsu-waza* and *Shime-waza* when compared to the *Osaekomi-waza*.

Tactical analysis

Tactical analysis is complicated in nature, this research considered six directions of attack and concluded lightweight women have the same preference for forward techniques previously described in the literature. Laterality was presented as *Ai-yotsu* and *Kenka-yotsu*. Previous research agreed that there was a preference for attacking in *Kenka-yotsu* and the 2010 analysis from this study agreed. The 2014 data however, shows a similar number of attacks in both grip configurations suggesting rule changes may have affected this. In *Ai-yotsu*, *Ippon-seoi-nage* and *Sode-tsuri-komi-goshi* were most common whilst in *Kenka-yotsu* it was *Uchimata* followed by *Ippon-seoi-nage*. *Ashi-waza* was the most common category of throws in both *Ai-yotsu* and *Kenka-yotsu*.

Handedness was defined as the direction an athlete turns in to attack. There appeared to be no preference here despite previous literature suggesting a left-handed dominance. It is not

known if this is specific to this population or because left-handed dominance is diminishing in general. The most common techniques presented by left-dominant athletes were *Ippon-seoi-nage* followed by *Sode-tsuri-komi-goshi*, the same as *Ai-yotsu* and for right-handed athletes it was jointly *Ippon-seoi-nage* and *Uchimata* at the top followed by *Sode-tsuri-komi-goshi*, similar to right-handed dominant players shown above.

In terms of combinations this study found a high frequency of direct attacks that was very inefficient. There was a low frequency of *Renraku-waza* and *Renzoku-waza* that was coupled with a relatively low efficiency, 1.02 and 0.38 respectively. *Kaeshi-waza* (counter attacks) also saw a low frequency but presented a very high efficiency of 4.56 (39.4% of all attempts scored). *Uchimata-sukashi* was the most prolific *Kaeshi-waza*.

When considering penalties, *Shido*'s were most commonly awarded for passivity. The next four most common *Shido*'s were also for perceived negative actions – intentionally avoiding grip, excessively defensive posture, false attack/pulling down into *Ne-waza* and going outside the contest area. Consideration should be made as to how penalties could contribute to the development of understanding the original philosophies of judo, particularly *Seiryoku-zenyo* (maximum efficiency) as well as managing the sportification of judo.

Overview of original contribution

Other research has considered lightweight women's judo as part of an analysis of all weight categories or as a comparison across genders. This work is the only research to data that has focussed solely on lightweight women's judo. To that end, much of the data presented in this work, whether supportive of previous literature or in contrast to it, provides original contribution to the field. The section above provides an overview of where this work contrasts to the work before.

In terms of original methodology, this work presents two concepts that have not been seen before in the literature. This is the first research that considers fatigue in high performance contests using performance analysis and the comparison of first and last work blocks of a contest. This analysis has worked well and should be considered as a method of analysis across all weight categories.

The analysis of penalties demonstrated in this work also appears to be a first. It breaks down both *Shido*'s and *Hansoku-make* into the offences committed. Doing this has presented an

understanding of what penalties are most often awarded for, it has also highlighted differences with the IJF databases.

Implications for practice

One of the key intentions for this research was to understand the differences between lightweight female *Judoka* as a specific population. Understanding the differences allows coaches and support staff to deliver specific training programmes for conditioning, technical development and tactical development. From this work, it can be concluded that strength and conditioning programmes need not differ greatly from other groups as the time-motion analysis data is similar to that reported previously although ratios of work to rest do differ slightly.

In terms of technical and tactical training, coaches should work on the techniques presented as efficient with their athletes and work on counters to those techniques with high frequency. Particular attention should be paid to *Kaeshi-waza* (counters) as this show a high efficiency, especially *Uchimata-sukashi*. Tactical preparations should consider the most common penalties awarded and focus on preventing athletes from receiving them but also on forcing them upon opponents. Penalties are considered very efficient.

A final consideration is one of time. Competition organisers plan the schedule for tournaments based upon predicted contest time. The natural assumption with the rule changes for women that shortens contests by one minute is to reduce predicted contest time by one minute. However, this research has shown that the actual contest time has only shortened by 43 seconds meaning there will be a potential for an error of 17 seconds per contest. Whilst this might not seem a lot, if we took day three of the world championships in 2014 there were 110 contests, that's over 31 minutes of error. Factor into this scheduling for television companies, issues with athletes warming up, issues around eating arrangements and transport, suddenly 17 seconds is a big deal! Further analysis would need to be conducted to determine if this is a similar issue across all weight categories.

Concluding thoughts

There are a large number of similarities between lightweight women and the general judo population, particularly in the time-motion characteristics. Technically however, there are slight nuances such as the frequency and efficiency of *Sode-tsurikomi-goshi*, the number of penalties for passivity and lack of variety in *Kansetsu-waza* and *Sime-waza*. It is not yet known if this is specific to this group as the literature suggests or if it is because of the recent rule changes and it is now seen across all weight categories and genders.

In order to summarise the work concisely Figure 8.2 has been created based upon the frequency of certain words throughout this thesis. The larger the word in the figure the more frequently it was used, much of the work seems to have focussed upon judo, technique, and efficiency. At the start of this work it was acknowledged that *“the research undertaken in this thesis is aimed at developing what Kano describes as the lowest level of judo. However, it is hoped that by disseminating this knowledge to a wider community, in an academic context, whilst focussing on a lesser developed area and aligning it to academic research in other sports, this work can be seen as a contribution to society.”* It is hoped that the highlighted themes in Figure 8.2, judo, technique and efficiency add to the understanding of judo in the context Kano originally envisaged.

Figure 8.2: Words used most often throughout the thesis. The larger the word the more frequently it was used. Source: www.wordle.net.

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Appendices

Appendices 1: Challis, D.G., Scruton, A., Cole, M. and Callan, M., 2015. A Time-Motion Analysis of Lightweight Women's Judo in the 2010 World Championships. International Journal of Sports Science and Coaching, 10(3).

[Article redacted due to copyright]

Available online at <http://dx.doi.org/10.1260/1747-9541.10.2-3.479>

Appendices 2: **Challis, D.G.**, 2013. *A Temporal Analysis of the u52kg Women's Judo in the 2010 World Championships*. 8th International Judo Federation World Judo Research Symposium, *Rio de Janeiro, Brazil*.



A Temporal Analysis of the u52kg Women's Judo in the 2010 World Championships

Abstract

Developing an understanding of the temporal components within a contest can assist coaches in developing training methodology that is time effective. This study aimed to develop an understanding of the temporal components in the under 52kg division.

Pre-recorded footage was coded into temporal sequences. The results showed that on average there were 10.3 temporal blocks (hajime-matte) per contest, this was divided into work to rest ratios and the contribution of tachi waza and ne waza to the work segments. Furthermore the average duration of the contest, including matte blocks was 5.03 minutes. Some of the results of this study concur with previous research.

Introduction

A major development in judo was the inclusion of women in the 1992 Barcelona Olympic games. Women had the same number of weight categories as men and therefore could produce the same number of medals.

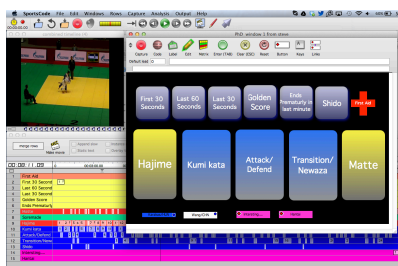
Contests for both men and women can be up to five minutes in duration and can include extra time (golden score) of an additional 3 minutes (this changed in 2013 but was the case during this research). Developing an understanding of the work to rest ratios and the contribution of different technical components within a contest can assist coaches in developing training methodology that is time effective. Whilst the components of a contest have been studied previously there is little research that focuses solely on women's judo and therefore this study aimed to develop an understanding of the under 52kg division at the 2010 world championships.

Method

Pre-recorded footage of the 47 fights contested in the 2010 world judo championships under 52kg division was coded using sportscodelite performance analysis software (Sportstec, Australia) into temporal sequences of hajime-matte blocks. These blocks were then subdivided into tachi waza (standing) and Ne Waza (groundwork).

A 'coding window' was developed by the researcher using sportscodelite software (Sportstec, Australia) on an imac desktop computer (Apple, US). Figure 1 shows an example of the coding window.

Figure 1: Screen shot of sportscodelite being used to analyse the u52kg weight group. On the right hand side is the coding window that was developed for this temporal analysis.



The kumi kata phase included lead grip and main grip and therefore started at hajime and ended on the first attack or matte. Newaza included the transitional phase from nage waza.

Post data collection the results of "average time" for each contest was analysed in a one way ANOVA.

Selected References

Marcon, G., Franchini, E., Jardim, J.R. and Barros Neto, T.L. (2010) Structural Analysis of Action and Time in Sports: Judo. *Journal of Quantitative Analysis in Sports*. 6: (4)

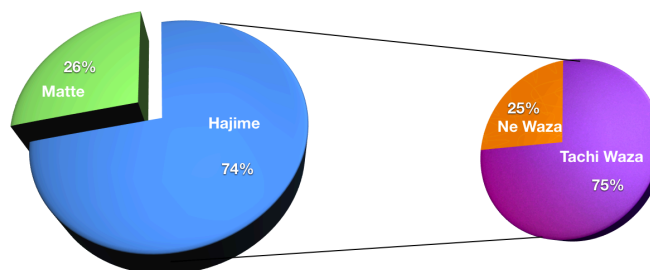
Sikorski, W. (2010). Identification of judo contest from physiological viewpoint. *Journal of Combat Sports and Martial Arts*. 2(2):115-118

Sterkowicz, S. (1999). Differences in the Specific Movement Activity of Men and Women Practising Judo. *Journal of Human Kinetics*. 1, 99-113.

Results

The results showed that on average there were 10.3 temporal blocks (hajime-matte) per contest. The average duration of this block was 23.1 seconds. The average duration of the contest, including matte blocks was 5.03 minutes which was split 74% work (hajime) and 26% rest (matte). The work blocks were further divided into divided into Tachi waza (standing) and ne waza (ground work) which were 75% and 25% of the work time respectively.

Figure 2: Chart showing total contest time divided in work (hajime) and rest (matte) with the percentage of hajime time spent in ne waza (ground work) and Tachi waza (standing work).



Discussion and Conclusion

The initial conclusion that there were 10.3 temporal segments per contest is slightly less than other authors who reported 11 segments (Casterenas and Planas, 1997; Sikorski et al. 1987) or 12 segments (Sterkowicz's, 1999).

At an average duration of 23.1s (± 6.5) the work segments are similar to the findings of Sterkowicz (1999) who suggested they were between 15-30s and Sikorski (1987 & 2010) who suggests mean segment time was no more than 25s.

This study suggests an average rest segment of 8.2s. (± 3.3 s). This fits within the boundaries of 5-10s suggested by Franchini et al. (2011) but is slightly shorter than the average 10s reported by Casterenas and Planas, (1997), Sikorski et al. (1987) and Sikorski (2010).

Figure 2 shows the work:rest ratio for the average contest as 3:1, this concurs with other researchers (Miarka et al., 2012; Franchini et al., 2011).

Studies of what occurs within each segment is limited. Of particular interest is the study by Marcon et al (2010), the authors considered four sections of the work segment as preparation, grip, technique & groundwork they also considered the recovery period (matte). This is similar to how this author views the structure of the contest as lead grip, main grip, attack/defend, transition, ne waza; although this was studied, for the purpose of this poster only tachi waza versus ne waza is presented. The 25% ne waza versus 75% tachi waza appears to agree with previous sources and could be useful for conditioning and metabolic training but first of all the true metabolic cost of tachi waza and ne waza must be understood.

In conclusion the duration of the work segments appears to agree with the published literature and is increasingly becoming established. A slightly lower frequency and duration of the rest segment could be indicative of a difference between lightweight women and other weight groups/genders but further research is needed to clarify. Further research should also consider the exact construct of the work segment.

Appendices 3: Challis, D.G., 2011. A Temporal Analysis of the u48kg Women's Judo in the 2010 World Championships. 7th International Judo Federation World Judo Research Symposium, Paris

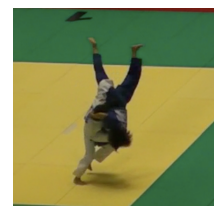


A Temporal Analysis of the u48kg Women's Judo in the 2010 World Championships

Abstract

Developing an understanding of the work to rest ratios and the contribution of different technical components within a contest can assist coaches in developing training methodology that is time effective. This study aimed to develop an understanding of the under 48kg division.

Pre-recorded footage was coded into temporal sequences. The results showed that on average there were 12.3 temporal blocks (hajime-matte) per contest, this was divided into kumi kata (32%), attack/defend (26%), transition/newaza (19%) and matte (23%) of the contest. Furthermore the average duration of the contest, including matte blocks was 5.53 minutes. Some of the results of this study concur with previous research.



Introduction

In 1964 judo became an Olympic sport for men and although it was not included in the following Olympics it has been since 1972. A major development in judo was the inclusion of women in the 1992 Barcelona Olympic games. Women had the same number of weight categories as men and therefore could yield the same number of medals. They had been included in the 1988 Seoul Olympic games as a demonstration event.

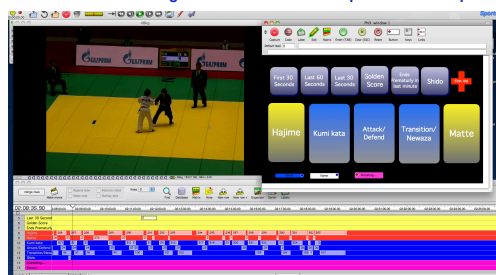
Contests for both men and women can be up to five minutes in duration and can include extra time (golden score) of an additional 3 minutes. Developing an understanding of the work to rest ratios and the contribution of different technical components within a contest can assist coaches in developing training methodology that is time effective. Whilst the components of a contest have been studied previously there is little research that focuses solely on women's judo and therefore this study aimed to develop an understanding of the under 48kg division.

Method

Pre-recorded footage of the 48 fights contested in the 2010 world judo championships under 48kg division was coded using sportscode elite performance analysis software (Sportstec, Australia) into temporal sequences of hajime-matte blocks. These blocks were then subdivided into kumi kata (Gripping), attacking/defending and ne waza (groundwork).

A 'coding window' was developed by the researcher using sportscode Elite software (Sportstec, Australia) on an imac desktop computer (Apple, US). Figure 1 shows an example of the coding window.

Figure 1: Screen shot of sportscode being used to analyse the u48kg weight group. On the right hand side is the coding window that was developed for this temporal analysis.



The kumi kata phase included lead grip and main grip and therefore started at hajime and ended on the first attack or matte. Newaza included the transitional phase from ne waza.

Selected References

Marcon, G., Franchini, E., Jardim, J.R. and Barros Neto, T.L. (2010) Structural Analysis of Action and Time in Sports: Judo. *Journal of Quantitative Analysis in Sports*. 6: (4)

Sikorski, W. (2010). Identification of judo contest from physiological viewpoint. *Journal of Combat Sports and Martial Arts*. 2(2):1 115-118

Sterkowicz, S. (1999). Differences in the Specific Movement Activity of Men and Women Practising Judo. *Journal of Human Kinetics*. 1, 99-113.

Results

The results showed that on average there were 12.3 temporal blocks (hajime-matte) per contest. The average duration of this block was 28.7 seconds. These were divided into kumi kata (32%), attack/defend (26%), transition/newaza (19%) and matte (23%) of the contest. Furthermore the average duration of the contest, including matte blocks was 5.53 minutes.

Figure 2: Chart showing the breakdown of a hajime-matte block

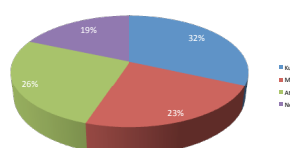
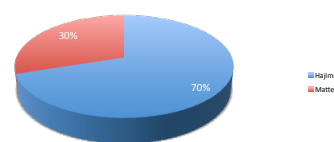


Figure 3: Percentage of time in Hajime (work) and Matte (recovery)



Discussion and Conclusion

The initial conclusion that there were 12.3 temporal segments per contest concurs with the conclusions of other authors such as Sterkowicz (1999) and Marcon et al (2010) who suggested 12 and 11 segments respectively. The duration of the segments is similar to the finding of Sterkowicz (1999) who suggested they were between 15-30s. However, Sikorski (1987 & 2010) suggests mean segment time was no more than 25s.

Studies of what occurs within each segment is limited. Of particular interest is the study by Marcon et al (2010), the authors considered four sections of the work segment as preparation, grip, technique & groundwork they also considered the recovery period (matte). This is similar to how this author views the structure of the contest as lead grip, main grip, attack/defend/counter, transition, ne waza; although for the purpose of this study lead grip and main grip were combined as were transition and ne waza. Marcon et al suggested that preparation was 12.6%, grip was 51.3%, technique was 4%, ne waza was 14.3% and matte was 18% of a segment. As this study combined preparation and grip into 'kumi kata' the studies show vastly different results with this study suggesting 32% and Marcon et al suggesting 63.9% of each segment. It is unknown why this discrepancy is so large but could possibly be due to how the authors defined this section or possibly that the u48kg spend much less time in kumi kata.

The only other known study of time spent in kumi kata, attacking/defending and ne waza is that of Boguszewski & Boguszewska (2006) who broke down the structure of the contest from a time perspective but used 10s segments and therefore the data is not comparable. Of particular note Sterkowicz (1999) compared male and female competitors in the 1996 Olympic games. Whilst this data is useful it should be used with caution as since these games there has been a number of changes to the rules and contest duration, including females contest time increasing to 5mins from 4mins and the introduction of golden score.

Figure 3 shows the work:rest ratio for the average contest as 7:3, this information could be used for programming and future research could focus on whether these ratios differ by gender and by weight group.

In conclusion the duration and number of segments appears to agree with the published literature and is increasingly becoming established. Whilst further research could be conducted comparing gender and weight category possibly a more pressing issue is the exact construct of these segments and how they differ between gender and weight group.