# Cardiff School of Sport

**DISSERTATION ASSESSMENT PROFORMA:**

**Empirical**

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<tr>
<th>Student name:</th>
<th>Matthew Craythorne</th>
<th><strong>Student ID:</strong></th>
<th>10001813</th>
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<td>Programme:</td>
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<td>A post activation potentiation study: The acute effect of a heavy resistance Romanian dead lift and resisted sprint pull upon 30 metre sprint performances in sprinters</td>
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<td><strong>Supervisor:</strong></td>
<td>Joseph Esformes</td>
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## Title and Abstract
Title to include: A concise indication of the research question/problem. Abstract to include: A concise summary of the empirical study undertaken.

## Introduction and literature review
To include: outline of context (theoretical/conceptual/applied) for the question; analysis of findings of previous related research including gaps in the literature and relevant contributions; logical flow to, and clear presentation of the research problem/question; an indication of any research expectations, (i.e., hypotheses if applicable).

## Methods and Research Design
To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol.

## Results and Analysis
To include: description and justification of data treatment/data analysis procedures; appropriate presentation of analysed data within text and in tables or figures; description of critical findings.

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## Presentation
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CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE
(HONOURS)

SPORT CONDITIONING, REHABILITATION
AND MASSAGE

A POST ACTIVATION POTENTIATION STUDY:
THE ACUTE EFFECT OF A HEAVY RESISTANCE ROMANIAN DEAD LIFT AND A RESISTED SPRINT PULL UPON 30 METRE SPRINT PERFORMANCES IN SPRINTERS

PHYSIOLOGY

MATTHEW CRAYTHORNE

10001813
MATTHEW CRAYTHORNE

ST10001813

CARDIFF SCHOOL OF SPORT

CARDIFF METROPOLITAN UNIVERSITY
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Acknowledgements

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Abstract

Post activation potentiation (PAP) increases levels of muscle twitch force and synaptic activity through prior voluntary maximal muscle contractions (Folland et al., 2008). Performing muscle contractions with near maximal loads prior to an explosive movement of similar biomechanical properties improves subsequent peak force production and rate of force development (Hodgson et al., 2005; Lim and Kong, 2013). Sprint performance is a direct result of impulse (mean force x contact time) thus coaches have strived to improve the strength and power profiles of athletes (Alcaraz et al., 2009).

The aim of this study is to investigate whether performing a heavy resistance Romanian dead lift (RDL) would improve 30 metre sprint times and whether a resisted sprint pull would improve 30 metre sprint times and stride length.

4 male university level sprint athletes (21±1.6 years of age) completed three separate sprint trial tests on separate weeks. Randomised protocol consisted of a baseline maximal 30 metre sprint, 15 minutes rest, a control (active rest), RDL (3x1 at 80% 1RM) or resisted sprint pull (2x30 metre weighted sled pull) intervention, 7 minutes rest, then a maximal 30 metre sprint.

Individual athlete response was analysed, considering individual responses to PAP. A RDL did not significantly improve sprint times, although improved 10-20- and 30 metre times were observed and mean stride length significantly improved. Results from the RDL intervention presented evidence that potentiation is dependent upon strength levels. The resisted sprint pull did not significantly improve sprint times, although improved sprint times were observed and stride length and stride frequency significantly improved.

The results present evidence that a RDL and resisted sprint pull are both effective at significantly improving sprint technique. Through an improved protocol the results suggest the potential for both exercises to be successful at significantly improving sprint times as part of PAP protocol in future research.
CHAPTER ONE

INTRODUCTION
1.0 Introduction

Analysis of athlete performance indicates that speed, strength and power have an impact upon sport performance (Tonnessen et al., 2011; Fanchini et al., 2013; Ingebrigtsen et al., 2013), for instance, strength and power positively correlate with sprint time and jump distance (Comfort et al., 2012; Hermassi et al., 2012). Evolution of sport has heightened competitiveness and increased physiological demand thus emphasising the requirement for athletes to perform to their physical potential (Lim and Kong, 2013). Consequently, research has studied training methods that can be implemented during training and/or pre-competition preparation to optimise an athlete’s power thus enhancing performance. One such method is post activation potentiation (PAP).

PAP has been defined as the preconditioning of muscle through high resistance exercise that subsequently induces acute performance enhancement (Crewther et al., 2011). Performing muscle contractions with near maximal loads prior to an explosive movement of similar biomechanical properties improves subsequent muscle contraction properties, increasing peak force production and rate of force development (Hodgson et al., 2005; Lim and Kong, 2013). The magnitude of effect of potentiation in muscle has been observed to correlate to the intensity of activity, with effect suggested to peak 7-10 minutes post intervention (Lowery et al., 2012; Wilson et al., 2012). Although research has improved muscle peak power through prior isometric muscle contractions (Esformes et al., 2011), dynamic movements consisting of concentric and eccentric muscle contractions have also improved subsequent muscle performance. Plyometrics (Deneke et al., 2010), weightlifting (McBride et al., 2005; Moir and Yetter, 2008) and sport specific heavy resistance implements (Matthews et al., 2010; Judge et al., 2011) have all been proven to improve jumping, throwing and sprinting capability.
The precise mechanism of PAP that produces acute positive physiological adaptations has not been clarified and different theories are proposed. The phosphorylation of myosin regulatory light chain is one theory, increasing the sensitivity of actin and myosin to the presence of calcium thus increasing the number of cross-bridges and musculotendinous tension (Behm, 2004; Hodgson et al., 2005). Another theory attributes PAP to the increased excitability of alpha motoneurons after muscular activity, increasing the muscle response to stimuli (Gullich and Schmidtbleicher, 1996; Iglesias-Soler et al., 2011).

Research has investigated the effect of PAP upon sprint performance, considering that sprint performance is a direct result of impulse (mean force x contact time) thus associates with strength and power (Alcaraz et al., 2009). Movements of perceived compatible biomechanical properties to sprinting have been implemented in an attempt to improve sprint times. A heavy resistance back squat and front squat significantly decreased sprint times (McBride et al., 2005; Yetter and Moir, 2008; Linder et al., 2010), although a back squat (Comyns et al., 2010; Lim and Kong, 2013), dead lift (Till and Cooke, 2009) and power clean (Guggenheimer et al., 2009) have been ineffective in improving performance. The failure of weightlifting exercises to enhance sprint performance has been attributed to the ineffective transfer of exercises to sprint specific movement (Young, 2006). Literature identifies the relationship between hip extensor activation and velocity with acceleration and maximal velocity sprinting performance (Bezodis, N. et al., 2008; Bezodis, I. et al., 2008; Hunter et al., 2005), considering that a Romanian dead lift (RDL) activates the hip extensors greater than a back squat (Wright et al., 1991; Bird and Barrington-Higgs, 2010). Alternatively, literature proposes a sport specific resistance exercise, such as a weighted sled pull, as the most appropriate longitudinal training modality to produce beneficial sprint performance adaptations (Young, 2006; Alcaraz et al., 2008). However, according to this author only one published study has researched the acute effects of a resisted sprint pull within PAP intervention, which significantly decreased times (Matthews et al., 2010).
Acknowledging the relationship between sprint performance and hip extensor biomechanics, whilst identifying exercises that effectively activate the musculature, aims to contribute to PAP protocol literature. A track based resisted sprint pull PAP modality has not been published, although proven effective within ice based sprints, whilst research supports the biomechanical compatibility between sprint technique and a RDL. Additionally, research has reported the performance outcomes of PAP interventions but failed to analyse performance descriptors, an area of research that this study aims to investigate whilst contributing to the debate surrounding the specificity of resistance training of sprint athletes.
CHAPTER TWO
LITERATURE REVIEW
2.0 Literature Review

2.1 Introduction

Sports science professionals have investigated the efficacy of chronic and acute training interventions with the potential to enhance athletic performance, attempting to improve their athlete’s competitiveness and success within sport. Empirical evidence proposes PAP as an effective performance enhancement method that can optimise power production during training and/or competition, although the optimal combination of variables in a protocol has not been clarified. Although recommendations are proposed, the selection of variables within a protocol ranges and literature continues to debate procedure.

2.2 Post Activation Potentiation Research

Research has investigated the existence of potentiation in skeletal muscle, confirming the presence in both animals and humans (MacIntosh and Willis, 2000; Rassier and Herzog, 2002; Folland et al., 2008). In context to sport, the presence of potentiation has been investigated through electromyotherapy, which indicates increased levels of muscle twitch force and synaptic activity following voluntary maximal muscle contraction (Folland et al., 2008). The proposed practical application is that an athlete which performs a preload activity requiring muscle contractions with near-maximal load prior to a movement of similar biomechanical characteristics will enhance ensuing muscle contractions (Lim and Kong, 2013), increasing peak power and rate of force development (Hodgson et al., 2005). The higher recruitment of fast twitch muscle fibres during peak muscle contraction (Coburn et al., 2005) highlights the beneficial effect upon performance PAP can produce through improving the muscle contraction properties of a fast twitch muscle fibre, transferring to improved performance during speed and power movements that require peak muscle contraction.
PAP research has been described as contradictory showing large variations in methods and results (Till and Cooke, 2009). Current literature has investigated the efficacy of exercises in an effort to determine the optimal exercise in which to elicit PAP, utilising plyometrics, weightlifting and heavy weight sport specific implements as modalities. Judge et al. (2011) improved throw distance of high school athletes, performing heavy implement throws prior to maximal effort performance with a lighter competition weight implement. Deneke et al. (2010) improved the 3 step approach vertical jump height in volleyball players, inserting 1x10 maximal countermovement jumps wearing a weighted vest with 20% of body weight in the players warm up. McBride et al. (2005) improved sprint performance performing 3x1 at 90% 1RM repetitions of back squat prior to a sprint. Matthews et al. (2010) used a resisted sprint method to also improve sprint times, decreasing 25 metre sprint times in ice hockey players. However, Guggenheimer et al. (2009) reported that performing 3 power clean repetitions at 90% 1RM before a 40 metre sprint failed to enhance performance, which is an exercise claimed to be biomechanically compatible with and proven to correlate with sprint performance (Hori et al., 2008). Additionally, a back squat has also proved ineffective at enhancing subsequent sprint performance (Lim and Kong, 2013), although proven as an effective exercise in former studies. Evidently, the magnitude of effect of PAP is dependent upon the protocol. Ineffective protocols within PAP research could be attributed to various factors, consisting of the combination of inconclusive research upon the recommendations of variables in protocol and mechanisms of PAP.

2.3 Physiological Mechanism of Post Activation Potentiation

The mechanism of PAP has been studied to clarify and explain the precise contributing factors that result in enhanced physiological function, improving understanding and perhaps therefore practical application. A known factor is that the capability of skeletal muscle to respond to volitional stimuli is affected by its contractile history, the most obvious affect of contractile history being fatigue (Hodgson et al., 2005). However, fatigue can coexist with potentiation and it is known that higher levels of potentiation exist in fatigued muscle in
comparison to rested muscle, experiencing the benefits of potentiation once fatigue dissipates (Rassier and Herzog, 2001; Hodgson et al., 2005). Although the beneficial effects of PAP have been effectively applied in practice, literature is inconclusive upon the mechanism of PAP thus different theories exist.

2.3.1 Phosphorylation of Regulatory Light Chains

Skeletal muscle myosin light chain kinase is a calcium dependent protein kinase that is found in great abundance in skeletal muscle fast twitch fibres, in comparison to skeletal muscle slow twitch fibres (Stull et al., 2011). Skeletal muscle sarcomeres consist of actin and myosin filaments that form cross bridges through the release of calcium that binds troponin to actin filaments, which shorten producing muscle contraction when force is applied through them (Kamm and Stull, 2011; Stull et al., 2011). Literature suggests that the phosphorylation of the regulatory light chains of these myosin fibres is the mechanism responsible for PAP (Razzier and Herzog, 2001). Phosphorylation of the regulatory light chains increases the sensitivity of myosin to calcium and increases the intensity of calcium release, through the insertion of additional neural impulses with increased motor neuron impulse activity (Razzier and Herzog, 2001; Behm, 2004; Hodgson et al., 2005). Consequently, muscle stiffness is enhanced as a result of an increased number of cross-bridges and a decrease in compensation of slack in musculotendinous units (Behm, 2004). Muscle stiffness is an important component in optimising the stretch shortening cycle of skeletal muscle, an important component of muscle contraction that influences sprinting (Harrison and Gaffney, 2004).

2.3.2 Recruitment of Motor Units

Another theory attributes PAP to the increased excitability of alpha motoneurons after muscular activity, increasing the muscle response to an afferent neural volley (Gullich and Schmidtleicher, 1996). This theory can be measured through the Hoffman reflex, which measures the efficacy of
synaptic transmission between afferent fibres and alpha motoneurons resulting from changes in spinal excitability (Iglesias-Soler et al., 2011). However, research has concluded that when effectively eliciting potentiation the Hoffman reflex failed to show a change in spinal activity (Iglesias-Soler et al., 2011). However, one study reported evidence of both electrical and mechanical potentiation post PAP intervention in the quadriceps muscle following a 10 second voluntary maximal isometric contraction of the quadriceps, failing to enhance performance but reporting increased levels of muscle twitch force and H-reflex post intervention (Folland et al, 2008). Literature presents evidence of the existence of both electrical and mechanical potentiation theories post voluntary maximal activity, although no performance enhancement was reported with the presence of electrical potentiation and thus debates the contribution of the theory to performance in comparison to the mechanical potentiation theory.

2.4 Biomechanical Demands of Sprinting

Another inconclusive area within PAP literature is the selection of exercise to effectively potentiate muscles improving sprint times. Research has made future recommendations regarding the specificity of training exercises to combat the failure of PAP protocol exercises, highlighting the lack of consideration of performance mechanics. A theoretical solution proposed by literature is to consider the demands of a sprint, identifying key technical components of performance and their mechanics, consequently highlighting a potential compatible and rational resistance exercise to utilise within PAP protocol.

Sprint speed is determined by the optimal combination of both step length and step frequency, although literature has not concluded which is the most critical factor (Debaere et al., 2013). The start phase of a sprint requires an athlete to rapidly accelerate from a stationary set position, an important phase of a sprint in athletics (Bezodis, N. 2008). An athlete that exerted the greatest power upon sprint blocks during a sprint start experienced the greatest range of motion and angular velocity during hip extension (Bezodis, N. et al., 2008).
During the acceleration phase, hip extensors are active and increase in activity as speed increases, suggesting their importance for both acceleration and maximal speed sprinting (Young et al., 2001; Bezodis, I. et al., 2008). Hunter et al. (2005) investigated the relationship between ground force reaction data and kinematics of sprint running, reporting the greatest predictor of maximal sprint velocity was relative horizontal impulse. Considering this information, a greater hip joint extension velocity mean during the stance phase in relation to horizontal propulsion was partially supported. This was an expected result because athletes with good acceleration ability would experience greater horizontal velocity during each stance phase, according to the authors.

![Figure 1. Correlation between horizontal impulse and maximal sprint velocity (Hunter et al., 2005).](image.png)

Empirical research presents the partial correlation between hip extensor angular velocity with horizontal impulse, considering that horizontal impulse has a direct relationship with maximal sprint velocity, which is a predictor of sprint performance. Additionally, the relationship between hip extensor activation, range of motion and superior sprint performance during the start, acceleration and maximal velocity phases of sprint performance is evident. This highlights the potential acute enhancement of acceleration and maximal velocity thus decreasing sprint times through potentiating the hip extensor musculature (biceps femoris, semitendinosus, semimembranosus and gluteus
maximus), increasing activation and potentially velocity therefore impulse and performance.

2.5 PAP Research upon Sprints and Heavy Resistance Exercise

Sprint performance is a direct result of impulse (mean force x contact time) thus coaches have strived to improve the strength and power profiles of athletes across sport (Alcaraz et al., 2009). Performance enhancement will only occur with the overload of movements similar to sport context (Keogh et al., 2010), evident through heavy resistance exercises improving sprint times through PAP, potentiating the hip, quadriceps and hamstring musculature (McBride et al., 2005; Moir and Yetter, 2008).

2.5.1 Back Squat

The back squat exercise has been proven to be largely effective at enhancing sprint performance over a range of distances. Linder et al. (2010) improved 100 metre sprint times of female athletes, using a single set of 4RM half squat procedure. Moir and Yetter (2008) improved 40 metre sprint times when implementing a parallel back squat procedure consisting of 1x5 at 30% 1RM, 1x4 at 50% 1RM and 1x3 at 70% 1RM. Although both studies used effective protocols, their methodology included participants with varying levels and type of sport participation, decreasing the practical application to elite athletes. The data would not transfer to elite level athletes due to differences of physiological adaptations in trained versus recreational individuals, such as fatigue resistance and higher muscle fibre adaptation (Razzier and Herzog, 2001; Ereline et al., 2011).

Reviewing studies that have used athletes as participants improves the practical application of data to elite athletes. McBride et al. (2005) used football players and implemented a protocol consisting of 3x1 repetitions at 90% 1RM with 4 minutes rest between intervention and sprint trials. The intervention improved subsequent 40 metre sprint times but did not significantly improve 10- and 30 metre sprint splits. Similarly, Lim and Kong
(2013) had sprinters perform a back squat with 3x1 repetitions at 90% 1RM, with a 4 minute recovery period between intervention and trial. The protocol had no significant effect upon subsequent 10-, 20-, or 30 metre sprint times throughout participants. However, the authors reported some participants did experience decreased sprint times, highlighting the importance of the implementation of a unique protocol to performers to emphasize the magnitude of effect of PAP. Both studies used trained athletes (>1 year resistance training experience) and also with strength levels requiring athletes to be able to perform 150% body mass back squat, in accordance with research recommendations (Rassier and Herzog, 2001). The limiting factor of sprint acceleration during both investigations could be attributed to the limited rest period between intervention and sprint and the sub maximal activation of the hip extensors during squat technique.

2.5.2 Deadlift

PAP and sprint performance research has successfully improved sprint times using the back squat (McBride et al., 2005; Yetter and Moir, 2008; Linder et al., 2010), however the multi-dimensional nature of sprinting indicates the potential improvements through other specific exercises (Moir and Yetter, 2008). Till and Cooke (2009) did not report a significant improvement in 10 metre and 20 metre sprint times in academy soccer players when performing a 5x5 of 5RM dead lift. Although not significant enough an improvement, 10- and 20 metre sprint times did improve by 2.93% and 2.64% respectively in comparison to control group sprint times. Although all players were familiar with performing a dead lift, certain elements of the study could explain their lack of positive data, for instance the academy players were tested during their season potentially fatigued from competitive fixtures. Furthermore, the lack of sprint training experience of players could be of detriment to results and the rest period of 4, 5 and 6 minutes, in contrast to Wilson et al.’s (2012) recommendation of rest between 7-10 minutes. Furthermore, the intensity of the exercise is also questionable, falling into the lesser intense category in comparison to recommendation of moderate intensity activity (Wilson et al., 2012). This potentially suggests the importance of the potentiation of the
posterior chain and hip extensors during the acceleration phase, in comparison to a back squat only improving times at 40 metres.

2.5.3 Romanian Dead Lift

A Romanian dead lift elicited a greater hip moment and produced a superior activation of hip extensor muscles, indicated through electromyotherapy data extracted from the biceps femoris and semitendinosus muscles (Wright et al., 1999; Clewien et al., 2006; Ebben et al., 2010; Swinton et al., 2011). Furthermore, a dead lift allows a greater overload whilst producing similar ground force reaction data (Ebben et al., 2010; Swinton et al., 2011), potentially increasing the mechanical potentiation of muscle through greater intensity of movement whilst maintaining similar ground force reaction. Therefore, with the combination of recommended protocol and consideration of sprint mechanics and weightlifting biomechanics it is hypothesized that the RDL exercise would enhance sprint acceleration and maximal velocity through PAP.

![Graph showing EMG activity comparisons](image)

Figure 2. The EMG activity comparisons of concentric and eccentric muscle contractions during a leg curl (LC) RDL/Stiff leg dead lift (SLDL) and squat (SQ) (Wright et al., 1999).
2.5.4 Resisted Sprint Exercise

Weightlifting resistance exercises fail to transcend to sprint performance due to lack of specificity to sprint movement (Young, 2006). In accordance, Alcaraz et al. (2008) suggest a sprint athlete should perform sport specific resisted exercises in training, such as a weighted sled pull. A weighted sled pull is an effective longitudinal training method used to improve athlete sprint performance, particularly acceleration, allowing overload without detriment to an athlete’s technique when using the appropriate load in relation to athlete body mass (Alcaraz et al., 2007; Alcaraz et al., 2008; Bourke and Harrison, 2009; Bevan et al., 2012). Further recommendations include attaching the harness around the waist of the athlete to reduce torso lean and avoid reinforcement of incorrect technique and application of force to the ground, as the higher the resistance above the centre of mass the greater the lean required to counteract the load (Alcaraz et al., 2008).

When sprinting whilst pulling a weighted sled, athletes were observed to reduce stride frequency, reduce stride length and increase contact time (Lockie et al., 2003; Alcaraz et al., 2008), proposed to produce beneficial adaptations including increased stride length, increased stride frequency and development of specific strength (Alcaraz et al., 2008; Alcaraz et al., 2009; Lockie et al., 2012). Lockie et al. (2012) reported increased mean step length but no step frequency improvements after participants performed resisted sprint training twice a week for 6 weeks with 12.6% of their body mass. Research recommends that when implementing resisted sprint training into a training programme that 10% of body mass is the optimal weight in which to overload the athlete, not decreasing sprint velocity by more than 10% and to not be of detriment to technique (Alcaraz et al., 2008). However to potentiate muscles, the intensity of movement is recommended to be of moderate intensity, specifically between 60-84% (Wilson et al., 2012), with Keogh et al. (2010) in support stating that when overloading the muscles in movements similar to the sport will improvements only occur. Moreover, heavy resistance longitudinal training programmes have improved sprint times and without
detriment to technique, although using partner band resistive techniques which is a subjective measurement of resistance (Myer et al., 2007).

To the author’s knowledge, only one published study has practically applied the potential benefits of a resisted pull as a PAP intervention modality. Matthews et al. (2010) investigated the acute effects of a resisted sprint in ice hockey players. The players performed a resisted sprint for 10 seconds and then rested for four minutes before a 25 metre sprint trial. Compared to a control group, the intervention decreased sprint time on average 0.091 ± 0.088 seconds. However, the resistance was produced through a player holding on to a cord that looped around the waist, a subjective means of resistance that was not measured. Therefore, the resistance applied to each athlete would differ as well as the potentiating effects without an objective measure of resistance. Although the protocol was effective at improving sprint performance, the use of objective measures would improve the practical application of data, allowing replication by professionals. This research provides further efficacy for investigating the PAP effects of a resisted sprint pull activity.

![Ice based resisted sprint pull (Matthews et al., 2010).](image)

Figure 3. Ice based resisted sprint pull (Matthews et al., 2010).
2.6 Protocol

As mentioned previously, PAP research has shown large variations in methods (Till and Cooke, 2009). Wilson et al. (2012) recognised the issue and conducted a meta-analysis upon current PAP research, analysing the modalities that successfully induced PAP and enhanced subsequent performance. The meta-analysis results concluded that the optimal combination of factors consisted of multiple sets performed of exercise repetitions at 60-84% intensity, 7-10 minutes rest between intervention and performance and the use of trained athletes (>3 years). The research by Wilson et al. (2012) is hypothesized through the analysis of current literature but is yet to be shown largely effective through research results.

Participants 2.7

The degree of effect of potentiation produced through a protocol is evident to be unique to an individual. The failure to effect sprint performance with a particular preload activity is due to the specificity and pertinence to the physiological responses of an athlete (Guggenheimer et al., 2009; Till and Cooke, 2009; Lim and Kong, 2013). This suggests the importance of the consideration of the physiological factors of the participants, optimising the beneficial effects of PAP and enhancing performance.

Resistance trained athletes have shown to benefit greater from the effects of PAP, attributed to the combination of the increased resistance to fatigue and increased ability to potentiate (Rassier and Herzog, 2001). In accordance, the greater effect of PAP appears to be dependant upon the strength levels of the individual (McBride et al., 2005). Additionally, fast twitch fibres are evident to possess a greater capability to potentiate, a trainable attribute in power athletes (Ereline et al., 2011). An athlete will adapt to training stressors over a period of time and, although still unique to a degree in the individual, will effectively dissipate fatigue and adapt to stimulus in comparison to an untrained counterpart. Wilson et al. (2012) recommend the use of trained athletes with a minimum of 3 years resistance training to successfully...
potentiate muscles, whilst Till and Cooke’s (2009) study suggests the use of athletes that have also experience of sprint training. Therefore, using sprinters as participants who have suffice resistance training experience will address these recommendations.

2.8 Rationale

Research has failed to effectively implement traditional resistance exercises as part of PAP protocol, suggesting the lack of comparative biomechanical properties to sprinting. Considering appropriate literature, the rationale of a RDL as a PAP intervention is subject to the role of the hip extensors as an important component of sprint performance and the effective activation of this muscle group during the weightlifting exercise (Wright et al., 1999). Furthermore, research has not investigated the potential PAP effects of a resisted sprint upon track based sprint performance, although shown to improve stride length and sprint performance as part of a training programme (Lockie et al., 2012) but research does present the efficacy of protocol upon other surfaces (Matthews et al., 2010). Furthermore, research has reported performance outcome but not performance descriptors, not explaining how performance has improved. Additionally, few studies have been conducted comparing different methods of exercise that can elicit PAP (Till and Cooke, 2009), therefore this study will aim to contribute to the debate surrounding whether resisted sprints or weightlifting training methods are most effective at enhancing athlete performance.

2.9 Aims

The primary aim of this study is to observe and analyse the positive and negative effects of performance in relation to the proposed interventions. Analysing the potentiating effects of a weightlifting exercise and a resisted sprint exercise will aim to contribute to the debate surrounding the specificity of exercises in relation to training of sprint performance. Furthermore, adopting a case study approach and analysing the individual athlete reaction
to PAP protocol in relation to strength levels, will follow the recommendation of research to consider the individual physiological properties. Finally, PAP research has reported the performance outcomes of potentiation protocol but has failed to report how performance characteristics have changed to improve performance, therefore this research will analyse stride frequency, stride length and contact time of sprint performance.

2.10 Hypotheses

This research hypothesises that performing a 3x1 at 80% RDL would effectively elicit PAP, decreasing athlete 30 metre sprint times. A second hypothesis is that performing a weighted sled pull, with a load of 50% body mass would effectively elicit PAP and decrease athlete 30 metre sprint time. A third hypothesis is that a weighted sled pull will increase stride length.
CHAPTER THREE

METHODOLOGY
3.0 Methodology

3.1 Introduction

The current study will require four separate days of testing, performed within a weights room and an indoor running track. Testing will consist of one day of RDL 1RM determination followed by three separate testing sessions of randomized order, consisting of a control, RDL and resisted sprint pull intervention. Sprint intervention testing sessions will be conducted on separate weeks, allowing adequate rest between trials whilst not disrupting the athletes training schedules. Additionally, prior to RDL 1RM determination, athletes will attend a RDL technique familiarisation session in the weightlifting room in an attempt to ensure correct technique during RDL lifting, preventing injury and optimising activation of hip extensors. Participants are, however, familiar with the weighted sled pull technique, utilising the exercise during training, therefore not requiring a familiarisation session with this exercise. The study will require four Smart speed timing gates (SMART speed smart jump, Fusion Sport, Brisbane, Australia) to record sprint split times and the Optojump system (Version 3.01.0001, Microgate, Bolzano, Italy) to record descriptive sprint performance data.

3.2 An Experimental Approach

The aim of the current study is to compare the individual responses of subjects to an RDL and weight sled pull as a PAP stimulus upon 30 metre sprint times and descriptive performance data, consisting of stride length, stride frequency and contact time. The study is hypothesised to significantly improve 30 metre sprint times through a RDL and resisted sprint pull intervention. An additional hypothesis is that the resisted sprint pull, in the form of a weighted sled pull, will significantly improve stride length.

Subjects participated in a control group where they performed a dynamic warm up before performing a baseline sprint, then having active rest for 15 minutes until performing another maximal sprint trial. On a separate week
participants performed a dynamic warm up, 30 metre baseline sprint and rested 15 minutes before performing 3x1 at 80% 1RM RDL, resting 2 minutes between sets and resting 7 minutes prior to performing a maximal 30 metre sprint trial. Finally on a separate week again, participants performed a dynamic warm up, a 30 metre baseline sprint and then rested 15 minutes before performing 2x30 metre sled pulls, resting for 2 minutes between sets and 7 minutes between intervention and maximal 30 metre sprint trial.

### 3.3 Participants

The subjects were recruited from a university athletics team and were eligible if they competed in a track sprint discipline, possessed weightlifting training experience extending over the previous 3 years, as recommended by Wilson et al. (2012), and did not have an injury that would affect physical participation. 5 male sprint athletes (21±1.6 years of age) were eligible for voluntary participation, competing in 60-, 200- and 400 metre sprint disciplines. Participants were informed of the risks of participating in this research and presented with a study information form and also completed an informed consent sheet. Data was collected during the indoor competition/winter training season.

### 3.4 Instruments

The study required an Olympic standard barbell and accompanying weighted discs (Ivanko, Nevada, USA), a lifting platform, weight lifting blocks and a resisted sprint training sled with waist harness to complete the prescribed resistance exercises. The weighted sled pull and sprint performances were performed upon a competition standard indoor athletics track, presenting a flat surface for the sled to move over and for athletes to sprint on. Athletes performed sled pulls and sprint trials wearing their training sprint spikes, maintaining reliability and practical application of data. A SMART speed light gait was positioned at 10 metre intervals for 30 metres, accurately recording sprint trial times. A measuring tape was used to measure 10 metre intervals where SMART speed gaits were positioned, although not a highly accurate
method of measurement, great care was taken to maintain a high level of accuracy when measuring 10 metre intervals with the tape. Optojump recorded data for 15 metres from athlete performances, allowing the study to analyse stride frequency (Hz), stride length (cm) and contact time (seconds). Approval from Cardiff Metropolitan University’s Ethics Committee was granted and written informed consent attained from each subject.

3.5 Procedure

Protocol was selected on the day through a randomised, blind, crossover design.

3.5.1 1RM Testing

Initially, participants visited the weightlifting gym during a technique familiarisation session to practice the RDL technique, conducted on a day prior to when the 1RM test was conducted. A 1RM determination test was conducted so subsequent loads could be calculated when athletes performed the RDL intervention. Procedure started with a standardised dynamic warm up, including sub maximal RDL lifts which consisted of ascending loads and descending volume. Subjects then estimated the maximal load that could be lifted for 1 repetition and then added 2.5-5kg until the athlete reached the maximal load they could lift prior to fatigue, as recommended by Akalan et al. (2003). Subjects were advised to aim to attain their 1RM score within 5 attempts, reducing the affect of fatigue upon absolute load lifted. Subjects rested for 2 minutes between attempts, recommended by Bibbee (2010). A successful lift was judged following the criteria set of retaining the correct technique, which consisted of retaining spinal integrity, a constant angle at the knee joint, heels in contact with the floor and arms extended with the bar in contact with the thighs. Correct technique was to be accompanied by full range of motion of exercise, with criteria set at lowering the bar to the top of the patella, arms extended, before returning to an upright standing position.
3.5.2 Control Testing

30 metres was measured along the track with a 30 metre measuring tape, using the lines of a lane to retain a straight line. Smart speed gaits were placed either side of a lane, starting at 0 metres which was at the start of the tape and then 10 metre intervals thereafter for 30 metres. The gates were then switched on and aligned and walked through to check they were switched on and ready to record times. The Optojump system was then aligned along the inside of the same lane for 15 metres, positioned inside of SMART speed gaits, with transmitter bars and receptor bars parallel. Optojump was checked to work by calibrating the system and ensuring all green lights were showing, turning the lights red if a subject disrupted the signal between parallel bars by placing a foot on the track between the bars.

Volunteers performed their standard pre track session dynamic warm up, consisting of dynamic stretches, technical drills and sub-maximal sprinting. Participants started sprints from a standing position, starting on their own accord, inhibiting reaction times affecting data. Participants performed a baseline 30 metre maximal sprint then had active rest for 15 minutes before performing another 30 metre maximal sprint.

3.5.3 Resisted Sprint Pull

The Smart speed gaits and Optojump system were set up following the same procedure during the control protocol. Participants body mass was weighed and calculated to the nearest 1.0 kg using a calibrated scale system (Seca, UK) to obtain the load of the weighted sled pull, with the weight of the sled included in the total weight (12 kg). Weighted discs were then applied to the sled until 50% of body mass, to the nearest 1.0 Kg, of the athlete was reached. The harness was attached to the waist as opposed to the shoulders, decreasing the lean of the torso which is detrimental to technique (Alcaraz et al., 2008). Participants performed the same pre track session dynamic warm up described during the control protocol before a baseline sprint. Participants rested for 15 minutes before performing 2x30 metre sled pulls at 50% body
mass, resting for 2 minutes between pulls. Participants then rested for 7 minutes before performing a maximal 30 metre sprint trial.

3.5.4 Romanian Dead Lift

The SMART speed gaits and Optojump system were set up following the same procedure during the control protocol. Participants performed the same pre track session dynamic warm up described during the control protocol before a baseline sprint. Subjects then rested for 15 minutes prior to 3 sets of single repetitions at 80% 1RM of a RDL, resting for 2 minutes between sets. Participants rested for 7 minutes after final set completion before performing a maximal 30 metre sprint trial.

4.0 Statistical Data Analysis

Data extracted from the protocols was entered into IBM SPSS Statistics software package (Version 2.0). Sprints split time, stride length, stride frequency and contact time data was analysed from the three tests. Descriptive analysis of individual’s data was produced, calculating participant means and standard deviations. The magnitude of effects was qualitatively assessed according to Hopkins (2000) as follows: r Trivial <0.1, small 0.1 < r < 0.3, moderate 0.3 < r < 0.5, large 0.5 < r < 0.7, very large 0.7 < r < 0.9, nearly perfect r > 0.9, and perfect r=1. Correlation effect sizes were assessed with coefficient of determination. The effect size was calculated to assess the significance of differences.
CHAPTER FOUR

RESULTS
4.0 Results

4.1 Introduction

Individual responses to protocol indicate that sprints split times were significantly decreased post RDL and weighted sled pull intervention, however improvements in sprint times were observed. Individual responses to protocol indicate significant increased and decreased stride length, stride frequency and contact time unique to the individual. Data presented indicates that the ability to potentiate is dependent upon strength levels.

Descriptive data upon sprint performance was only recorded consistently up to 10 metres, as opposed to the 15 metres noted in methodology, due to Optojump equipment technical difficulties. Furthermore, one participant dropped out due to injury sustained during training outside of the study.

Table 1. RDL 1RM results

<table>
<thead>
<tr>
<th>Participant</th>
<th>RDL 1RM (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>175</td>
</tr>
<tr>
<td>Participant 2</td>
<td>170</td>
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<tr>
<td>Participant 3</td>
<td>140</td>
</tr>
<tr>
<td>Participant 4</td>
<td>180</td>
</tr>
</tbody>
</table>

Figure 4. Participant 1 sprint split times.
Figure 5. Participant 2 sprint split times.

Figure 6. Participant 3 sprint split times.
4.2 Romanian Dead Lift

4.2.1 Participant 1

Participant 1 performed significantly increased 10- (1.83s), 20- (2.98s) and 30 metre (4.11s) sprint times in comparison to baseline 10- (1.73s), 20- (2.89s) and 30 metre (4.01s) sprint times. Participant 1 performed significantly decreased mean stride frequency (4.11 Hz) compared to baseline (4.15 Hz), increased mean stride length (291.3cm) compared to baseline (289.8cm), and increased mean contact time (0.141s) compared to baseline (0.172s).

4.2.2 Participant 2

Participant 2 performed a faster 10- (1.77s), 20- (3.02s) and 30 metre (4.20s) sprint split times post RDL intervention compared to baseline 10- (1.81s), 20- (3.06s) and 30 metre (4.22s) times, although improvement effect size was not deemed significant. In addition, participant 2 significantly decreased mean stride length (271.8cm) compared to baseline (273.7cm), although mean stride frequency increased although not significantly.
4.2.3 Participant 3

Participant 3 performed significantly slower 10- (2.03s), 20- (3.30s) and 30 metre (4.49s) sprint times compared to baseline 10- (1.86s), 20- (3.11) and 30 metre (4.33s) sprint times post RDL intervention. Participant 3 produced significantly increased mean stride length (314.3cm) compared to baseline (313.9cm).

4.2.4 Participant 4

Participant 4 performed a faster 30 metre (4.13s) sprint time post RDL intervention compared to baseline (4.16s) sprint time, although not significant. Participant 4 significantly increased mean stride length (293.4cm) compared to baseline (291.8cm) post RDL intervention.

Table 2. RDL Intervention Sprint Performance Descriptors

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Stride Length (cm)</td>
<td>289.8</td>
<td>273.7</td>
<td>313.9</td>
<td>291.8</td>
</tr>
<tr>
<td>Mean Stride Frequency (Hz)</td>
<td>4.15</td>
<td>4.64</td>
<td>4.10</td>
<td>4.29</td>
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<tr>
<td>Mean Contact Time (s)</td>
<td>0.141</td>
<td>0.125</td>
<td>0.149</td>
<td>0.140</td>
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<tr>
<td><strong>RDL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Stride Length (cm)</td>
<td>291.3</td>
<td>271.8</td>
<td>314.3</td>
<td>293.4</td>
</tr>
<tr>
<td>Mean Stride Frequency (Hz)</td>
<td>4.11</td>
<td>4.65</td>
<td>4.15</td>
<td>4.29</td>
</tr>
<tr>
<td>Mean Contact Time (s)</td>
<td>0.172</td>
<td>0.129</td>
<td>0.151</td>
<td>0.142</td>
</tr>
</tbody>
</table>
4.3 Resisted Sprint Pull

4.3.1 Participant 1

Participant 1 performed slower 10- (1.62s), 20- (2.80s) and 30 metre (3.91s) sprint split times compared to baseline 10- (1.60s), 20- (2.77s) and 30 metre (3.87s) sprint times, although not significant. However, significant increases in mean stride length (292.2cm) compared to baseline (292.2cm) and increased mean stride frequency (4.26 Hz) compared to baseline (4.18 Hz) were found.

4.3.2 Participant 2

Participant 2 performed faster 10- (1.67s), 20- (2.91s) and 30 metre (4.09s) sprint times post sled pull intervention compared to baseline 10- (1.73s), 20- (2.96s) and 30 metre (4.14s) sprints, although not significant. Participant 2 significantly decreased mean stride length (270.2cm) compared to baseline (270.2cm) and increased mean stride frequency (4.68 Hz) compared to baseline (4.74 Hz).

4.3.3 Participant 3

Participant 3 performed significantly slower 10- (1.80s), 20- (3.10s) and 30 metre (4.28s) sprint times compared to baseline 10- (1.73s), 20- (3.02s) and 30 metre (4.18) sprint times, significantly increasing mean stride length (314.5cm) compared to baseline (312.5cm).

4.3.4 Participant 4

Participant 4 performed no significantly increased or decreased sprint split times compared to baseline, although significantly decreasing mean stride length (289.9cm) compared to baseline (292.7cm) and increased mean contact time (4.38 Hz) compared to baseline (4.31 Hz).
Table 3. Resisted sprint pull intervention sprint performance descriptors.

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Stride Length (cm)</td>
<td>291.5</td>
<td>279.1</td>
<td>312.5</td>
<td>292.7</td>
</tr>
<tr>
<td>Mean Stride Frequency (Hz)</td>
<td>4.18</td>
<td>4.68</td>
<td>4.17</td>
<td>4.31</td>
</tr>
<tr>
<td>Mean Contact Time (s)</td>
<td>0.143</td>
<td>0.122</td>
<td>0.143</td>
<td>0.190</td>
</tr>
<tr>
<td><strong>Weighted Sled Pull</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Stride Length (cm)</td>
<td>292.2</td>
<td>270.2</td>
<td>314.5</td>
<td>289.9</td>
</tr>
<tr>
<td>Mean Stride Frequency (Hz)</td>
<td>4.26</td>
<td>4.74</td>
<td>4.12</td>
<td>4.38</td>
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<tr>
<td>Mean Contact Time (s)</td>
<td>0.142</td>
<td>0.121</td>
<td>0.147</td>
<td>0.139</td>
</tr>
</tbody>
</table>
CHAPTER FIVE

DISCUSSION
5.0 Discussion

5.1 Introduction

The primary aim of this study was to investigate the PAP effects of a RDL and a resisted sprint pull upon sprint performance, analysing performance outcomes and performance characteristics. A RDL was hypothesised to improve 30 metre sprint times, whilst another hypothesis was that a resisted sprints pull, in the form of a weighted sled pull, would improve 30 metre sprint times and increase stride length.

Results were analysed and presented positive and negative responses of performance within individuals. A RDL did not significantly improve 30 metre sprint times with significant negative affects upon performance characteristics found, although significant positive data and improvements were presented. A weighted sled pull did not significantly improve 30 metre sprint times but did significantly increase stride length in some participants. In addition, other significant positive responses were presented in sprint descriptors and improved sprint times were found, although not significant.

5.2 RDL Effect upon Sprint Performance

Literature attributes the lack of improvement of performance in training studies to the incompatibility of resistance exercises to sprint technique (Young, 2006). An heavy resistance back squat has been proven effective as both a chronic training method and an acute intervention within PAP protocol but literature suggests the multidimensional aspects of sprinting technique indicates the potential for improvements through other specific exercises (Moir and Yetter, 2008). Through the review of research this study identified the RDL as an exercise that is compatible with sprinting performance, activating musculature that is a mechanism within components of sprint technique.

This study’s analysis of participant performances found the significant increase of sprint times and negative effects upon sprint technique in individuals, consisting of decreased mean stride length, decreased mean stride frequency and increased
mean contact time. However, findings also included improved sprint times, although not significant, and significantly improved sprint technique in some participants, including increased mean stride length.

The ability of an individual to potentiate has been found to correlate with strength levels of the individual (McBride et al., 2005), in accordance, participant 4 recorded the greatest 1RM score during testing and did record a faster 30 metre sprint time post RDL intervention, although not a significant improvement. However, the same participant did record a significant improvement in mean stride length (293.4cm) compared to baseline (291.8cm), suggesting the improved performance outcome could be attributed to more effective sprinting technique through increased stride length. The significant improvement in stride length potentially suggests an improvement of hip extensor velocity therefore horizontal impulse thus horizontal velocity and so displacement per stride, as found by Hunter et al. (2005). The improved 10-, 20- and 30 metre sprint splits in participant 2, although not significant, also suggests the potentiation of the hip extensor component of sprint technique. However, participant 2 performed significantly decreased mean stride length but did improve mean stride frequency, potentially a result from hip extensor velocity resulting in increased stride frequency in this case. This participant recorded consistently shorter mean stride lengths and higher mean stride frequencies throughout all test trials, potentially relying less upon horizontal propulsion and more reliant upon stride frequency and repeatedly applying impulse thus force to the ground more frequently. Participant 3 recorded the lowest 1RM RDL score and significantly increased their sprint times. Participant 1 struggled to consistently perform competent technique thus potentially explaining also significantly increased sprint times, fatiguing musculature but not activating thus potentiating the hip extensors sufficiently enough to improve times.

Findings presented from the RDL intervention test suggest the potentiation of hip extensors, improving sprint times and significantly improving stride length. However, the ability to potentiate appears to be dependant upon the strength levels of the individual when comparing the 1RM RDL scores and individuals who presented positive responses. In addition, incorrect technique may not allow proper potentiation of muscles as participant 1 struggled to consistently demonstrate
competent technique and did not benefit from the intervention. Recommendations concerning the practical application of results may be extracted. To effectively implement the RDL within PAP protocol the athlete that is subject to the procedure is recommended to use the exercise within their training programme, allowing practice of competent technique thus allowing overload of the muscles through higher activation of the hip extensors. In addition, through a training programme that implements appropriate progression of overload, the athlete will attain higher levels of strength thus enhancing the ability to potentiate musculature (Rassier and Herzog, 2001).

5.3 Resisted Sprint Pull Effect upon Sprint Performance

The weighted sled pull is a commonly used training method by coaches to improve acceleration capability in athletes, proposed to improve stride length, stride frequency and specific strength (Alcaraz et al., 2007; Alcaraz et al., 2009; Lockie et al., 2012). Empirical research recommends the use of the weighted sled pull as an effective longitudinal sprint training method but has not been investigated upon acute track based sprint performance within PAP protocol, although proven effective within ice based sprints (Matthews et al., 2010). Literature recommends the use of 10% body mass as the maximal load during weighted sled pulls, avoiding detriment to sprint technique (Alcaraz et al., 2008), although current literature does report successful heavy resistance resisted sprint pull training methods (Myer et al., 2007). Contradictory literature recommendations proposes the issue that to overload the muscles to sufficiently potentiate musculature the load will be contradictory to resisted sprint training literature recommendations, with high loads suggested to be of detriment to technique. In accordance with these recommendations, during this study participants did significantly decrease mean stride length and one participant increased mean contact time, suggesting detriment to sprinting technique. However, participants did experience significant increases in mean stride length and mean stride frequency post weighted sled pull intervention, with improvements in sprint split times.

Participant 2 improved 10-, 20- and 30 metre sprint split times post sled pull intervention compared to baseline, although not significant. This participant did
significantly decrease mean stride length but significantly increased mean stride frequency also. As discussed previously, the sprinting technique of this athlete implies a shorter stride length but faster stride frequency during sprinting technique. Participant 1 did not improve sprint times but in accordance with the suggestions of Alcaraz et al. (2008) and the findings of Lockie et al. (2012) they did significantly improve mean stride length and mean stride frequency compared to baseline. The improvement in sprint performance technique could be attributed to the potentiation of mechanics and velocity of movement but decreased ability to exert force when in contact with the ground. Similarly, participant 3 did not improve sprint times but did significantly improve mean stride length, although possessing the lowest RDL 1RM score and presenting the largest negative difference between baseline and sprint split times post weighted sled pull. This result potentially indicates potentiation is dependant upon strength during resisted sprint pull also, allowing fatigue to dissipate and muscles to potentiate (Rassier and Herzog, 2001). Participant 4 also did not improve sprint times but did significantly improve mean stride length but also increased mean contact time. The significant increase of contact time is detrimental to sprinting technique, negatively affecting impulse therefore sprint performance (Alcaraz et al., 2009).

The results presented from the sled pull trials concur with resisted sprint pull training literature, finding an improvement of stride length similar to the findings of Lockie et al. (2012) whilst increased stride frequency was proposed by Alcaraz et al. (2008). The improvements in sprint technique characteristics suggest sprint time performance should improve (Debaere et al., 2013). However, the participants that produced increased mean stride length did not improve sprint times, with one participant increasing mean contact time which is contradictory to literature suggestions of improved specific strength through resisted sprint training. The absence of significant improvement of sprint performance could be attributed to fatigue. Matthews et al. (2010) used a single set resisted pull when significantly improving sprint times, as opposed to the multiple set of resistance exercises recommended by Wilson et al., (2012), with the latter recommendation used during this study. Resting 2 minutes between sets of sled pulls may have been too short a recovery with such an intense volume of work, demanding subjects to sprint maximally for 30 metres whilst resisted for two repetitions over a short period of time.
The potential result is that the unbalanced ratio within muscles between potentiation and fatigue inhibited participant’s sprint specific strength, such as the ability to apply force through the ground thus decreased impulse and sprint performance. Adopting either a longer rest period between multiple sets of sled pulls or a single set protocol may prove more effective protocols, allowing fatigue to dissipate and the magnitude of effect of potentiation to increase. An improved protocol may compliment the significant increase in stride length with the ability to apply force through the ground, improving horizontal impulse therefore maximal velocity and sprint times.

5.4 Theoretical Implications

5.4.1 RDL Theoretical Implications

The results presented suggest the further reduction in sprint times through the appropriate application of protocol. As participants did not implement the RDL exercise during training they firstly had to familiarise with the technique, increasing the challenge to activate the muscles through performing incorrect technique thus less overload of the muscles therefore less potentiation. In addition, strength levels were lower than would be expected when compared to an individual that regularly performed the exercise, progressively increasing overload therefore strength levels. With regard to the strength levels of the individual seeming to be dependent upon the ability to potentiate, in accordance with McBride’s et al. (2005) findings, two subjects improved sprint times post RDL intervention, with one subject significantly improving mean stride frequency and another significantly improving mean stride length. The significant improvements in sprint technique present the potential for the sprint times to also significantly improve if the athlete possesses the appropriate technique of RDL and strength levels.

5.4.2 Resisted Sprint Pull Theoretical Implications

The resisted sprint pull results presented in this research suggest that developing an improved protocol for a weighted sled pull PAP intervention would improve sprint performance. Evidence from this study presents the beneficial acute responses to the intervention in sprint technique, although potentially musculature was too
fatigued to exert force. Through either adopting a single set approach similar to Matthews et al. (2010) or maintaining the recommendation of multiple sets (Wilson et al., 2012) but allowing longer recovery between sets may prove an effective protocol. The potentially improved protocol would allow fatigue to dissipate thus avoiding inhibition of application of force through the ground and horizontal impulse. These results suggest the potential for sprint time improvement through acute improvements in sprinting technique, facilitated through an improved protocol.

5.5 Practical Implications

The practical implications of the study are consistent with the findings of improved sprint times and significantly increased mean stride length and mean stride frequency. An athlete that integrates a RDL exercise within their training may implement the technique within training or pre competition as part of PAP procedure to improve sprint performance. Furthermore, the weighted sled pull may be implemented during training and/or pre competition as part of PAP procedure to improve sprint performance if a longer rest between sets is used. However, this information can only be valid once implications have been clarified.

5.6 Limitations

The correct technique of a RDL limits the implications of the results of this study. An athlete that possesses the correct execution of technique and higher levels of strength may only significantly potentiate musculature through the intervention. Concerning the weighted sled pull, the potential of the exercise to significantly improve sprint performance through PAP can only occur once an effective protocol has been established. Furthermore, although observing individual responses to interventions allows detailed analysis of response, a study using larger numbers will allow greater practical application to the population through a larger sample of data therefore providing more reliable results. Finally, due to Optojump technical difficulties the sample of data consisting of sprint performance descriptors was limited to 10 metres. A newer and more reliable version is now available allowing larger amounts of data collected thus contributing to the sample of data and knowledge upon the subject.
5.7 Future Research

Future research can contribute to the results of this study through investigating certain elements of protocol. Due to the lack of empirical research upon track based resisted sprint pull PAP effects there is a lack of knowledge surrounding the optimal protocol. To the author’s knowledge there is not a study published that has successfully implemented a resisted sprint pull modality within PAP protocol and used an objective resistance. In addition, research should investigate the optimal rest between sets during resisted sprint pull protocol, potentiating muscle competently whilst not fatiguing muscle and inhibiting technique, negatively affecting impulse. In addition, considering the results of participant 3’s lower strength levels and negative response to resisted pull intervention research should investigate the relationship between potentiation and strength levels with resisted sprint pulls. Concerning the RDL, published research has not used the RDL within PAP protocol. Future research investigating the effect of a RDL as a PAP intervention are recommended to use athletes that are familiar with the technique and incorporate the exercise into their training programme, as potentiation is dependent upon strength (McBride et al., 2005). Future research that investigates either intervention should use a larger number of participants, increasing the reliability of data. Finally, future research is recommended to analyse sprint performance descriptors, contributing to PAP literature by explaining how performance increases further expanding knowledge.
CHAPTER SIX
CONCLUSION
6.0 Conclusion

The current study has presented evidence that a RDL and weighted sled pull significantly improve aspects of sprint technique as a PAP intervention. Significantly increased mean stride length and increased mean stride frequency potentially present theoretical implications of significantly enhancing sprint performance with the use of either modality providing the development of effective protocol. Observed improved times suggest the potential for either intervention to enhance sprint performance in future research considering an improved protocol is developed regarding participants and rest intervals. Furthermore, results indicate that in relation to weightlifting modalities that potentiation is dependent upon strength levels. Although this study has not been able to determine whether a resisted sprint pull or weightlifting resistance exercise is more specific and therefore more effective as an acute training modality to improve sprint performance, both methods have been observed to significantly improve sprint technique and improve sprint times.

6.1 Future Recommendations

This study indicates that the balance between fatigue and potentiation is crucial, evidenced through significant positive and negative affects of both interventions upon sprint performance. Sufficient recovery is needed between sets during resisted sprint protocol whilst participant familiarisation with technique and appropriate strength levels is required to benefit from the RDL intervention. Neither areas are well published in respect of PAP research and would benefit from further investigation, investigating variables of protocol and using larger numbers of participants. However, research should follow the example set by this study and continue to analyse sprint performance descriptors to explain how performance improves rather than focussing upon the performance outcome, contributing to the knowledge of coaches regarding the beneficial effects of PAP.
List of References


Appendices

Appendix A

Project Title: The post activation potentiation effect of Romanian dead lift and weighted sled pull upon sprint performance

This document describes:
1. Background and aim of research
2. My role as the researcher
3. Your role as the participant
4. Benefits of participating
5. How data will be collected
6. How the data/research will be applied practically

This document is designed to help you make an informed decision as to whether you wish to be a participant in this research, contributing to a niche in the area of research.

1. Background and aim of research

Athletes warm up before exercise to optimise the performance of their muscles. A warm up can contain different methods to which to enhance performance, post activation potentiation is one way. Post activation potentiation consists of performing short volume but high intensity exercise before an explosive activity, preparing the muscles for performance. The aim of the research is to enhance sprint times by performing a Romanian dead lift and weighted sled pull prior to a 30 metre sprint.

2. My role as the researcher

The research involves me (Matthew Craythorne), the researcher, recording research upon your 30 metre sprint times with and without post activation potentiation included in the warm up.

3. Your role as the participant

Your role as the participant is to perform the exercises and sprint trials to the best of your ability, whilst completing the health questionnaire to the best of your knowledge.

4. Benefits of participating

The research will benefit you through the expansion of your knowledge. First of all, through the 1RM testing you will be able to test and evaluate your current level of strength. Secondly, you will also attain a highly accurate 30 metre sprint time, allowing you to track current training progress. In addition, regarding the results of the research, the post activation potentiation exercises could be applied to your own warm up to enhance your performance in the future.
5. How data will be collected

Requiring just three separate days taking up a little of your time, a 1RM test will be conducted, a sprint trial without post activation potentiation and finally a sprint trial with post activation potentiation. Several days of rest in between tests is necessary to allow full recovery. Data will be collected through the use of the SMART speed gait system and Optojump.

6. How the data/research will be applied practically

Through agreeing to become a participant you are allowing me to collect data from your performances and analyse the data. The data will then be entered into a larger data sample including other participants’ data, so to analyse the results. Your personal data will anonymous and not be reported alone, but within a group of samples.

Your rights
As a volunteer, during the research you are in complete control of what you choose to participate in. You are allowed to withdraw at any time and without any consequence. Your data is kept completely anonymous.

Protection to privacy
Concerted efforts will be made to hide your identity in any written transcripts, notes, and associated documentation that inform the research and its findings. Furthermore, any personal information about you will remain confidential according to the guidelines of the Data Protection Act (1998).

Contact
If you have any queries, feel free to contact me on the email address below.

Matthew Craythorne
Cardiff School of Sport
Cardiff Metropolitan University
CF23 6XD, United Kingdom
Email: st10001813@outlook.cardiffmet.ac.uk
Appendix B

Cardiff Metropolitan Informed Consent Form

CSS Reference No:
Title of Project
Name of Researcher

Participant to complete this section: Please initial each box

1. I confirm that I have read the information sheet dated ………….. for this evaluation research. I have had the opportunity to consider the information, ask questions and had the questions answered to my satisfaction.

2. I understand that my participation in the study is voluntary and that I can stop participation at any time, without giving a reason.

3. I understand that if this occurs, my relationship with Cardiff Metropolitan University or our legal rights will not be affected.

4. I understand that information from the research may be used for reporting purposes, but my identity will remain confidential.

5. I agree and consent to participate in the study?

Name of Participant

Signature of Participant                                               Date

Name of person taking consent

Signature of person taking consent                                     Date

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