Impact of match performance on countermovement jumps when analysing post-match recovery status in elite soccer players.

Principle Researcher: Jeremy Poulson

First Supervisor: Mark Waldron

Second Supervisor: Stephen Patterson

18th June 2017

This Research Project is submitted as partial fulfilment of the requirements for the degree of Master of Science, St Mary's University

Table of Contents

List Of Figures 3

List of Tables 4

Acknowledgments 5

Abstract 6

CHAPTER 1

Introduction 7

CHAPTER 2

Methods 11

- Participants and Design 11
- Movement Analysis 12
- Countermovement Jump 14
- Participants Ratings 15
- Statistical Analysis 16

CHAPTER 3

Results 17

CHAPTER 4

Discussion 29

References 37

Appendices

- Appendix 1 - Ethics Application 42
- Appendix 2 - Risk Assessment 54
- Appendix 3 - Information Sheet and Consent Form 57
- Appendix 4 - Physical Activity and Readiness Questionnaire 59
- Appendix 5 - Letter of Consent from Organisation 60
- Appendix 6 - Ethical Approval 61

List Of Figures

Figure 1. CMJ variables, comparing pre-match test and the four proceeding jump tests, assessing both legs used in the CMJ. 18

Figure 2. CMJ variables, comparing pre-match test and the four proceeding jump tests, analysing independent legs used in the CMJ with the dominant and non-dominant kicking leg compared individually. 21

Figure 3. (a) Jump Height, (b) Peak Power (Both Legs), (c) Peak Power (Dominant Leg) and (d) Peak Power (Non-Dominant Leg). The deficit in CMJ performance from pre-match to 24 hours post-match, with the match performance variables. 23-27

Figure 4. Predicting the deficit in jump height for pre-match to 24 hours post-match. 28

List of Tables

Table 1. Participant Characteristics 12

Table 2. Subjective Data 19

Acknowledgments

I would firstly like to thank my fiancé, Jessica, who has always been there when I have needed her to help me through my degree. With the completion of the degree, I will be making sure that I can dedicate my time to her and we can plan our future together with our forthcoming wedding. Also my parents, Edwina and Richard, have helped support me both financially with the payment instalments, as well as all the time that have devoted with my upbringing that has got me to where I am now. Not forgetting my brother Robin, that I can now spend more time with him playing FIFA on the Xbox.

A huge thank you to both of my supervisors, Mark Waldron and Stephen Patterson, who have devoted hours of the working time to read through my work and provide knowledgeable feedback and advice to my work. I would like to thank Mark for the prompt reply's on email and allocating time in the day to speak with me via skype and call meetings to help guide me through my thesis, helping me so much which I appreciate greatly.

Lastly I would like to thank Sheffield Wednesday Football Club for funding my Master's degree on my completion of the degree. Also the players that participated in my study from the Under 23's squad, including the first team players that were involved in these matches. Also to the Sheffield Wednesday FC staff for allowing me the time and opportunity to work with the players, as well as the assistance provided from the staff throughout the study.

Abstract

The aim of the study was to assess what relationship effects match performance measures had on countermovement jump (CMJ) and monitoring the recovery status by comparing pre-match baseline values to post-match and proceeding three consecutive days. Seven Under 23 Professional League matches were analysed using 10 Hz Global Positioning Systems (GPS), with players performing three countermovement jumps (CMJ) pre-match, post-match and 24, 48 and 72 hours post-match on two 1,000 Hz portable force platforms, whilst providing subjective physical ratings. Jump height decreased from pre-match (0.32 ± 0.05 m) to 24 hours post-match (0.27 ± 0.05 m) (*P* = 0.001; ES = 0.47; CI = 0.04, 0.07 m). Differences found in individual leg CMJ performance was peak power of the non-dominant leg decreased from pre-match (1769.5 ± 668.8 W) to 24 hours post-match (1511.8 ± 729.4 W) (*P* = 0.043; ES = 0.18; CI = 8.8, 506.6 W). The jump height deficit for both legs was lowest at 24 hours post-match, having a relationship with match performance variables; metabolic power band one total duration and high IMA change of direction left (Adjusted R^2 = .18, SEE = 0.37, $p < 0.05$). The results showed the match related movements performed at a low velocity, whilst still at a high-intensity which reduced CMJ post-match with the greatest difference occurring 24 hours post-match. Reductions in CMJ suggested muscle fatigue was limiting this, the nature of fatigue was not explained fully by match performance variables monitored. Findings suggest other measurements of fatigue are required to explain the relationship with match performance. Findings help practitioners utilise CMJ height as a marker of fatigue and recovery status, consequently prevent injury.

Key Words: Soccer; match performance; stretch-shortening cycle; countermovement jump; fatigue.

CHAPTER 1

Introduction

The stretch-shortening cycle (SSC) is an important component of a professional soccer player's performance. This is required in order to perform repeated intense actions and movements on a frequent basis during competitive matches. These fast and intense movements, include sprinting, jumping, kicking and turning which all require high power over a short time period (Aagaard, 2003). Regularity of matches, can be frequent (2 - 3 matches per week) or irregular (7 or more days gap between matches), with a review by Waldron & Highton (2014) suggesting pacing strategies are employed by players to manage energy resources to optimise match-running performance for the given situation. Therefore, planning of the training mesocycles between matches where there is little time to prepare and recover is crucial. Players performing in matches can reach a level of fatigue that increases over the duration of the match, impacting physical performance (Mohr, Krustrup & Bangsbo, 2003). Recovery strategies employed to overcome fatigue are crucial in preparation for the next match. Subsequent to the match, management of training load has to be monitored closely, preventing players being exposed to high load, which impacts the neuromuscular and perceptual recovery (McLean, Coutts, Kelly, McGuigan & Cormack, 2010). If a player returns to high-intensity training too soon post-match and the appropriate methods of recovery are not adhered to, the player will suffer from overreaching and the risk of sustaining an injury is increased (Hagglund, Walden & Ekstrand, 2013).

Assessment of the activity profile of elite soccer players and the various positional demands have been undertaken (Bradley et al., 2009). The physical capabilities of payers playing comparing between the competitive divisions of elite soccer (Bradley et al., 2013). Studies have reported high-intensity actions are seen as crucial indictors of performance in matches (Andersson, Randers, Heiner-Moller, Krustrup & Mohr 2010; Carling, Le Gall & Dupont, 2012). High-intensity running is reduced during different periods of a match, with high-intensity activity being affected by the presence of fatigue (Bradley, Di Mascio, Peart, Olsen & Sheldon, 2010). Oliver, Armstrong and Williams (2008) found the effect that soccer-specific exercise has on the SSC during jump performance. The study concluded the reduction in jump performance was factored by fatigue, which was from intense match-play periods involving jumping and sprinting, which are seen as crucial moments specific to soccer. Jakobsen et al. (2012) investigated the effects of strength training, recreational soccer and running exercises on CMJ. Heavy-resistance strength training on untrained males led a quicker take-off phase and greater power production, suggesting the SSC had adapted positively. Whereas, the steady state running and recreational soccer demonstrated no effects on CMJ.

The energetics of movement in soccer performance is classed as the energy required above the resting level to transport the player's body over one unit distance (Di Prampero et al, 1993). Early studies have been conducted more than 40 years ago (Reilly & Thomas, 1976), with studies proceeding using small sample sizes (Rienzi, Drust, Rielly, Carter & Martin, 2000; Strudwick & Reilly, 2001). The assessment of competitive soccer match performance through video automated tracking systems, was used to measure running distances over different speed thresholds (Di Salvo, Gregson, Atkinson, Tordoff & Drust, 2009). Technology advancements have allowed global positioning tracking systems (GPS) to provide greater detail on match physical performance as well as more reliable and valid measurements (Harley, Lovell, Barnes, Portas & Weston, 2011). The GPS provides measurements through the accelerometer and gyroscope to calculate movement and accelerations, the energy cost and metabolic power values are calculated using an algorithm taken from Osgnach, Poser, Bernardini, Rinaldo and

Di Prampero (2010) theoretical model. As this technological advancement has helped to analyse performance in greater detail, metabolic load accumulates throughout the whole match with intensity fluctuating throughout and the subsequent five minutes following the peak period affected all physical variables (Fox, Patterson & Waldron, 2017). Intense actions over a smaller distance are also measured through this method, as this still has an impact in fatigue accumulation (Osgnach et al., 2010; Hewitt, Cronin, Button & Hume, 2011).

The actions performed in soccer matches are not always symmetrical due to the nature of the movements required in soccer performance, the most common skill related action being the kicking of the ball. Other aspects of movement such as change of direction, applying more force through one side of the body and the overall load will be different for each lower limb (Wong, Chamari, Chaouachi, Wisloff & Hong, 2007). Maly, Zahalka, and Mala (2014) suggest that the strength and power movements found in a game accumulate in both lower limbs, which occurs in an asymmetrical manner. This study found over 50% of players have one lower limb strength asymmetry, with muscle strength differing in the knee flexor and extensor muscle strength. A link was not made between the cause and amount of fatigue that accumulated in each leg to create the asymmetry. Asymmetry has only been researched in isolation, with recruitment of soccer players with no causal effect from soccer training or matches. Therefore, asymmetry in legs could be affected by the match physical performance and the amount of fatigue induced in each leg could have an association with injury risk (Croisner, Ganteaume & Ferret, 2005). Studies showing players that participate in soccer have asymmetries in muscle strength, but this might be a sports conditioned effect because of the dominant kicking foot, therefore, warranting further investigation (Fousekis, Tsepis & Vagenas, 2010; Sannicandro, Rosa, De Pascalis & Piccino, 2012). Fousekis, Tsepis and Vagenas (2010) found concentric strength asymmetries was greater at the knee flexor and extensor at 60°/s and ankle plantar flexor at 180°/s with the longer the professional training age balances the differences out.

The above studies help explain the rationale for this study as previous literature has primarily focused on strength and soccer training effects on jump performance (Oliver et al, 2008; Jakobsen et al, 2012), with only one study focusing on youth soccer (Thomas et al, 2009). It is evident that there is a research gap to quantify what the effects are from professional competitive soccer matches on the post-match recovery of jump performance. It is important to investigate the effects that fatigue has on the jump performance on the days following the competitive match, to help provide an understanding as to how long the effects of fatigue are still impairing jump performance. In addition, it is also important to determine the difference of the level of fatigue between the dominant and non-dominant leg, as the intense and repeated actions may be determined by the soccer specific kicking actions found more in the dominant leg. The findings can help adjust the content of training, based on recovery status of each individual player and make more informed decisions in the preparation for the next fixture. Therefore, players will be given better recovery which in turn will lower the injury risk in individuals. The aims of the study was to measure the extent of the decrease of jump performance post-match and what the duration was to recover to baseline values. The study used daily measurements to evaluate the differences between both legs individually and together, to analyse how long each leg took to return to baseline force values. It was hypothesised that the match performance measures that required the most high-intensity actions had the greatest effect on jump performance and the dominant leg showed a greater decrease in jump performance.

CHAPTER 2

Methods

Participants and Design

The participants (Table 1) were all players (n = 16) from the same professional soccer team competing in the Professional Under 23 Development League 2. Competitive matches (n = 7) were analysed, whilst CMJ performance was assessed pre-match and post-match, along with 24, 48 and 72 hours post-match measurements of CMJ and subjective ratings. Throughout the study period, the same coaches were responsible for team selection. Goalkeepers were excluded in this study as well as participants who played less than 75 minutes or participants that sustained an injury impairing their jump test performance. These were also excluded from the analysis. Participants were requested not to intake any caffeine on days of testing and not adopt any different recovery treatments (cold bath, massage, compression garments) throughout the post-match data collection period, which may have affected their recovery. The St Mary's University School of Sport, Health and Applied Science Ethics Sub-Committee gave ethical approval for the study and written informed consent was obtained from the participants. The participants typically undertook four training sessions per week consisting of field-based conditioning, technical and tactical training and gym-based resistance training, along with one competitive match per week. The weekly training volume typically consists of 240 minutes, with GPS measurements of 1,790 player load, 18,100 m total distance and 780 m high-intensity distance.

Table 1. Participant characteristics represented as the mean and standard deviation for the study group (n=16).

	Participants
	n = 16
Age (y)	19.8 ± 3.8
Stature (cm)	180.7 ± 8.7
Body mass (kg)	74.0 ± 4.9
20m sprint (sec)	3.0 ± 0.1
Arrowhead agility (sec)	16.0 ± 0.9
YYIRTL2	25.0 ± 3.7
CMJ (cm)	58.5 ± 6.7

Over the January to March period of the season, a total of 52 performances were analysed, across seven matches. Mean matches were 3.3 ± 1.8 for each participant. Of the seven matches analysed, five were home (*n = 36)* and two were away (*n* = 16), with four won (*n* = 31), one draw (*n* = 7) and two were lost (*n* = 14). The right (*n* = 38) and left (*n* = 14) leg were the participants dominant kicking leg.

Movement Analysis

Movement analysis of match performance was conducted using GPS devices (MinimaxX S4, Catapult Innovations, Canberra, Australia) with a 10 Hz sampling frequency. Participants wore a GPS vest that was the correct size for comfort and ensuring the GPS device was located in the middle of the upper back, tilting slightly forward. The GPS device was switched on 30 minutes prior to the warm-up, allowing the GPS device to link up with satellites as instructed in the manufacturer's guidelines. The GPS device was inserted into the vest of the participant when initiating the warm up. After the match, data was recorded onto the GPS device, the participants raw data file was downloaded and transferred onto a computer to commence analysis using the Openfield 1.12.2 software package (Catapult Innovations, Canberra, Australia). The GPS units were all synchronised in time with each, ensuring the start and end point of each half was the same for every player for accuracy.

The movement variables that were collated and accounted for within the analysis were: the total running, high-intensity and sprint distances (m); the maximum velocity (ms^{-1}); low, medium and high inertial movement analysis (IMA) accelerations and decelerations; IMA changes of direction for both right and left. Metabolic variables consisting of metabolic energy (J/kg), peak metabolic power (W/kg) and estimated distance index (EDI). Accelerations total distance and duration was assessed using eight zones: -20 - -3, -3 - -2, -2 - -1, -1 - 0, 0 - 1, 1 - 2, 2 - 3, 3 - 20 ms^{-1}. Metabolic power total distance and duration was also banded into five categories: 1 - 10, 10 - 20, 20 - 35, 35 - 55, 55 - 100 W/kg. Measuring accelerations and decelerations are important variables to identify the metabolic load on athletes. The contribution of energy exerted towards high-intensity actions in soccer is the metabolic power to be produced. The GPS analyses movement estimating energy costs the same way as the Osgnach et al. (2010) theoretical model. There are two important components to estimating energy cost; an inclined terrain and vertical orientation of an athlete is considered similar to constant speed up an ‘equivalent slope’, whereas, ‘equivalent mass’ is the additional force to overcome acceleration, found when sprinting, exerting greater force than body weight. Energy cost is calculated by multiplying equivalent slope with equivalent mass, as well as the grass environment constant of 1.29.The positions of players in matches was categorised as: centre back (CB), full back (FB), centre midfield (CM), wide midfield (WM) and attacker (A).

Countermovement Jump

CMJ performance was measured over five periods. The initial CMJ test was conducted on the day of the competitive match, with players performing the test before the match day warm up routine. Players that met the inclusion criteria (playing time and injury), were then required to perform the jump test again as the players return to the changing room, straight after the conclusion of the match. The participants were then required to perform the test for the next three consecutive days, which provided readings for 24, 48 and 72 hours post-match. The daily schedules of the participants were controlled due to their professional role. Time was allocated for the tests before their usual training sessions. Internal consistency reliability tests showed that the jump measurements throughout the study was 0.79 using Cronbach's alpha reliability test, being > 0.7, this shows the CMJ measurements were reliable to be used for statistical analysis.

Prior to the CMJ test commencing, players performed a standardised warm-up of 10 minutes at 100 W on a cycle ergometer. Players performed three CMJ on two portable force platforms (Pasco 2141, Roseville, California, USA) with the best jump recorded and this data being used for analysis. The force platforms sampled at 1,000 Hz. Both feet were placed on separate force plates for both the take-off and landing. Platforms were marked with kicking and non-kicking foot, so analysis could compare their dominant and non-dominant leg used when playing soccer in match performance. Players were instructed to jump explosively upwards immediately after descending to a self-selected depth keeping hands on the hips throughout the jump duration. The data was collected using the force plate software package (version 1.8.0, Pasco Capstone, California, USA).

For each of the five time points of the study, the participants performed three countermovement jumps trials, with the best performance based on jump height was used for analysis. Jump height (m) was calculated following:

$$\text{Jump Height (m)} = ut + ½\ at*2$$

The initial velocity (u) = 0, t was half of the flight time (s) as they only jump up for half of that time. The force plates produced two vertical force readings relating to the dominant and non-dominant leg. This allowed to calculate the value for each leg and to obtain a total amount for the following variables: the duration of the eccentric and concentric phase (seconds); the peak eccentric and concentric force (N); vertical velocity of centre of gravity at take-off (ms^{-1}) and peak power (W).

Participants Ratings

A seven point Likert Scale, adapted and validated by Impellizzeri and Maffiuletti (2007), was used to monitor each participant's quality of sleep, physical fatigue, muscle soreness and mental stress on a daily basis over the four day period of testing. The rate of perceived exertion of the match was rated on a scale from six (no exertion) to 20 (maximal exertion). The recovery from training and matches in preparation for the day's activity was rated using the total quality recovery (TQR) scale, again from six (not recovered at all) to 20 (completely recovered).

Statistical Analysis

Statistical analysis was performed using statistics software package (version 22.0, SPSS Inc, Chicago, USA). CMJ was initially analysed by comparing pre-match, post-match, 24, 48 and 72 hours post-match, expressed as means and standard deviations (SD). An one-way analysis of variance (ANOVA) with repeated measures was used to establish whether any subsequent post-match CMJ test results for both legs, dominant and non-dominant kicking legs, were significantly different from pre-match test results ($P > 0.05$). A secondary analysis of the jump height, peak power of both and independent legs was performed, assessing the CMJ deficit from pre-match to 24 hours post-match to the match performance variables, using Pearson's bivariate analysis. The significant variables found from the previous test performed, were entered into a step-wise multiple regression model to help explain the variance of the deficit of CMJ due to the actions undertaken in match performance. The effect sizes (ES) were measured by the calculated differences of the means and divided by the SD (Cohen 1992), whilst presented with lower and upper boundary's associated with the 95% confidence intervals (CI) (Cumming & Finch, 2001). ES were classified as: trivial < 0.2, small 0.2 - 0.5, medium 0.5 - 0.8 and large > 0.8 (Batterham & Hopkins, 2006).

CHAPTER 3

Results

The jump height decreased from pre-match (0.32 ± 0.05 m) to post-match (0.31 ± 0.03 m) ($F_{(1, 51)}$ = 2676.5, P = 0.001; ES = 0.22; CI = 0.01, 0.03 m); to 24 hours post-match (0.27 ± 0.05 m) (P = 0.001; ES = 0.47; CI = 0.04, 0.07 m) and 48 hours post-match (0.30 ± 0.05 m) (P = 0.001; ES = 0.22; CI = 0.01, 0.03 m). The flight duration was affected as jump height decreased from pre-match (0.51 ± 0.04 s) to post-match (0.50 ± 0.04 s) ($F_{(1, 51)}$ = 10617.8, P = 0.001; ES = 0.20; CI = 0.01, 0.02 s); to 24 hours post-match (0.47 ± 0.05 s) (P = 0.001; ES = 0.48; CI = 0.04, 0.06 s) and 48 hours post-match (0.50 ± 0.04 s) (P = 0.001; ES = 0.33; CI = 0.01, 0.03 s), due to the direct interaction with one another.

The comparison of time points, assessed both legs force production for the jumps, found that the duration of the eccentric phase was affected from pre-match (0.58 ± 0.32 s) to 72 hours post-match (0.45 ± 0.14 s) ($F_{(1, 51)}$ = 667.4, P = 0.015; ES = 0.54; CI = 0.03, 0.23 s), whilst the peak eccentric force production also decreased from pre-match (725.8 ± 104.5 N) to post-match (688.7 ± 91.4 N) ($F_{(1, 51)}$ = 5812.3, P = 0.023; ES = 0.19; CI = 5.4, 68.7 N) and to 24 hours post-match (660.7 ± 95.6 N) (P = 0.001; ES = 0.31; CI = 32.0, 98.1 N). The vertical velocity of the centre of gravity at take-off decreased from pre-match (2.46 ± 0.39 ms^{-1}) to 24 hours post-match (2.29 ± 0.33 ms^{-1}) ($F_{(1, 51)}$ = 6433.3, P = 0.048; ES = 0.22; CI = 0.03, 0.30 ms^{-1}) and 48 hours post-match (2.36 ± 0.35 ms^{-1}) (P = 0.001; ES = 0.14; CI = 0.01, 0.21 ms^{-1}). The peak power produced for the total jump decreased from pre-match (3179.4 ± 526.2 W) to 24 hours post-match (2974.1 ± 571.4 W) ($F_{(1, 51)}$ = 3391.5, P = 0.021; ES = 0.18; CI = 31.6, 379.0 W) and 48 hours post-match (3011.4 ± 526.1 W) (P = 0.042; ES = 0.16; CI = 5.9, 330.2 W) (Figure 1).

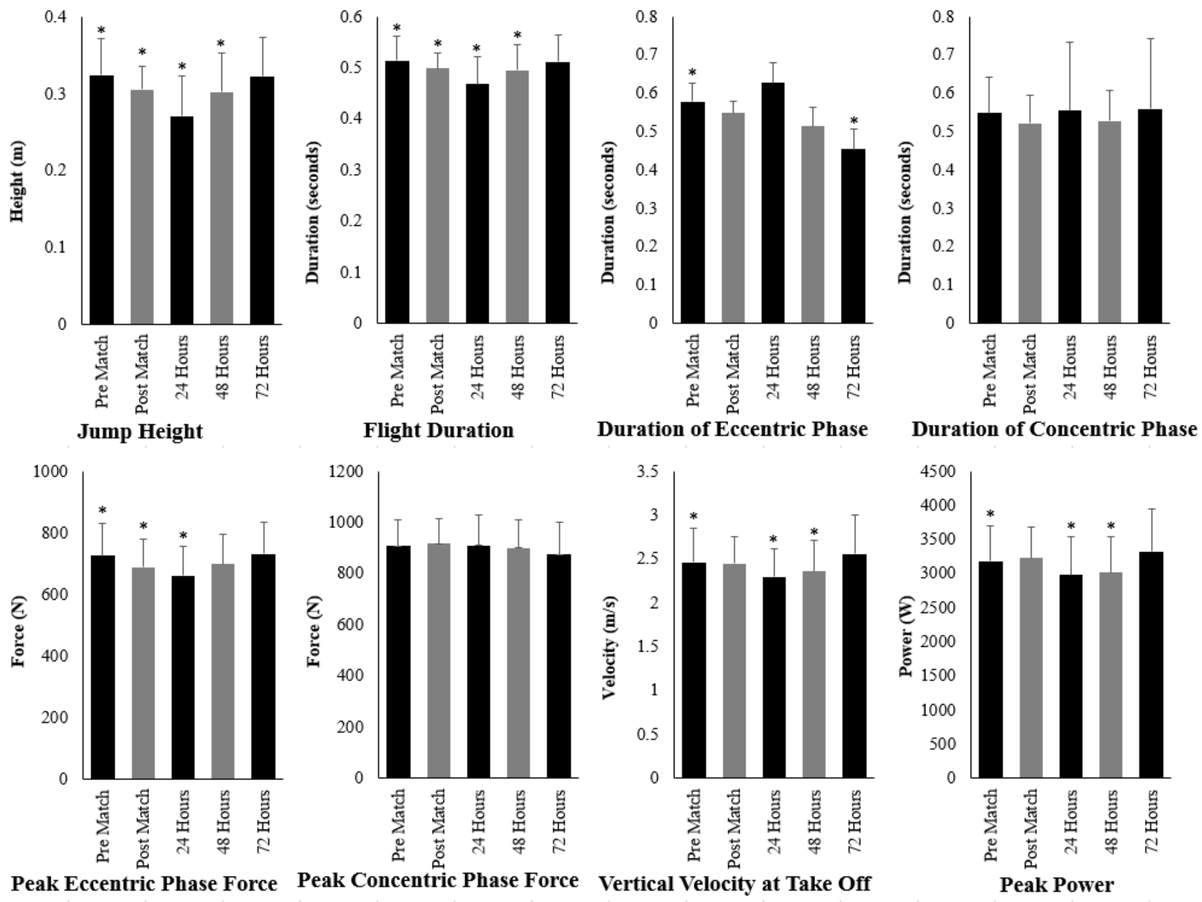


Figure 1. A one-way ANOVA Bonferroni post-hoc test focusing on CMJ variables, comparing pre-match test and the four proceeding jump tests, assessing both legs used in the CMJ, error bars represent 95% confidence interval. * Significant difference with the pre-match CMJ ($p < 0.05$).

The sleep quality of participants decreased from pre-match (5.3 ± 0.7) to 24 hours post-match (4.2 ± 1.2) ($F_{(1, 51)}$ = 2643.4, P = 0.001; ES = 0.50; CI = 0.7, 1.5), to 48 hours post-match (4.6 ± 1.2) (P = 0.001; ES = 0.32; CI = 0.3, 1.0) and to 72 hours post-match (4.8 ± 0.9) (P = 0.001; ES = 0.26; CI = 0.1, 0.8). This was the same case for: physical tiredness from pre-match (2.2 ± 0.7) to 24 hours post-match (5.1 ± 1.1) ($F_{(1, 51)}$ = 2871.9, P = 0.001; ES = -0.86; CI = -3.3, -2.6), to 48 hours post-match (4.3 ± 0.8) (P = 0.001; ES = -0.83; CI = -2.5, -1.9) and to 72 hours post-match (3.3 ± 1.1) (P = 0.001; ES = -0.56; CI = -1.5, -0.8); muscle soreness from pre-match (2.0 ± 0.6) to post-match (5.3 ± 1.0) ($F_{(1, 51)}$ = 1941.7, P = 0.001; ES = -0.90; CI = -3.6, -3.1), to 24 hours post-match (5.0 ± 1.1) (P = 0.001; ES = -0.86; CI = -3.3, -2.6), to 48 hours post-match (4.1 ± 1.3) (P = 0.001; ES = -0.72; CI = -2.5, -1.7) and to 72 hours post-match (3.3 ± 1.2) (P = 0.001; ES = -0.56; CI = -1.7, -0.9); mental tiredness from pre-match (1.3 ± 0.5) to 24 hours post-match (2.5 ± 1.1) ($F_{(1, 51)}$ = 562.3, P = 0.001; ES = -0.54; CI = -1.5, -0.8) and to 48 hours post-match (1.8 ± 1.0) (P = 0.001; ES = -0.29; CI = -0.7, -0.2) and the TQR rating from pre-match (17.2 ± 1.2) to 24 hours post-match (11.3 ± 2.1) ($F_{(1, 51)}$ = 9313.4, P = 0.001; ES = 0.87; CI = 5.4, 6.6), to 48 hours post-match (13.2 ± 1.6) (P = 0.001; ES = 0.82; CI = 3.5, 4.6) and to 72 hours post-match (14.8 ± 1.8) (P = 0.001; ES = 0.62; CI = 1.8, 3.1) (Table 2).

Table 2. Subjective Data

	Pre-Match	**Post-Match**	**24 Hours Post-Match**	**48 Hours Post-Match**	**72 Hours Post-Match**
Sleep Quality	5.3 ± 0.7*	-	4.2 ± 1.2*	4.6 ± 1.2*	4.8 ± 0.9*
Physical Tiredness	2.2 ± 0.7*	-	5.1 ± 1.1*	4.3 ± 0.8*	3.3 ± 1.1*
Muscle Soreness	2.0 ± 0.6*	5.3 ± 1.0*	5.0 ± 1.1*	4.1 ± 1.3*	3.3 ± 1.2*
Mental Tiredness	1.3 ± 0.5*	-	2.5 ± 1.1*	1.8 ± 1.0*	1.5 ± 0.8
TQR Rating	17.2 ± 1.2*	-	11.3 ± 2.1*	13.2 ± 1.6*	14.8 ± 1.8*
RPE	-	16.8 ± 1.6	-	-	-

The dominant leg was affected by the duration of the eccentric phase from pre-match (0.61 ± 0.42 s) to 72 hours post-match (0.46 ± 0.19 s) ($F_{(1, 51)}$ = 347.8, P = 0.024; ES = 0.21; CI = 0.02, 0.27 s); as well as the duration of concentric phase from pre-match (0.49 ± 0.23 s) to 48 hours post-match (0.49 ± 0.19 s) (P = 0.032; ES = -0.02; CI = 0.01, 0.11 s). The eccentric phase peak force was affected from pre-match (746.7 ± 167.0 N) to post-match (679.7 ± 171.8 N) ($F_{(1, 51)}$ = 2177.4, P = 0.033; ES = 0.19; CI = 5.6, 128.5 N), and to 24 hours post-match (632.7 ± 181.3 N) (P = 0.001; ES = 0.31; CI = 52.4, 175.6 N); the concentric phase peak force decreased from pre-match (903.2 ± 110.3 N) to 72 hours post-match (845.6 ± 180.1 N) ($F_{(1, 51)}$ = 3840.9, P = 0.026; ES = 0.19; CI = 7.3, 108.0 N). Whereas the non-dominant leg had decreased the vertical velocity of centre of gravity at take-off from pre-match (2.8 ± 1.1 ms^{-1}) to 24 hours post-match (2.3 ± 1.0 ms^{-1}) ($F_{(1, 51)}$ = 827.2, P = 0.013; ES = -0.23; CI = 0.1, 0.9 ms^{-1}); and the peak power of the non-dominant leg altered from pre-match (1769.5 ± 668.8 W) to 24 hours post-match (1511.8 ± 729.4 W) ($F_{(1, 51)}$ = 751.7, P = 0.043; ES = 0.18; CI = 8.8, 506.6 W) (Figure 2).

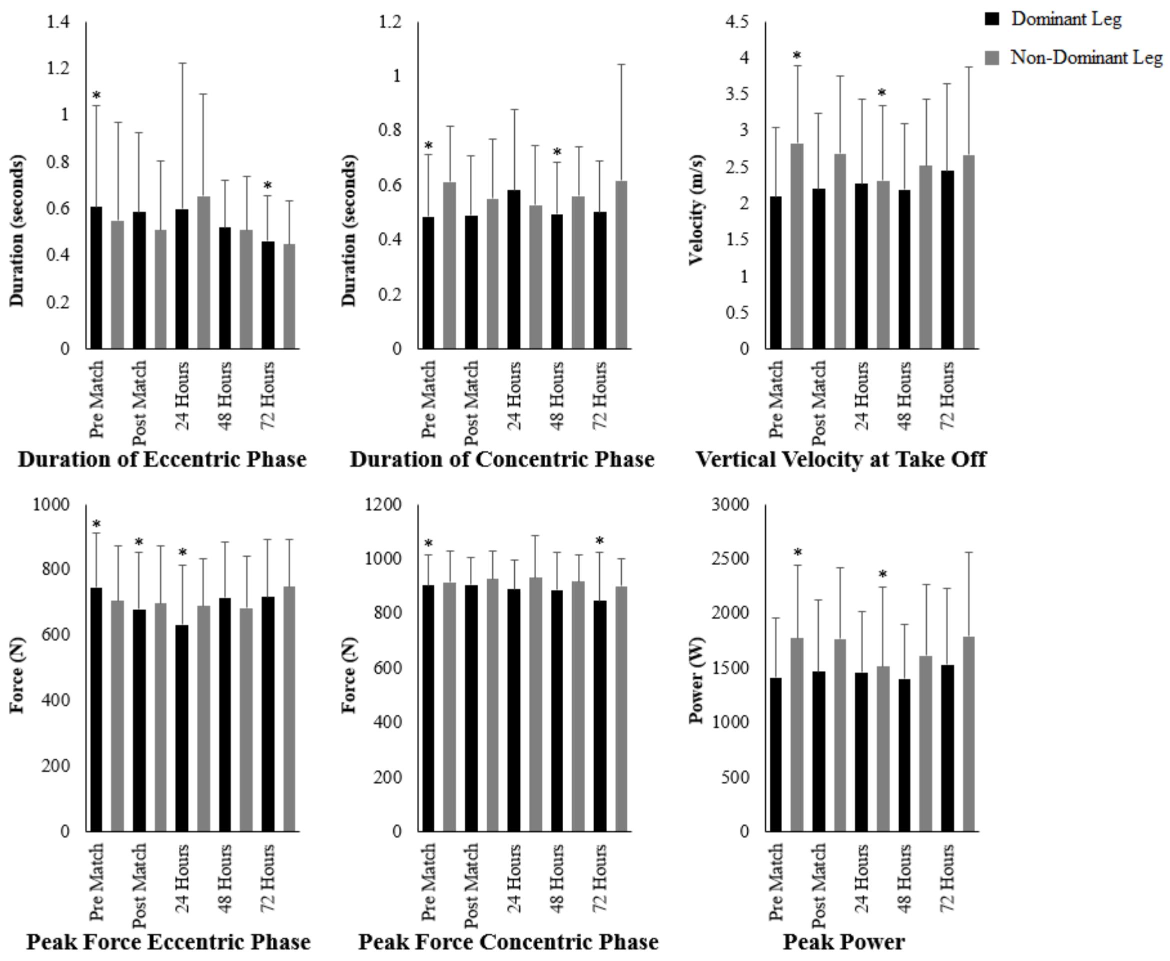


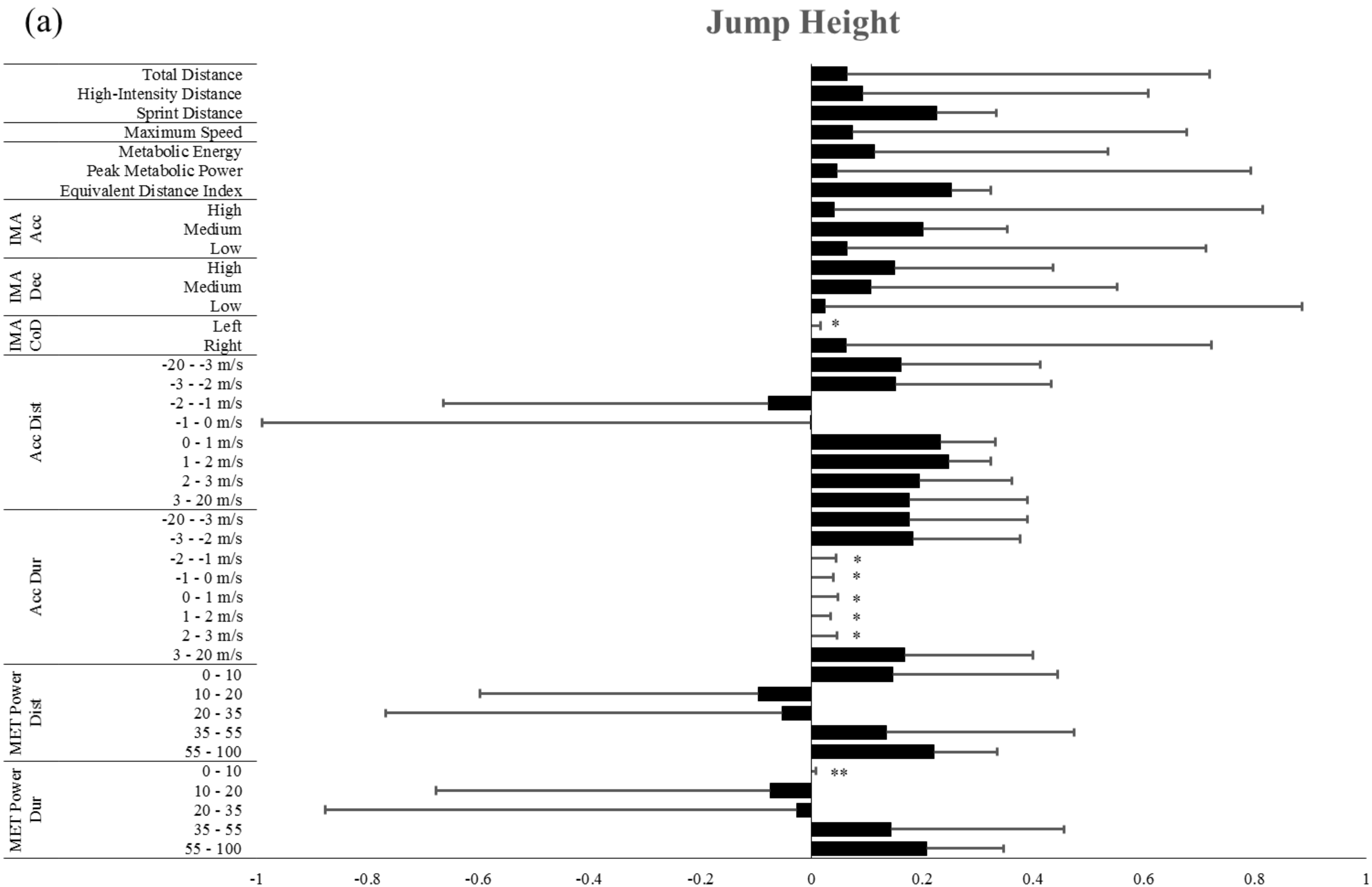
Figure 2. A one-way ANOVA Bonferroni post-hoc test focusing on CMJ variables, comparing pre-match test and the four proceeding jump tests, analysing independent legs used in the CMJ with the dominant and non-dominant kicking leg compared individually, error bars represent 95% confidence interval. * Significant difference with the pre-match CMJ ($p < 0.05$).

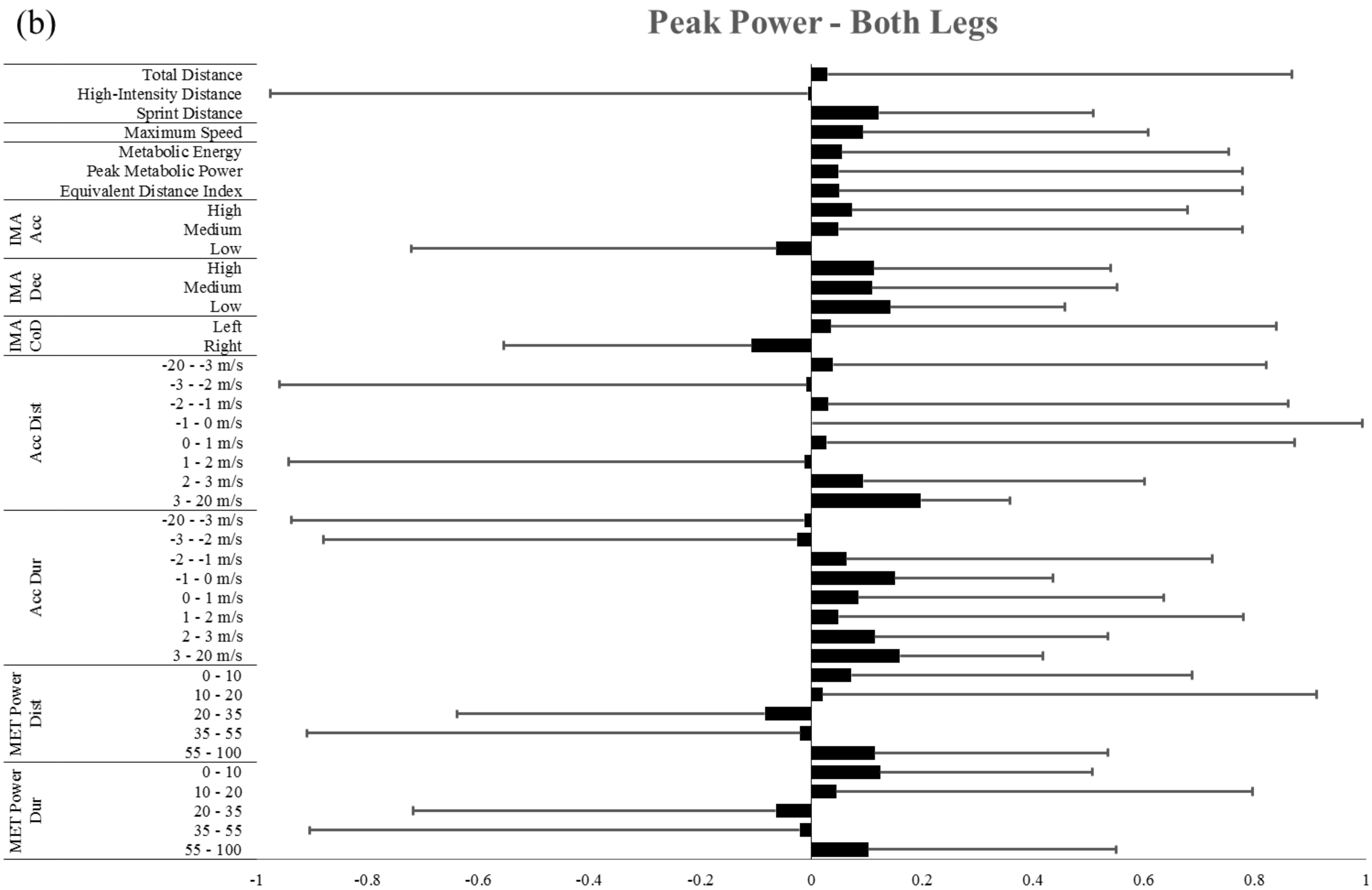
The jump height deficit from pre-match to 24 hours post-match was found to be significantly correlated with the match performance variables: IMA change of direction left (*P* = 0.017); Acceleration bands total duration -2 - -1 ms^{-1}, -1 - 0 ms^{-1}, 0 - 1 ms^{-1}, 1 - 2 ms^{-1} and 2 - 3 ms^{-1} (*P* = 0.044; *P* = 0.039; *P* = 0.048; *P* = 0.034; *P* = 0.047, respectively); and metabolic band total duration 0 -10 (*P* = 0.009). The peak power deficit comparing both legs and the dominant leg to the match performance variables found no significant correlations. Whereas the peak power deficit in the non-dominant leg was correlated with the high IMA decelerations (*P* = 0.032) (Figure 3).

The dependant variable was jump height deficit and the two independent variables that significantly accounted for some of the variance was metabolic power band 1 total duration and high IMA change of direction left (Adjusted R^2 = 0.18, SEE = 0.37). These factors help explain 18% of the variance by using these match performance variables (Figure 4). The equation is shown below:

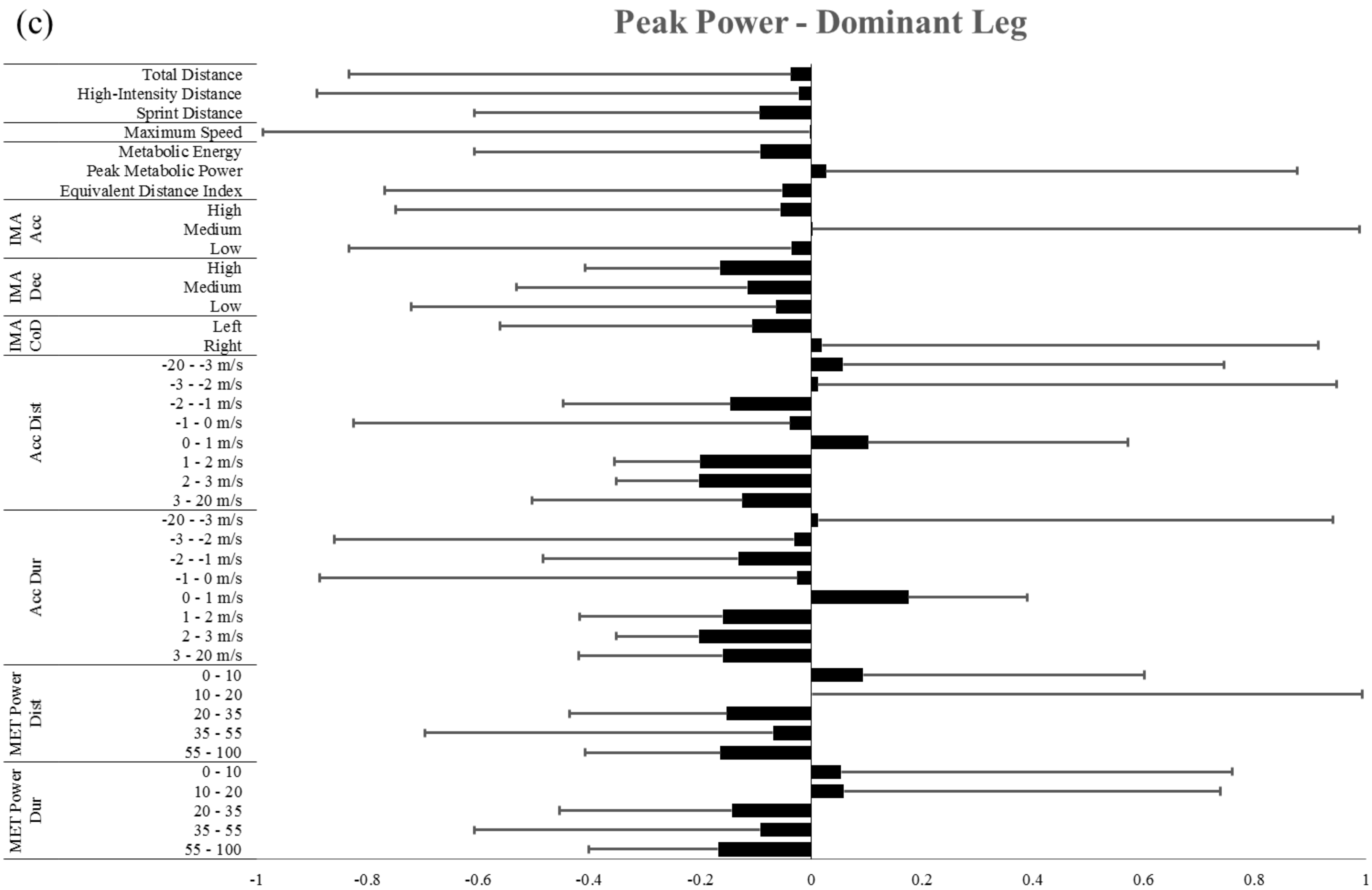
$$\textit{Jump Height Deficit} = 3.277\text{E-}5_{\text{metabolic power band 1 total duration}} + .003_{\text{high IMA change of direction left}} + -.105$$

(a)

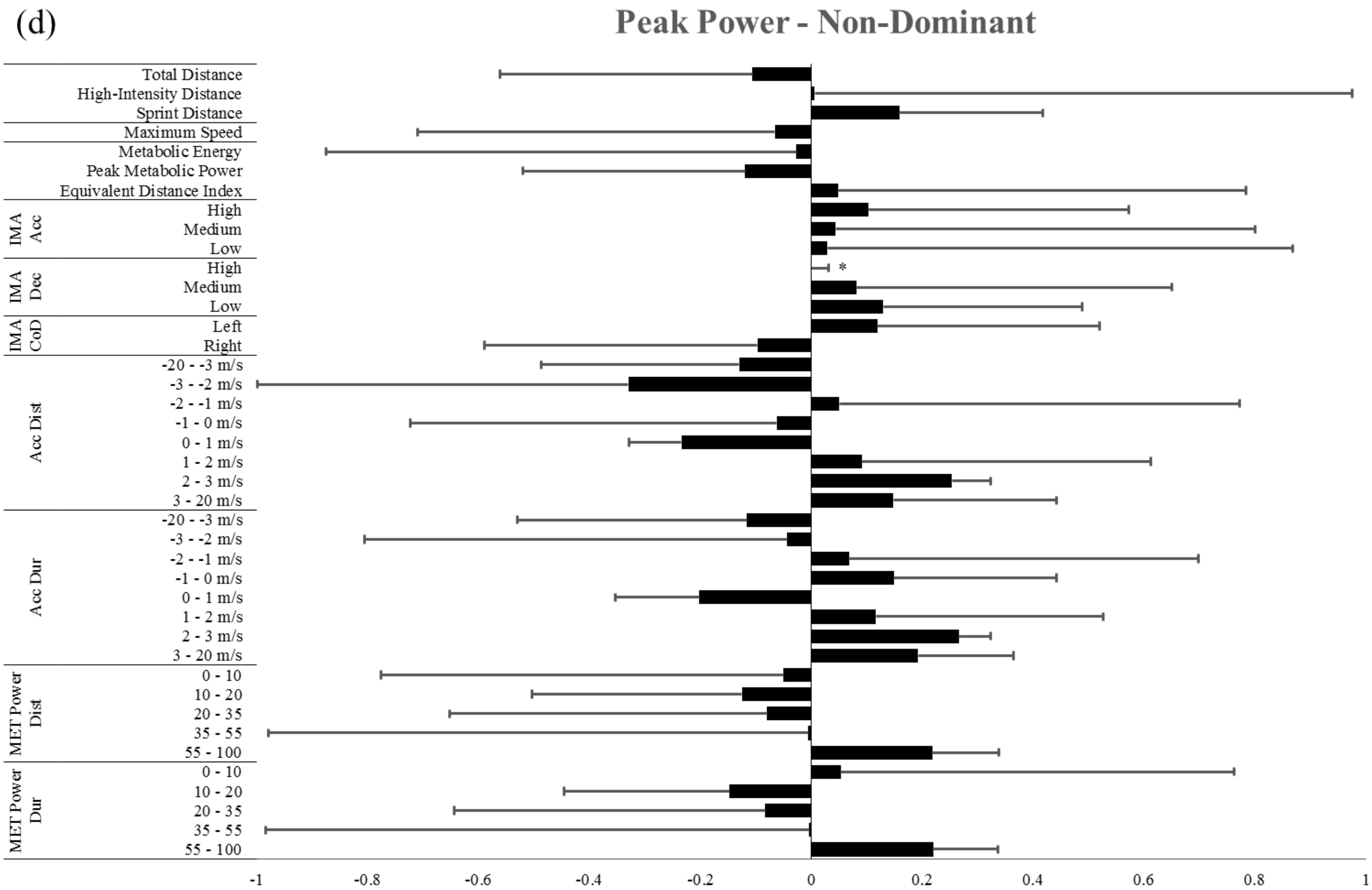

Jump Height
Total Distance
High-Intensity Distance
Sprint Distance
Maximum Speed
Metabolic Energy
Peak Metabolic Power
Equivalent Distance Index
IMA Acc
High
Medium
Low
IMA Dec
High
Medium
Low
IMA CoD
Left
Right
Acc Dist
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
Acc Dur
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
MET Power Dist
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
MET Power Dur
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
*
**
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


(b)
Peak Power - Both Legs
Total Distance
High-Intensity Distance
Sprint Distance
Maximum Speed
Metabolic Energy
Peak Metabolic Power
Equivalent Distance Index
IMA Acc
High
Medium
Low
IMA Dec
High
Medium
Low
IMA CoD
Left
Right
Acc Dist
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
Acc Dur
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
MET Power Dist
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
MET Power Dur
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

(c)


Peak Power - Dominant Leg
Total Distance
High-Intensity Distance
Sprint Distance
Maximum Speed
Metabolic Energy
Peak Metabolic Power
Equivalent Distance Index
IMA Acc
High
Medium
Low
IMA Dec
High
Medium
Low
IMA CoD
Left
Right
Acc Dist
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
Acc Dur
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
MET Power Dist
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
MET Power Dur
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

(d)



Peak Power - Non-Dominant
Total Distance
High-Intensity Distance
Sprint Distance
Maximum Speed
Metabolic Energy
Peak Metabolic Power
Equivalent Distance Index
IMA Acc
High
Medium
Low
IMA Dec
High
Medium
Low
IMA CoD
Left
Right
Acc Dist
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
Acc Dur
-20 - -3 m/s
-3 - -2 m/s
-2 - -1 m/s
-1 - 0 m/s
0 - 1 m/s
1 - 2 m/s
2 - 3 m/s
3 - 20 m/s
MET Power Dist
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
MET Power Dur
0 - 10
10 - 20
20 - 35
35 - 55
55 - 100
*
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

Figure 3. (a) Jump Height, (b) Peak Power (Both Legs), (c) Peak Power (Dominant Leg) and (d) Peak Power (Non-Dominant Leg). A Pearson two-tailed bivariate analysis was used to find the correlation between the deficit in CMJ performance from pre-match to 24 hours post-match, with the match performance variables. * Correlation is significant at $p < 0.05$. ** Correlation is significant at $p < 0.01$.

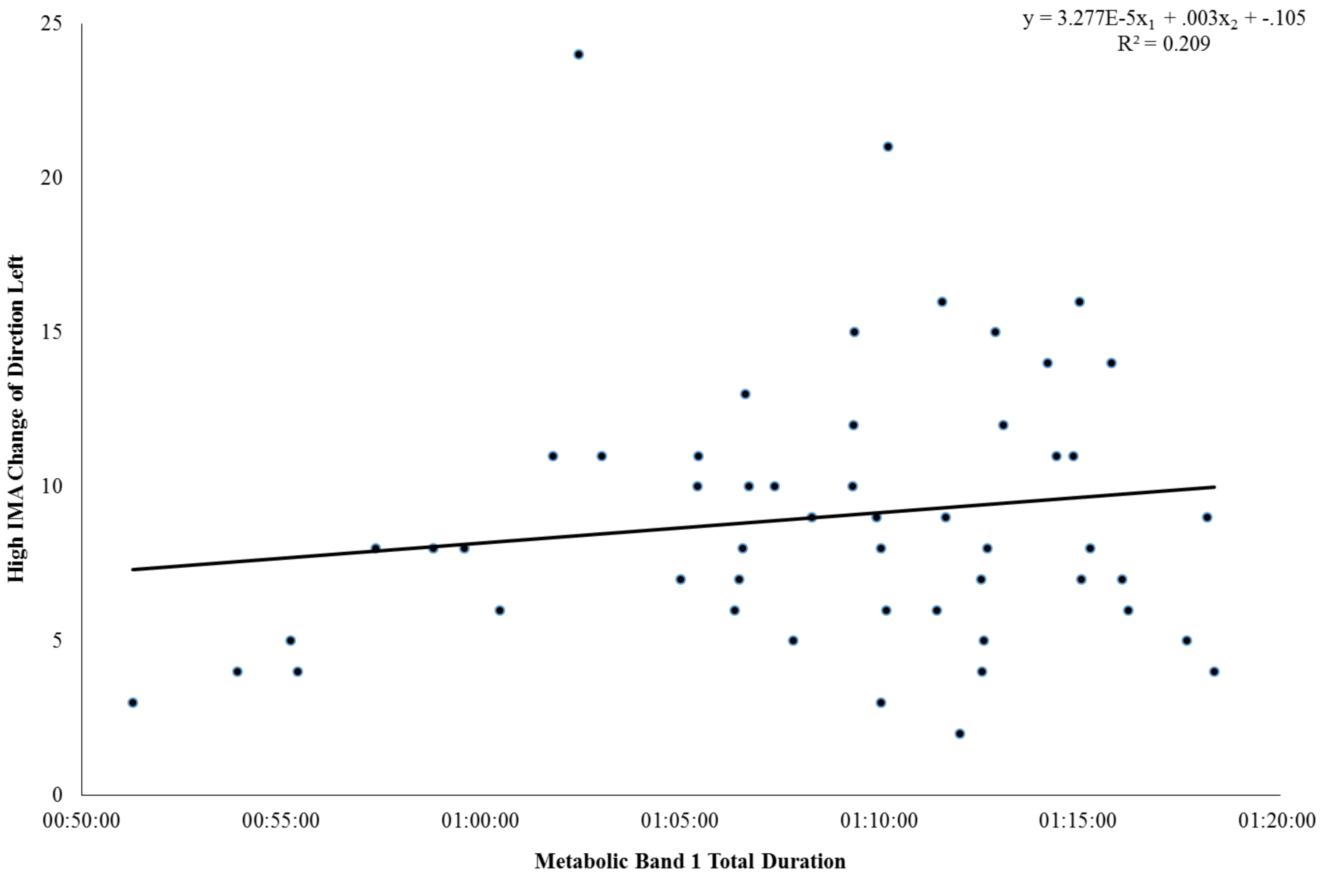


Figure 4. A step-wise multiple linear regression for predicting the deficit in jump height for pre-match to 24 hours post-match. R^2 coefficient for approximate of actual data. * Using Metabolic Power Band 1 Total Duration to predict jump height deficit, significance at $p < .05$ ($R^2 = .130$). * Using Metabolic Power Band 1 Total Duration and IMA Change of Direction High Left to predict jump height deficit, significance at $p < .05$ ($R^2 = .209$).

CHAPTER 4

Discussion

The aim of this study was to establish the difference in CMJ performance from the baseline measure pre-match and subsequent tests that followed post-match. This study found 24 hours post-match was the peak period which CMJ was most affected. The study evaluated what the difference was between the two legs, highlighting any asymmetries. Aspects of the eccentric and concentric duration and force was affected in the dominant leg, however, the non-dominant leg peak power was affected. Ultimately, the study tried to identify the cause of the CMJ performance deficit in the legs post-match, by establishing any relationships with the match performance data. This study only found two relationships between CMJ and match performance.

The participants jump height and flight duration dropped post-match (1.8 cm, 0.01 s) and for the following two days (5.3 cm, 0.04 s; 2.2 cm, 0.01 s, respectively). The jump height and flight duration correlate due to their direct relationship, therefore, as jump height decreased, flight duration correlated accordingly. The 24 hour post-match deficit of jump height of 5.3 cm shows that the following day after the match is when CMJ is most affected. Strength and conditioning (S&C) practitioners provide the first 24 hours post-match for full recovery or active recovery, would avoid any training load when players are peak fatigue. Throughout this study, all players that participated in the study followed a squad recovery protocol of no training and either a light bike cycle with stretching or physio treatment for the first 24 to 48 hour period post-match. This may have helped the recovery for player's measurements from the 24 to 48 hour CMJ test. Despite this, even 48 hours post-match, players are still jumping 2.2 cm less than prior to the match but have recovered almost 50% from the 24 hour post-match measure. Russell et al. (2015) suggested that training schedules in the days following a match should be adjusted as more than 48 hours is needed to restore metabolic and performance perturbations based on their findings. Russell et al. (2016) highlight the caution of using match activities as a part of training when performed > 24 hours post-match. Both studies reinforce the trend found in this data, which training load has to be reduced 48 hours post-match, but some form of soccer training activity could start to be reintroduced, whilst avoiding any form of high-intensity movements.

The subjective data showed that sleep quality, physical tiredness, muscle soreness, mental tiredness and the recovery were all affected post-match and all aspects were affected for the following three days in their perception with mental tiredness returning to baseline after 48 hours post-match. This data follows the same trend as the CMJ measurements for the first two days post-match, with the participants reporting significant ratings, still feeling below the baseline 72 hours post-match where CMJ has returned to normal values for all the variables except the duration of the eccentric phase (0.13 s). The interesting measurement was the 72 hours post-match. As the data suggest physical measures from the CMJ were still affected by the match performance with fatigue and muscle damage present up to the 48 hour post-match test. The 72 hour post-match ratings provided by the players may have more of a psychological impact. Players would tend to be returning to full training on the third day following a match, with players anticipating this and expecting a greater load to be placed upon their body again, the score may have been a protective barrier where they may felt the information could be passed to the coach or the readiness to exert a high percentage of effort could be based more on their mood state rather than a physical state.

Analysing the same period of the jump using both legs, the eccentric phase peak force decreased for both post-match (37.1 N) and 24 hours post-match (65.1 N). The eccentric phase duration had not altered, therefore, showing the CMJ is performed very similar to pre-match but is exerting less force during the downward phase of the jump. Whereas the upward phase of the CMJ focusing on the vertical velocity of centre of gravity at take-off decreased for both 24 and 48 hours post-match (0.17 and 0.10 ms^{-1}, respectively). This maybe a result of the reduced downward force, of which Newton's second law could explain that the opposite force was directionally proportional with the vertical velocity being less compared to the pre-match measurement. Players affected by fatigue may inhibit the peak power during the eccentric phase. Muscles are required to eccentrically contract for the initiation of the jump, the amount of energy stored within the muscle depends on the velocity and magnitude of the shortening of the muscle. When bending the knees, a force is applied into the surface, however, it is the combination of all factors when applying the force that will have the interaction with the surface to produce the CMJ. Stiffness of joints, as well as angular displacements at the knee and ankle, will all impact the force produced during the eccentric phase. Despite energy stores reduced within the muscle, the CMJ can be influenced by the kinematics of the jump found with fatigue, resulting in different muscles or joint movement being compensated, increasing injury risk. Therefore, as a result, the peak power of jump was decreased over the same two days post-match period (205.3 and 168.0 W, respectively). The interaction between all the CMJ variables help to explain why the jump height was impacted for 24 and 48 hours post-match. Newton's second law is evident within these values showing that the lowered force following the match in the eccentric phase had a direct impact on the vertical velocity, peak power and overall jump height.

The analysis found differences between legs found the dominant leg had a decrease in concentric phase duration after 48 hours post-match (0.01 s) and the peak eccentric force for both post-match (67.0 N) and 24 hours post-match (114.0 N). Whilst the non-dominant leg had a slower vertical velocity of centre of gravity at take-off at 24 hours post-match (0.5 ms^{-1}) with peak power also dropping off at the same time point (257. W). These results could suggest that the dominant leg may have been more fatigued by producing less force and being slower in the CMJ movement, suggesting the non-dominant leg is trying to compensate for it. The reduced peak power in the non-dominant leg would still suggest that this leg is still fatigued by producing significantly less power 24 hours post-match. The peak power reduction at 24 hours for the dominant leg was not affected in performance as seen in the non-dominant leg. The causal effect of the fatigue to still be present in the non-dominant side, may be due to the increase load and stress placed through this limb to compensate for the dominant leg to perform a sport related skill. Therefore, the impact this has on the asymmetry found between legs would highlight the increased injury risk of the non-dominant kicking leg.

The most common period where the significant decrease in CMJ for both and single legs in isolation was 24 hours post-match. Analysis then focused on the jump height (5.4cm) and peak power deficit for both legs (205.3 W), as well as the dominant (-53.5 W) and non-dominant leg (5.5 W). Finding the association of match performance variables that factor both jump height and peak power causing the deficit 24 hours post-match would help provide a deeper understanding. Jump height deficit was linked with MET power total duration band 1, high IMA change of direction left, acceleration total duration band 3, 4, 5, 6 and 7. Peak power deficit for both legs and dominant leg had no significant relationship with the match performance variables. The non-dominant leg peak power was affected by high IMA decelerations. The jump height deficit has shown to be the most affected by the match performance variables. The multiple regression helped provide an insight as to which factors had the most impact on the jump height deficit, with seven match variables having a relationship. The two variables that had a significant impact were the MET power total duration band 1 and high IMA change of direction left, which accounted for 17.9% of the variance of jump height deficit. All the match performance measures that had a significant relationship with CMJ decrease are movements performed at a low velocity whilst still requiring a high intensity action, being classed as IMA accelerations, decelerations and MET power.

MET power is comprised of energy cost and velocities derived from the GPS to provide a power output measure. Banding of MET power provides information about the time, number of efforts and average power throughout the duration of a match. Most efforts are banded one or two, due to the nature constant pace running, with intense events registering in the higher bands. Whilst the lower bands are less intense movements, these actions are still demanding on the players and due to the volume accumulated in these bands, the findings from this study shows this has a greater impact on CMJ. As hypothesised it would be the intense actions in the higher bands that would impact CMJ, in fact, it shows the low velocity, high powered actions have greater detriment on CMJ. The relationships with acceleration bands three to eight could be the velocity ranges at which MET power is affected, again due to the lower velocity nature of the demanding acceleration movement. Accelerations come under 'equivalent mass', which is part of the calculation of energy cost, with energy cost one of the inputs of the equation to calculate MET power.

Focusing on the match performance measures that correlated with CMJ, the total duration of the accelerations falling between bands three to seven were accelerations performed at speeds ranging from -2 to 3 ms^{-1}. These acceleration bands are classed as slower velocity accelerations and decelerations, however they are still are still intense actions performed by the players. The MET power band one total duration is the power accumulated between 0 - 10 W/kg. The majority of the metabolic power accumulated in band one is through constant pace running and medium accelerations events that are sometimes registered within this band too. IMA data collected from the GPS allows to determine the nature of the intensity of movement. Therefore, the two variables, high IMA change of direction left and high IMA deceleration, both had a relationship with match performance. To classify a movement as a high change of direction, this means a high-intensity deceleration has to be then followed by a high-intensity acceleration immediately in a different plane, with this case being to the left. Whereas a high IMA deceleration is a movement classed as ≤ 3.5 ms^{-1}, which is the same speed threshold for a high IMA change of direction. The common nature of these movements are that they are high-intensity actions that are performed at a low velocity, but this still only accounts for 18% of the CMJ decrease.

The aim of the initiation of an acceleration is to apply maximal horizontal force, in the shortest time possible. The force-velocity relationship curve helps explain where acceleration requires high force in a short space of time, but performed when velocity is low. The hip extensors, especially the hamstrings, are important contributors for sprint acceleration performance through horizontal ground reaction force production. When decelerating a lateral pivoting occurs at the knee, as well as the load being transferred through the hip and ankle. High injury rates have occurred during the deceleration phase, this is due to the load transferred through the knee with incorrect alignment.

Due to the analysis comparing jump and match performance only accounting for 18% of the direct relationship for 24 hour post-match drop off, there may be more underlying complex reasons that factor the decrease following the soccer performance that are not easily explained by the GPS measures. The first reason may be due to muscle damage sustained within the match. Creatine kinase and myoglobin are reliable markers for muscle damage (Ascensao et al, 2008), which is increased when rapid accelerations and decelerations are performed. The frequency of accelerations and decelerations in a soccer match, with special attention to the landing phase when decelerating, eccentric activation of the hamstrings allow hip flexion and knee extension to slow down. It is the eccentric activation of the hamstring that causes high tension over the cross-section of the muscle mass, creating structural damage to the muscle fibres found with the z-lines being streamed within the sarcomere. These physical changes reduce force capabilities (Thorpe & Sunderland, 2012) and increase creatine kinase (Brancaccio, Maffulli & Limongelli, 2007). Ispirlidis et al. (2008) found that delayed onset muscle soreness (DOMS) caused by soccer match performance peaked 24 hours post-match and creatine kinase peak levels at 48 hours post-match. With DOMS and creatine kinase peak levels present during the 24 and 48 hour post-match period could explain why a lot of the significant CMJ measurements were affected during the same period.

The fatigue in muscles following a match have been found to affect the power and coordination of both agonist and antagonist muscle groups. The peak eccentric force phase of a CMJ was shown to be affected with post-match measures, therefore, future research should investigate this initiation phase of the CMJ in greater detail. An interesting point to investigate further would be the differences between the CMJ and drop jump in a similar setting. The ability to perform a CMJ requires SSC characteristics of the muscle groups along with coordination of joint movements, increasing the potential capabilities. Analysing the drop jump would assess the performance of more proprioceptive functions required of the SSC to produce the muscle activity, including muscle spindles, Golgi-tendon organ and joint receptors, as well as joint and leg stiffness. A drop jump requires propulsion off the ground to counteract the downward force. In comparison the CMJ can sometimes be benefited by more efficient technique, whereas the drop jump relies on the capability of the muscles to perform the jump. Another limitation of the study was the technique or screening of the jump was not analysed or controlled. Joint angles or displacements in movements to generate the force, could be at the detriment of the movement. The kinematics have not been assessed as a result, with all analysis of the movement investigating the kinetics of the CMJ. An uncontrollable variable that may have impacted the recovery of players, would be the training sessions players undertook in the period post-match. The amount of load effort and intensity was not accounted for in the study, which could be the reason why players took longer to return to baseline and dependent on the content this could be different from match to match.

In conclusion, the study has found that match performance impacts the ability to reproduce the same CMJ 24 hours post-match, and this is due to the consistent nature of the low velocity intense movements performed in the competitive match. The low metabolic measures of match performance have found that fatigue impacts CMJ, however movement variables measured in matches do not have a full direct relationship with fatigue development. Such findings might help practitioners utilise jump height as a measurement and marker of fatigue, to adjust individuals training load and in turn prevent injury. A limitation of this study could be that the number of matches did not reflect the true variation found within a season, and this could be investigated by repeating the study over a longer duration. Another area of consideration is that the CMJ may not have reflected the same nature of the force development rate required to compare the intense actions performed. As mentioned above, a drop jump may have a closer relationship in terms of the kinetic and kinematic requirements which again would be a suggestion for to further build on this study.

References

Aagaard, P. (2003). Training-induced changes in neural function. *Exercise and Sport Sciences Reviews, 31*(2), 61-67.

Akenhead, R., French, D., Thompson, K. G., & Hayes, P. R. (2013). The acceleration dependent validity and reliability of 10hz gps, *Journal of Science and Medicine in Sport, 17*(5), 562-566.

Andersson, H. Å., Randers, M. B., Heiner-Møller, A., Krustrup, P., & Mohr, M. (2010). Elite female soccer players perform more high-intensity running when playing in international games compared with domestic league games. *The Journal of Strength & Conditioning Research, 24*(4), 912-919.

Ascensão, A., Rebelo, A., Oliveira, E., Marques, F., Pereira, L., & Magalhães, J. (2008). Biochemical impact of a soccer match—analysis of oxidative stress and muscle damage markers throughout recovery. *Clinical Biochemistry, 41*(10), 841-851.

Batterham, A. M., & Hopkins, W. G. (2006). Making meaningful inferences about magnitudes. *International Journal of Sports Physiology and Performance, 1*(1), 50-57.

Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. *Journal of Sports Sciences, 27*(2), 159-168.

Bradley, P. S., Di Mascio, M., Peart, D., Olsen, P., & Sheldon, B. (2010). High-intensity activity profiles of elite soccer players at different performance levels. *The Journal of Strength & Conditioning Research, 24*(9), 2343-2351.

Bradley, P. S., Carling, C., Diaz, A. G., Hood, P., Barnes, C., Ade, J., Bobby, M., Krustrup, P., & Mohr, M. (2013). Match performance and physical capacity of players in the top three competitive standards of English professional soccer. *Human Movement Science, 32*(4), 808-821.

Brancaccio, P., Maffulli, N., & Limongelli, F. M. (2007). Creatine kinase monitoring in sport medicine. *British Medical Bulletin, 81*(1), 209-230.

Carling, C., Le Gall, F., & Dupont, G. (2012). Analysis of repeated high-intensity running performance in professional soccer. *Journal of Sports Sciences, 30*(4), 325-336.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*(1), 155-159.

Croisier, J. L., Ganteaume, S., & Ferret, J. M. (2005). Preseason isokinetic intervention as a preventive strategy for hamstring injury in professional soccer players. *British Journal of Sports Medicine, 39*(6), 379.

Cumming, G., & Finch, S. (2001). A primer on the understanding, use, and calculation of confidence intervals that are based on central and noncentral distributions. *Educational and Psychological Measurement, 61*(4), 532-574.

Di Prampero, P. E., Capelli, C., Pagliaro, P., Antonutto, G., Girardis, M., Zamparo, P., & Soule, R. G. (1993). Energetics of best performances in middle-distance running. *Journal of Applied Physiology, 74*(5), 2318-2324.

Di Salvo, V., Gregson, W., Atkinson, G., Tordoff, P., & Drust, B. (2009). Analysis of high intensity activity in Premier League soccer. *International Journal of Sports Medicine, 30*(3), 205-212.

Fousekis, K., Tsepis, E., & Vagenas, G. (2010). Lower limb strength in professional soccer players: profile, asymmetry, and training age. *Journal of Sports Science and Medicine, 9*(3), 364-373.

Hägglund, M., Waldén, M., & Ekstrand, J. (2013). Risk factors for lower extremity muscle injury in professional soccer: the UEFA Injury Study. *The American Journal of Sports Medicine, 41*(2), 327-335.

Harley, J. A., Lovell, R. J., Barnes, C. A., Portas, M. D., & Weston, M. (2011). The interchangeability of global positioning system and semi-automated video-based performance data during elite soccer match play. *Journal of Strength and Conditioning Research, 25*(8), 2334-2336.

Hewitt, J., Cronin, J., Button, C., & Hume, P. (2011). Understanding deceleration in sport. *Strength and Conditioning Journal, 33*(1), 47-52.

Impellizzeri, F. M., & Maffiuletti, N. A. (2007). Convergent evidence for construct validity of a 7-point likert scale of lower limb muscle soreness. *Clinical Journal of Sport Medicine, 17*(6), 494-496.

Ispirlidis, I., Fatouros, I. G., Jamurtas, A. Z., Nikolaidis, M. G., Michailidis, I., Douroudos, I., & Alexiou, V. (2008). Time-course of changes in inflammatory and performance responses following a soccer game. *Clinical Journal of Sport Medicine, 18*(5), 423-431.

Jakobsen, M. D., Sundstrup, E., Randers, M. B., Kjær, M., Andersen, L. L., Krustrup, P., & Aagaard, P. (2012). The effect of strength training, recreational soccer and running exercise on stretch–shortening cycle muscle performance during countermovement jumping. *Human Movement Science, 31*(4), 970-986.

Johnston, R. J., Watsford, M. L., Pine, M. J., Spurrs, R. W., Murphy, A. J., & Pruyn, E. C. (2012). The validity and reliability of 5-hZ global positioning system units to measure team sport movement demands. *Journal of Strength and Conditioning Research, 26*(3), 758-765.

Maly, T., Zahalka, F., & Mala, L. (2014). Muscular strength and strength asymmetries in elite and sub-elite professional soccer players. *Sport Science, 7*(1), 26-33.

McLean, B. D., Coutts, A. J., Kelly, V., McGuigan, M. R., & Cormack, S. J. (2010). Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players. *International Journal of Sports Physiology and Performance, 5*(3), 367-383.

Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences, 21*(7), 519-528.

Oliver, J., Armstrong, N., & Williams, C. (2008). Changes in jump performance and muscle activity following soccer-specific exercise. *Journal of Sports Sciences, 26*(2), 141-148.

Osgnach, C., Poser, S., Bernardini, R., Rinaldo, R., & Di Prampero, P. E. (2010). Energy cost and metabolic power in elite soccer: a new match analysis approach. *Medicine and Science in Sports and Exercise, 42*(1), 170-178.

Reilly, T., & Thomas, V. (1976). A motion analysis of work-rate in different positional roles in professional football match-play. *Journal of Human Movement Studies, 2*(2), 87-97.

Rienzi, E., Drust, B., Reilly, T., Carter, J. E. X. L., & Martin, A. (2000). Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *Journal of Sports Medicine and Physical Fitness, 40*(2), 162.

Sannicandro, I., Rosa, R. A., De Pascalis, S., & Piccinno, A. (2012). The determination of functional asymmetries in the lower limbs of young soccer players using the countermovement jump. The lower limbs asymmetry of young soccer players. *Science & Sports, 27*(6), 375-377.

Strudwick, T., & Reilly, T. (2001). Work-rate profiles of elite Premier League football players. *Insight, 2*(2), 28-29.

Thorpe, R., & Sunderland, C. (2012). Muscle damage, endocrine, and immune marker response to a soccer match. *The Journal of Strength & Conditioning Research, 26*(10), 2783-2790.

Waldron, M., & Highton, J. (2014). Fatigue and pacing in high-intensity intermittent team sport: an update. *Sports Medicine, 44*(12), 1645-1658.

Wong, P. L., Chamari, K., Chaouachi, A., Wisløff, U., & Hong, Y. (2007). Difference in plantar pressure between the preferred and non-preferred feet in four soccer-related movements. *British Journal of Sports Medicine*, *41*(2), 84-92.

Appendices

Appendix 1 - Ethics Application

St Mary's University Twickenham London

Ethics Application Form

1) Name of proposer(s)	Jeremy Poulson
2) St Mary's email address	154992@live.stmarys.ac.uk
3) Name of supervisor	Dr Mark Waldron

4) Title of project

The effect of match-load on post-match lower limb asymmetries in elite soccer players.

5) School or service	School of Sport, Health and Applied Science
6) Programme (whether undergraduate, postgraduate taught or postgraduate research)	MSc in Strength and Conditioning
7) Type of activity/research (staff/undergraduate student/postgraduate student)	Postgraduate Student

8) Confidentiality

Will all information remain confidential in line with the Data Protection Act 1998?	YES

9) Consent

Will written informed consent be obtained from all participants/participants' representatives?	YES

10) Pre-approved protocol	
Has the protocol been approved by the Ethics Sub-Committee under a generic application?	Not applicable Date of approval:

11) Approval from another Ethics Committee	
a) Will the research require approval by an ethics committee external to St Mary's University?	NO
b) Are you working with persons under 18 years of age or vulnerable adults?	NO

12) Identifiable risks	
a) Is there significant potential for physical or psychological discomfort, harm, stress or burden to participants?	NO
b) Are participants over 65 years of age?	NO
c) Do participants have limited ability to give voluntary consent? This could include cognitively impaired persons, prisoners, persons with a chronic physical or mental condition, or those who live in or are connected to an institutional environment.	NO
d) Are any invasive techniques involved? And/or the collection of body fluids or tissue?	NO
e) Is an extensive degree of exercise or physical exertion involved?	YES
f) Is there manipulation of cognitive or affective human responses which could cause stress or anxiety?	NO

g) Are drugs or other substances (including liquid and food additives) to be administered?	NO
h) Will deception of participants be used in a way which might cause distress, or might reasonably affect their willingness to participate in the research? For example, misleading participants on the purpose of the research, by giving them false information.	NO
i) Will highly personal, intimate or other private and confidential information be sought? For example sexual preferences.	NO
j) Will payment be made to participants? This can include costs for expenses or time.	NO If yes, please provide details
k) Could the relationship between the researcher/ supervisor and the participant be such that a participant might feel pressurised to take part?	NO
l) Are you working under the remit of the Human Tissue Act 2004?	NO

13) Proposed start and completion date

Please indicate:

- When the study is due to commence.
- Timetable for data collection.
- The expected date of completion.

Please ensure that your start date is at least 3 weeks after the submission deadline for the Ethics Sub-Committee meeting.

The study will cover all match fixtures that are in the months of January to March. Data will be collected on the day of the fixture and the following three days after the fixture. The fixtures are subject to change, i.e. cup matches, venue change, postponement of fixture due to weather. The current fixture list to the current date means that nine fixtures will be observed as well as the 78 hours post each fixture.

The nine fixtures are on the following dates:
- Friday 6th January 2017
- Monday 16th January 2017
- Sunday 29th January 2017
- Saturday 6th February 2017

- Monday 20th February 2017
- Monday 6th March 2017
- Friday 10th March 2017
- Monday 20th March 2017
- Monday 27th March 2017

The analysis of the data will follow the last fixture and the write up of the study will be completed at the end of April 2017.

14)Sponsors/Collaborators

Please give names and details of sponsors or collaborators on the project. This does not include your supervisor(s) or St Mary's University.

- Sponsor: An individual or organisation who provides financial resources or some other support for a project.
- Collaborator: An individual or organisation who works on the project as a recognised contributor by providing advice, data or another form of support.

Collaborator – Sheffield Wednesday Football Club

The collaboration will provide the participants for the study, along with the data from the equipment that the Football Club have to analyse matches and forces when jumping.

15. Other Research Ethics Committee Approval

- Please indicate whether additional approval is required or has already been obtained (e.g. the NHS Research Ethics Committee).
- Please also note which code of practice / professional body you have consulted for your project.
- Whether approval has previously been given for any element of this research by the University Ethics Sub-Committee.

N/A

16. Purpose of the study

In lay language, please provide a brief introduction to the background and rationale for your study.

- Be clear about the concepts / factors / performances you will measure / assess/ observe and (if applicable), the context within which this will be done.

- Please state if there are likely to be any direct benefits, e.g. to participants, other groups or organisations.

Professional soccer players are required to perform frequent competitive matches over a season, with matches played up to twice per week, interspersed by 2-7 day periods (Andersson et al, 2007). Planning of the training mesocycles between matches with the small time to prepare and recover is crucial (Wells & Hattersley, 2013). Players performing in matches sustain fatigue temporary during and significantly at post-match (Mohr et al, 2003), show a decline in physical performance. Recovery strategies employed to overcome fatigue are crucial in preparation for the next match (Reilly & Ekbolm, 2005). Management of training load during this time is important as training overload could prevent or delay the neuromuscular and perceptual recovery (Bangso, 1994). If the appropriate methods of recovery are not adhered to and players are exposed to the incorrect loads the chance of injury might be increased (Reilly & Ekbolm, 2005).

Studies have investigated the demands of competitive soccer matches and, as such, have developed an understanding of the distances and intensity of matches. These studies have also reported the differences in running demands of players based on field position (Bloomfield et al, 2007; Di Salvo et al, 2007). Studies have reported the high-intensity actions are seen as crucial indictors of performance in matches (Bangsbo et al, 1991; Bangsbo, 1994). Mohr et al (2003) found that after the most intense high-intensity running period in the match, the following period significant drop off in performance was shown to be due to fatigue, which is supported by Krustrup et al (2002). Coaches should use this information to gauge the volume and intensity of a match or training sessions as this might alter their recovery strategy. Nedelec et al (2014) found that significant neuromuscular fatigue is evident in soccer player 72 hours post-match.

Quantifying the intensity and volume (i.e. load) of a match based on the total distance or other kinematic variables is problematic as this does not give a true reflection on the other energetically demanding factors that also contribute to the total load of the match. So-called 'metabolic power' values have been suggested to provide a more thorough reflection of match load, owing to the quantification of accelerative and decelerative actions that accompany steady state running (Buchheit et al, 2015). Using the metabolic load in conjunction with the running distances has been suggested to provide a more comprehensive evaluation of the physical performance (Aslan et al, 2012).

The actions performed in soccer matches are not symmetrical, with the most common being kicking of the ball. Other aspects, such as change of direction, applying more force through one side of the body and the overall load will be different for each lower limb. Knapik et al, (1991) suggested that an imbalance of muscle strength greater than 15% were 2.6 times more likely to suffer injury in the weaker leg. Yamada (2012) found that after just the first half of a match, there is a significant difference between the dominant and non-dominant leg in stability and power. Therefore, within a game, asymmetry fatigue would occur, but the extent to which fatigue develops in each leg at the end of the game, has not been researched. Asymmetry has only been researched in isolation, with recruitment of soccer players with no causal effect from complete soccer match. Menzel et al (2013) show players that participate in soccer have asymmetries in muscle strength, but this might be a sports conditioned effect because of the dominant kicking foot, warranting further investigation.

This study will investigate if there is a post-match decrement in jumping physical performance in force produced from the baseline measure pre-match, using 2 force platforms. Twist and Highton (2013) used GPS to measure movement velocity, as well as jump tests as a combination to measure neuromuscular function and fatigue in rugby league players. The metabolic energy cost and peak power from the match can be calculated, in turn, determining the load of the match. The study will evaluate if asymmetries exist between the 2 legs post-match, monitoring the duration that peak power takes to return to baseline force values, taking frequent force measurements. With close evaluation of post-match recovery kinetics on both legs, analysis will be conducted to identify if relationships exist between the peak power and match performance.

The effect this study have on the participants can help inform coaches and sport science practitioners of fatigue in each leg and could prevent injury of participants. The data can help adjust the content of training based on recovery status of each individual player. The organistation will overall benefit with each individual player being monitored will mean the whole team is managed in order to make more informed decisions in the preparation for the next fixture, being more recovered and lowering the injury risk of the team.

17. Study Design/Methodology

In lay language, please provide details of:

a) The design of the study (qualitative/quantitative questionnaires etc.)
b) The proposed methods of data collection (what you will do, how you will do this and the nature of tests).
c) You should also include details regarding the requirement of the participant i.e. the extent of their commitment and the length of time they will be required to attend testing.
d) Please include details of where the testing will take place.
e) Please state whether the materials/procedures you are using are original, or the intellectual property of a third party. If the materials/procedures are original, please describe any pre-testing you have done or will do to ensure that they are effective.

a) A prospective cohort study using quantitative measurements of the movement in matches and the effect of fatigue when jumping, whilst also taking perceptual measurements of the participants muscle soreness and tiredness.

b) The methodology of which data will be collected in the following study will be conducted in the following way:

Pre-Physical Testing

To provide a better understanding of the population of the participants within the study, the following measurements and tests will help provide the initial insight; anthropometrics (height, weight), the 30 m sprint test, the arrowhead agility test, the yo-yo intermittent recovery test level 2, 7 site skinfold body fat measurements and jump testing.

Physical Performance Test

Testing is conducted on the day of the competitive match, with players performing the test before the match day warm up routine and then players that have not been excluded due to playing time and injury then perform the test post-match and again 3 more times which are 24, 48 and 72 hours post-match. Due to the participants belonging to a professional team, tests were performed before their usual training sessions.

Before the physical performance test, players performed a standardized warm-up of 10 minutes at 100W on a cycle ergometer. Players perform 3 countermovement jumps (CMJ) on 2 portable force platforms (Pasco 2141, Roseville, California, USA) with the best jump recorded. The force signal is sampled at 1,000 Hz. Both feet are placed on separate force players for both the takeoff and landing. Players are instructed to jump explosively upwards immediately after descending to a self-selected depth keeping hands on the hips.

The force plates recording the data for both jumping legs, only accounting for the greatest height jumped out of the three, the following expressions of force are recorded:

- the duration of the eccentric phase (sec)
- peak eccentric force (N)
- peak concentric force (N)
- the ground reaction force (N)

The vertical component of the ground reaction force during the CMJ and the participants' body mass can be used to determine the instantaneous velocity and displacement of the participant's centre of gravity. Instantaneous power output can be determined using the following equation and the highest value produced are deemed the peak power output.

- Power (W) = vertical GRF (N) x Vertical velocity of centre of gravity (ms^{-1})

Match Analysis

Data will be collected using portable GPS devices (MinimaxX S4, Catapult Innovations, Canberra, Australia), in matches will be sampling at a frequency of 10 Hz. Players will wear GPS vests, which are to a size that is comfortable with the participants and the GPS device unit is located in the middle of the upper back, tilting slightly forward. The GPS device is switched on 30 minutes prior to the activity commencing, allowing the device to link up with satellites as advised in the manufacturer's guidelines. After the data is recorded onto the GPS device, the data will be downloaded and transferred onto a computer to commence analysis using the Openfield 1.12.2 software package (Catapult Innovations, Canberra, Australia).

The variables used to analyse the physical match-load are: (a) the total distance covered; (b) the high-intensity distance covered; (c) the high-intensity accelerations (d) the high-intensity decelerations, (e) the high-intensity change of directions and (f) MET power. Participant data is only included in the analysis of the study if meeting the following criteria: (a) playing as an outfield player; (b) completing at least 75 minutes of the game and (c) the player plays in the same position for the full game. The positions of players in matches will be documented to allow a comparison of position in analysis and will be categorised as: centre back (CB), full back (FB), centre midfield (CM), wide midfield (WM) and attacker (A).

Prior to the match, players undertake a 30 minute warm-up which involves jogging, dynamic movements, stretches, passing drill and a possession drill in a 35m x 25m area with 5v5. Players will be allowed to drink fluids prior to the warm up and pre- and post-match. Participants will be advised to continue a normal diet, with emphasis on keeping hydrated with water intake and increasing carbohydrates prior to matches. Pre-match meals are consumed two and a half hours prior to the warm-up commencing to allow for digestion. Players were requested not to use any different recovery treatments (cold bath, massage, compression garments) throughout the post-match data collection period, which may have affected their recovery.

Measuring energy cost of acceleration and decelerations is important to identify the metabolic load on athletes. The contribution of energy exerted towards high intensity actions in soccer is the metabolic power to be produced. The Osgnach et al, (2010) theoretical model in estimating energy cost will be used to calculate the following:

- Metabolic Energy (J/kg)
- Peak Metabolic Power (W/kg)
- Estimated Distance (ED)
- Estimated Distance Index (EDI)

Subjective Ratings

Players are required to rate their quality of sleep, fatigue, muscle soreness, and stress using a scale from 1 to 7 points. Perceived recovery was rated using the total quality recovery (TQR) scale, encompassing the anchor points 6 (not recovered at all) to 20 (completely recovered).

c) The study running over a 3 month period, with 9 fixtures in this period will mean the following commitment will be required from the participants:
- 1 physical pre-testing session lasting 1 hour
- Competing in 9 competitive league matches if selected by the coach
- 9 pre-match jump test on the force platform lasting only a few minutes
- 9 post-match jump tests performed 3 times on 24, 48 and 72 hours, each lasting only a few minutes
- Subjective scores on tiredness and fatigue when performing the jump tests
- Summary – 1 hour pre-test, 9 games and 36 jump tests performed 3 times each time

d) Physical Pre-testing will be undertaken in the indoor 3G surface facility which is an area of a ¾ sized full pitch; all the matches will be played on grass surface pitches, being played at home and away venues either being at the clubs stadium or training ground facilities, against opposition that are in the U23 professional development league; jump testing on the force plates will be conducted on a flat surface in the changing room facilities of the match and training facility.

e) The physical pre-testing tests have been used as standardised tests in many previous research literature when looking at the physical aspects of soccer. The use of GPS equipment has become very common tool to monitor movement in soccer and many studies have looked at the accuracy and validation of this equipment when interpreting the data produced. Performing a counter movement jump on a force plate is very common method when study fatigue and hen looking at asymmetry in lower limbs, using two force plates syncronised is a common way to compare differences and by using this equipment it can provide accurate and detailed measurements.

18. Participants

Please mention:

a) The number of participants you are recruiting and why. For example, because of their specific age or sex.
b) How they will be recruited and chosen.
c) The inclusion/exclusion criteria.
d) For internet studies please clarify how you will verify the age of the participants.
e) If the research is taking place in a school or organisation then please include their written agreement for the research to be undertaken.

a) The number of participants in the study will be all the players from the Under 23 squad that are selected because all participants would have reached the maturity age and the players would follow the same training schedule that the first team senior squad would. The results from the study can be interpreted basing the data from the participants replicating that of professional male senior soccer players.

b) The participants that are recruited for the study are the players that train and play for the Sheffield Wednesday FC Under 23 squad. The players that are training regularly with this squad and are fit and available for matches are selected.

c) The players that are excluded from this study are goalkeepers. The match data that is included in the study for data analysis and for the follow up jump tests on the force plates are players that compete in the match for a minimum of 75 minutes. Players that complete 75 minutes or more in the match that sustain an injury impairing their jump test performance will also be excluded from the analysis.

Players were requested not to use any different recovery treatments (cold bath, massage, compression garments) throughout the post-match data collection period, which may have affected their recovery.

d) N/A.

e) Attached is the organisations written agreement for the research to be undertaken allowing the usage of participants, data and equipment for this study.

19. Consent

If you have any exclusion criteria, please ensure that your Consent Form and Participant Information Sheet clearly makes participants aware that their data may or may not be used.

a) Are there any incentives/pressures which may make it difficult for participants to refuse to take part? If so, explain and clarify why this needs to be done

b) Will any of the participants be from any of the following groups?

- Children under 18
- Participants with learning disabilities
- Participants suffering from dementia
- Other vulnerable groups.

c) If any of the above apply, does the researcher/investigator hold a current DBS certificate? A copy of the DBS must be supplied **separately from** the application.

d) How will consent be obtained? This includes consent from all necessary persons i.e. participants and parents.

a) There will be no incentives or pressures placed on the participants to take part in the study.

b) No participants in this study will be from the following four groups:
- Children under 18
- Participants with learning disabilities
- Participants suffering from dementia
- Other vulnerable groups.

c) N/A.

d) Prior to the participants taking part in the study, a participant consent form will have to be completed and signed before the participant partakes. The participant consent form will be accompanied by a participant information sheet providing the following:
- The full detail of the research study and the participants role within the research

- The participants freedom to withdraw from research study at any time
- The information and data obtained in the study will remain confidential
- The participant is allowed to ask any questions at any time prior to and during the study

20. Risks and benefits of research/ activity

a) Are there any potential risks or adverse effects (e.g. injury, pain, discomfort, distress, changes to lifestyle) associated with this study? If so please provide details, including information on how these will be minimised.

b) Please explain where the risks / effects may arise from (and why), so that it is clear why the risks / effects will be difficult to completely eliminate or minimise.

c) Does the study involve any invasive procedures? If so, please confirm that the researchers or collaborators have appropriate training and are competent to deliver these procedures. Please note that invasive procedures also include the use of deceptive procedures in order to obtain information.

d) Will individual/group interviews/questionnaires include anything that may be sensitive or upsetting? If so, please clarify why this information is necessary (and if applicable, any prior use of the questionnaire/interview).

e) Please describe how you would deal with any adverse reactions participants might experience. Discuss any adverse reaction that might occur and the actions that will be taken in response by you, your supervisor or some third party (explain why a third party is being used for this purpose).

f) Are there any benefits to the participant or for the organisation taking part in the research (e.g. gain knowledge of their fitness)?

a) The matches could have potential risk of injury and discomfort to the participants whilst they are playing. As this part of the study is observational, there is no increase risk to injury as a consequence of the study design and all participants would normally experience the same physical discomfort as what they normally would too. Elimination of injury in matches is not achievable due to the nature of sport with contact injuries through tackles is a common injury.

b) The CMJ test on the force plate is relatively risk free with a warm up being conducted and with only 3 jumps being performed, the repetitions of maximum efforts is very low minimising the risk of injury.

c) No invasive procedures are performed.

d) Individual feedback forms will be providing number ratings of fatigue and tiredness, meaning no questions are being asked to the participant on the study.

e) The only adverse reaction a participant might encounter is when performing the jump test post-match and the individual feels a pain that they are unsure what has been the cause or a pain that has worsened as a cause of the jump test should mean the participant should withdraw from the test and seek medical treatment.

f) The benefit that the organisation has from allowing the participants to undertake the study are that the results from the analysis is specific to their training programme and can also be used as a procedure that the sport science team continue in order to track the fatigue status of participants to reduce the risk of injury.

21. Confidentiality, privacy and data protection

a) What steps will be taken to ensure participants' confidentiality?

- Please describe how data, particularly personal information, will be stored (all electronic data must be stored on St Mary's University servers).
- Consider how you will identify participants who request their data be withdrawn, such that you can still maintain the confidentiality of theirs and others' data.

b) Describe how you will manage data using a data management plan.

- You should show how you plan to store the data securely and select the data that will be made publically available once the project has ended.
- You should also show how you will take account of the relevant legislation including that relating data protection, freedom of information and intellectual property.

c) Who will have access to the data? Please identify all persons who will have access to the data (normally yourself and your supervisor).

d) Will the data results include information which may identify people or places?

- Explain what information will be identifiable.
- Whether the persons or places (e.g. organisations) are aware of this.
- Consent forms should state what information will be identifiable and any likely outputs which will use the information e.g. dissertations, theses and any future publications/presentations.

a) The forms that participants complete and data sheets with participant's data recorded on will be coded to represent each subject to remain anonymous. Data will not be shared with any of the participants, organisations or anyone else outside of the study. All files are kept in a laptop that is password protected for security. All paper documents signed by participants will stored in a locked cupboard.

b) The data will be stored on a St Mary's University server. The data will be collected and stored straight into excel files, saved under the dates of matches and jump testing. On the completion of data collection, the data will be transferred from the excel documents into SPSS data package to run the analysis to find results from the study carried out.

c) The 2 people that will have access to the data for this study will be myself (Jeremy Poulson) and the supervisor of the study (Mark Waldron).

d) The information produced from the results will not be able to identify the individual participants or the team from the football club within the study. To help hide the identity of participants when providing the data outputs to the relevant parties, the participants can be given individual subject numbers so they can be identified but hiding the identity.

22. Feedback to participants

Please give details of how feedback will be given to participants:

- As a minimum, it would normally be expected for feedback to be offered to participants in an acceptable to format, e.g. a summary of findings appropriately written.
- Please state whether you intend to provide feedback to any other individual(s) or organisation(s) and what form this would take.

The GPS physical match performance data from every game is always placed into a match report that is provided to the team manager and coach. This data is normally fed back to the players via the coaches providing opinion on their overall performance as well as the physical aspect.

The overall findings from the study will be presented to the squad showing the specific findings that are appropriate for the player's development and increasing their knowledge in certain aspects that could help with recovery strategies or conditioning specific areas.

The coaches working with the squad will also provide information on the findings that are specific to the group of players that they are working with on a daily basis and the information provided might help inform their decision making for the future and considering these findings when applying certain training drills or designing training programmes.

The proposer recognises their responsibility in carrying out the project in accordance with the University's Ethical Guidelines and will ensure that any person(s) assisting in the research/ teaching are also bound by these. The Ethics Sub-Committee must be notified of, and approve, any deviation from the information provided on this form.

Signature of Proposer(s) Jeremy Poulson	Date: 7th December 2016
Signature of Supervisor (for student research projects) Dr Mark Waldron	Date: 7th December 2016

Appendix 2 - Risk Assessment

Risk Assessment

	Risk	**Risk Level**	**Prevention**
Force Plate Jumps	Hitting head when jumping	Medium	Ensure the height of the ceiling is tall enough to allow the full jump to be completed without any risk of hitting the ceiling or object above the force plate.
	Falling off	Low	Start jump with feet on middle of force plate.
	Wires to laptop – trip hazard	Low	Tape down all the wires to the floor.
	Injury	Medium	Undertaking a warm up, prior to jumping. First aid kit. Medical questionnaire filled out.
Matches	Jewellery	Low	Match officials ensure players are not wearing any jewellery going out onto the pitch.
	Conduct of spectators	Medium	The spectators are behind the crowd barriers and club officials remain in the technical area.

	Dehydration	Medium	Ensure players drink adequate amounts prior, during and after the match. Provide water bottles for the players.
	Weather Extremes	Medium	Match officials consulted regarding the weather.
	Injury – Goal Posts	Low	Goal secured fixed and weighted down to the ground.
	Injury - Ball	Low	Ball fully inflated and no peeling
	Injury - Physical	Medium	Undertaking a warm up, prior to match. First aid kit. Medical questionnaire filled out. Shin pads worn.
	Pitch Condition	Low	Ground staff and match official consulted for the condition of the pitch. Suitable football boots worn.

Data	Losing Data	Low	Backing up data onto the St Marys University server.
	Confidentiality	Medium	Storing the data secured in a locked laptop which is password protected.

Appendix 3 - Information Sheet and Consent Form

St Mary's University Twickenham London

Participant Information and Consent Letter

Project Title: The effect of match-load on post-match lower limb asymmetries in elite soccer players.

Project by: Jeremy Poulson **e-mail**: 154992@smuc.ac.uk

Supervisor: Dr Mark Waldron **e-mail:** mark.waldron@stmarys.ac.uk

Ethics Coordinator: Claire Tapia **e-mail**: claire.tapia@smuc.ac.uk

The following study will involve participants performing competitive matches whilst wearing a GPS device. Individuals GPS device will be analysed for the activity profile assessing the physiological variables, running analysis and metabolic load using this data. Participants will also be required to perform three counter movement jumps on a force platform, prior- and post-match, 24, 48 and 72 hours post-match.

The main objective of the study is to compare the jumping performance between legs before and after the match. The physiological demands of competitive matches will be analysed for link with the jump performance if asymmetries exist between legs. Specifically, the study aims to investigate the specific physiological variables that would explain the causal effect of fatigue between legs.

The risks involved in this study are minimal in healthy subjects. Any contraindications for the testing methods noted above will be adhered to and a full risk assessment will be completed. Any information regarding this is available on request.

Data collected from the study is strictly confidential with none of your personal details being recorded. You are free to withdraw from this research project at any time and can do so by contacting any of the above contacts.

Please tick box

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason. ☐

3. I have read and completed the physical activity and readiness questionnaire. ☐

4. I agree that my data gathered in this study may be stored (after it has been anonymised) in a safe placee and may be used for any purposes connected with the research project as outlined to me. ☐

5. I agree to take part in the above study. ☐

By signing this form you agree to take part in this research study;

Print Name: **Signed:** **Date:**

Thank you for taking the time to fill out this questionnaire,

Jeremy Poulson

Appendix 4 - Physical Activity and Readiness Questionnaire

St Mary's University Twickenham London

Physical Activity & Readiness Questionnaire

Question	Yes	No
Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?	☐	☐
Do you feel pain in your chest when you do physical activity?	☐	☐
In the past month have you had chest pain when not doing physical activity?	☐	☐
Do you lose your balance because of dizziness or do you ever lose consciousness?	☐	☐
Do you have a bone or joint problem that could be made worse by taking part in physical activity?	☐	☐
Do you currently have high blood pressure or a heart condition?	☐	☐
Are you currently taking any medication?	☐	☐
Do you know of any other reasons why you should not take part in physical activity?	☐	☐

Participant Name: **Signed:** **Date:**

Appendix 5 - Letter of Consent from Organisation

SHEFFIELD WEDNESDAY FOOTBALL CLUB
Hillsborough Sheffield S6 1SW.
T 03700 20 1867 **F** 0114 221 2122
www.swfc.co.uk

THE FOOTBALL LEAGUE
FAMILY EXCELLENCE AWARD 2015

Sheffield Wednesday Football Club,
Sheffield Wednesday FC Training Ground,
Middlewood Road,
Sheffield,
S6 1TF.

30th November 2016

<u>Dissertation Data Approval</u>

Dear Sir,

We can confirm that our employee, Jeremy Poulson, who is currently undertaking his MSc Strength and Conditioning degree with yourselves at St Mary's University, has permission to use the data and our players as participants for his dissertation.

We will be providing equipment that we own to assist with his data collection.

Yours Sincerely,

Andy Kalinins

Sheffield Wednesday Football Club
Performance Director

CHANSIRI
Official Club Sponsor

Sondico PROFESSIONAL
Official Kit Supplier

Registered in England No. 2509978

Appendix 6 - Ethical Approval

St Mary's University Twickenham London

Approval Sheet

Name of applicant: Jeremy Poulson Name of supervisor: Mark Waldron Programme of study: MSc. Strength and Conditioning Title of project: The effect of match load on post-match lower limb asymmetries in elite soccer players

Supervisors, please complete section 1 or 2. If approved at level 1, please forward a copy of this Approval Sheet to the School Ethics Representative for their records.

SECTION 1 Approved at Level 1 Signature of supervisor (for student applications Date: 22/1/16
SECTION 2 Refer to School Ethics Representative for consideration at Level 2 or Level 3 Signature of supervisor... Date..
SECTION 3 To be completed by School Ethics Representative Approved at Level 2 Signature of School Ethics Representative: J Hill Date 08/12/2016