Cardiff School of Sport

DISSERTATION ASSESSMENT PROFORMA:

Empirical [1]

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Dissertation title: A Comparative Study Between Known and Unknown Loading	
Supervisor: Jeremy Moody	

Comments	Section
	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).
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	Discussion and Conclusions [2] To include: collation of information and ideas and evaluation of those ideas relative to the extant literature/concept/theory and research question/problem; adoption of a personal position on the study by linking and combining different elements of the data reported; discussion of the real-life impact of your research findings for coaches and/or practitioners (i.e. practical implications); discussion of the limitations and a critical reflection of the approach/process adopted; and indication of potential improvements and future developments building on the study; and a conclusion which summarises the relationship between the research question and the major findings.
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CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

SPORT CONDITIONING, REHABILITATION AND MASSAGE

TITLE: A Comparative Study Between Known and Unknown Loading

Dissertation submitted under the discipline of:

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SCHOOL OF SPORT

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A COMPARATIVE STUDY

BETWEEN KNOWN AND

UNKNOWN LOADING

Cardiff Metropolitan University

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<u>**TABLE OF CONTENTS**</u>

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

Firstly I would like to thank Jeremy Moody for his supervision and invaluable time throughout the duration of this project. I would also like to thank all the participants who volunteered to take part in the study, thank you.

ABSTRACT

The aim of the study was to investigate the effects unknown loading would have on the second pull from blocks in comparison to known loading. Ten male participants (stature 176.85 ± 8.05cm; mass 84.43 ± 30.7kg) from Cardiff Metropolitan University took part in the study, which involved performing 8 repetitions of the second pull from blocks, 4 known and then 4 unknown. The participants 1 – repetition maximum (1RM) was found, the loads at 60%, 70%, 80% and 90% (mean 1RM 162.5 ± 30.7) being used for the testing protocol. A TENDO linear transducer was used to collect data on Peak Power Output (PPO) and Peak Velocity (PV).

Analysis was conducted via One – Way Repeated Measures ANOVA to compare the effects of known and unknown loading on each of the intensities tested. Statistical analysis revealed no significant difference ($p > 0.05$) between intensities for PPO regardless of whether conditions were known or unknown. However, there were significant differences ($p > 0.05$) in PV between all loads apart from between 70% and 80% when loads were known, with significant differences ($p > 0.05$) between all intensities when loads were unknown.

Despite no significant differences between loads, the highest mean value for PPO was found at 80% 1RM for both known (1382.7 ± 194.6 W) and unknown (1357.3 ± 205.8 W). The highest mean values were found at 60% for both known (1.402 ± 0.256 m/s) and unknown conditions for PV (1.375 ± 0.237 m/s).

From these results it can be suggested that using unknown conditions has no effect on PPO or PV values, with known conditions proving more effective at reaching peak mean values for both variables. However, it does give strength and conditioning coaches and athletes an indication as to which intensity is best suited if improvements in PPO or PV are the main focus when using the second pull from blocks.

Key Words Clean Pull, Second Pull, Peak Power Output, Peak Velocity, Unknown Loading

CHAPTER I

INTRODUCTION

1.0 INTRODUCTION

The ability to produce maximum power is considered an essential component within many different sporting activities which involve an explosive production of force in a single effort or during repeated bouts (Comfort, Udall, & Jones, 2012). The term 'power' has become a common topic among strength and conditioning (S&C) research due to its importance within sporting movements, and has therefore acquired a range of definitions, including; the product of force and velocity, the work performed in a given period, or work per unit of time (Waller, Townsend, & Gattone, 2007).

Research into power has also led to the identification and testing of different characteristics of power and how they can be applied to improve sporting movements. Rate of force development (RFD) has been shown to have a direct correlation with vertical jump height (McLellan, Lovell, & Gass, 2011), while it has also been suggested that increasing peak power output (PPO) could help improve sprinting performance (Kilduff *et al*. 2007).

Due to the importance of these power characteristics to sporting performance and success, S&C professionals also look for the most effective methods to help increase power development. It has been accepted that using the Olympic weight lifting movements and their derivatives is one of the best ways to achieve this, due to the high levels of PPO and RFD that can be achieved while executing these lifts. They are also multi joint movements, therefore replicating sport specific movement patterns, most notably triple extension of the ankle, knee and hip, which can be seen in the second pull of Olympic weightlifting, as well as sprinting and jumping.

Previous research has opted to determine an optimal load for power development within the Olympic lifts to include in training programmes in order to enhance performance. However, conflicting results conclude that there is no optimal load, and that a range of loads should be used to enhance power, as this may improve power output across a greater portion of the force – velocity relationship (Chiu, 2008). When opting to use a load that is effective for power production, dynamic correspondence is an important consideration that must not be overlooked. Siff (2003) states that the intensity used in training must match the demands of the sport, if not exceed them. Training to display maximal strength can be achieved by using heavy loads for absolute strength, and light loads for speed of muscle contraction. The criteria for correspondence will only be achieved if the type of strength is identified and determined by calculating the speed of movement. Therefore, it would be deemed useless training with light loads alone even if the maximum achieved is close to the dynamic correspondence, as the duration and character of the effort must also be considered (Siff, 2003).

Along with PPO and RFD, it is also important to consider peak velocity (PV) when training to develop power. It is well known that maximal power requires high velocity and manipulating velocity during a resistance training bout needs to be considered in order to optimally train power development (Hatfield *et al*. 2006).

With these findings and considerations, S&C coaches have the option of using intensities that they feel will benefit their athlete's power development. However, if loads below an athlete's 90% of one repetition maximum are used, despite being instructed to perform the lift as explosively as they can, they may still not respond with a true maximal voluntary contraction. If this were the case, PPO and peak RFD would not be reached and therefore would not develop, as these values need to be reached in order for them to improve. This is evident as it has been suggested that a load must be heavy enough to recruit an adequate amount of motor units in order to elicit neurological adaptation within power development (McBride, Triplett – Mcbride, Davie, & Newton, 2002), and that it is the intention to move a given load quickly that determines the training response rather than the load (Behm & Sale, 1993).

Therefore, it would be appropriate to explore a method which would permit the exploitation of both research conclusions reached by McBride *et al*. (2002) and Behm and Sale (1993). The use of unknown loading may enhance the subjects' intention to move a given load maximally and as quickly as possible, resulting in PPO and peak RFD values being reached regardless of the load.

This study poses the question: What are the effects of unknown loading on PPO and Peak Velocity (PV) during the second pull from blocks when compared to known loading? By exploring this question, there is a possibility that it may produce a new training method that can be utilised when the aim of a training session or period is to increase power characteristics. There is also a possibility that the results of this study will aid in understanding an athlete's perception of a given load and how they are affected when they the weight they are being asked to lift is unknown to them.

CHAPTER II

LITERATURE REVIEW

2.0 LITERATURE REVIEW

2.1 Training and Olympic Lifts

The Olympic weight lifting movements and their derivatives have been widely used as a means of improving PPO and RFD within sports settings, as they are multi – joint movements with high mechanical specificity to athletic performance (Kawamori *et al*. 2005).

Olympic weight lifting consists of two main lifts, the snatch and the clean and jerk. Both require the athlete to lift a loaded barbell overhead but with two different methods. The snatch involves lifting the barbell from the floor, straight overhead in one continuous movement. Whereas the clean and jerk is a two – part lift, where the barbell is first lifted and caught on the front of the shoulders; it is then driven upwards and caught above head in the jerk (Storey & Smith, 2012).

Weightlifting movements have been reported as reaching some of the highest power outputs of all resistance training exercises (Haff, Whitley, & Potteiger, 2001). For example, Kawamori *et al*. (2005) stated that a 100kg male weightlifter can produce an absolute power output of 3000 W in the snatch, compared with the squat which can produce 1100 W.

Snatch and clean and jerk variations include the power snatch from various heights, power clean from various heights, and the clean and snatch pull from various heights, with all exercises producing high velocity (Hydock, 2001). When PPO and RFD development are the aims of training sessions designed by S&C coaches, performance of the second pull movement is often the main priority due to technical performance of the lifts and intensity that can be used to perform the pull (Hydock, 2001).

Recent research conducted by Comfort, Allen, & Graham- Smith (2011) investigated peak ground reaction force and RFD during variations of the power clean. The results showed that the greatest peak ground reaction force and instantaneous RFD were produced during the mid- thigh power clean and mid-thigh clean pull, when compared to the hang- power clean and power clean. The clean technique of weightlifters was also investigated by Enoka (1979), who found that the second pull phase resulted in a higher value for peak ground reaction force (average of 2809 N) than the first pull (2471 N) in experienced weightlifters. This suggests that competitive weightlifters not only have a high value for peak ground reaction force during the second pull, but also during the first. A comparative study on subjects with less experience in weight lifting would give a better understanding of not only the difference in peak ground reaction force during the pulls when compared to weightlifters, but will also highlight if there is a more significant difference between values obtained for the first and second pull. This information would allow for differences to be identified between force production in subjects who are less experienced in weight lifting movements compared to those who are considered more advanced.

Along with high levels of peak ground reaction force and RFD that can be produced during the second pull, the lower limb kinematics of the pull (triple extension of the ankle, knee and hips joints) replicate the same joint angles achieved during the drive phases of running and jumping (Comfort *et al.* 2011). It is also advantageous when the goal of the training period is to develop power production due to the technical aspects involved in the second pull. Performing the second pull alone helps reach PPO and instantaneous RFD without having to drop under the bar in the catch, which could potentially cause the athlete to prematurely finish their second pull phase, reducing power output production and RFD (Hydock, 2001).

2.2 Power

2.2.1 Peak Power Output

Power refers to the amount of force that can be generated over a distance in the shortest possible time (Waller *et al*. 2007), and can be determined by the force and velocity of muscle shortening (Smilios *et al*. 2012). The ability to produce power has been expressed through the use of the force – velocity relation, suggesting that with concentric contraction, velocity decreases with an increase in force and *vice versa* (Yamauchi, Mishima, Fujiwara, Nakayama, & Ishii, 2007). Therefore, it is a compromised level of force and velocity that produces peak power (Kawamori *et al*. 2005).

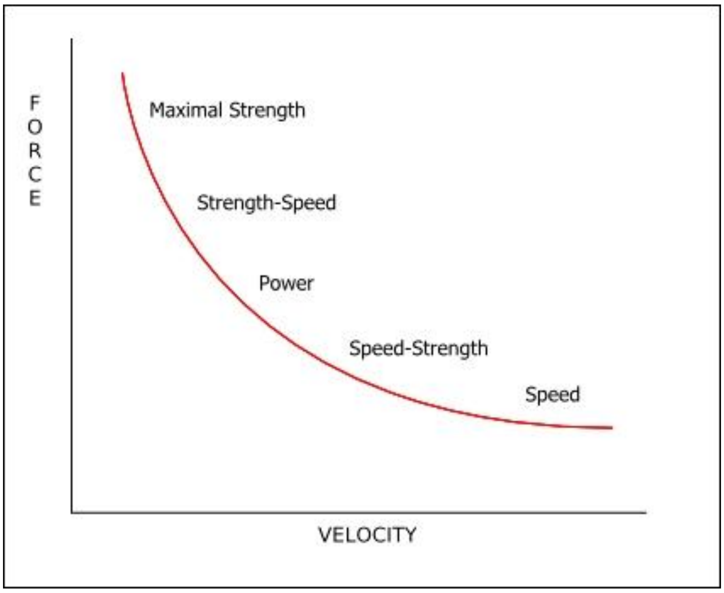

Figure 1 - The Force Velocity Curve – as cited by Brewer (2008)

The relationship between PPO and various sporting movements has been extensively researched due to the fact that the ability to generate power is considered an important aspect when developing sport – specific physiological profiling and is considered a key element to success (Duncan, Lyons, & Nevill, 2008). Harris, Cronin and Hopkins (2008) investigated how strength and power outputs of a machine jump squat affected different sprint times over ten and thirty or forty metres. The results of this study concluded that mean and peak power had a direct correlation with both sprinting distances, even when power was expressed relative to body mass. This is of particular interest as sprinting performance is considered a key attribute to success in a range of sports.

The force – velocity (see Figure 1) or power – load curves are the most widely used method of monitoring improvements in power (Alacaraz, Romero – Arenas, Vila, & Ferragut, 2011). Alacaraz *et al*. (2011) explain that there is no research to explain how the two curves should be expressed throughout the training season of sprinters, and therefore researched to define the power – load curve during a competitive training period, and to correlate sixty metre sprint performance with PPO. The testing protocol for this study used the concentric phase of a half back squat to test for peak power. The results concluded that there was no correlation between the best sixty metre sprint time and peak power, however the optimum intensity to use for sprinters during a competitive period is 60% 1RM if the goal is to increase power production. The results presented, along with the conclusion made by Harris *et al.* (2008), could suggest that peak power is an important factor at the acceleration phase of sprinting more so than the maximum speed phase, as the acceleration phase requires greater contributions of concentric muscle contractions and knee extensor activity (Harris *et al*. 2008).

Alcaraz *et al*. (2011) also describes the importance of force and velocity when considering the intensity of the load, showing that velocity and low load training contributes more to speed - strength, and maximal strength is more of an important factor when emphasis moves more towards strength - speed. However, as an athlete becomes stronger, the load required to produce peak power decreases as maximum power levels are reached and higher achievements become difficult to obtain (Alcaraz *et al.* 2011). This would imply that it is important for S&C coaches to monitor the progress of their athletes and the PPO values they are reaching during training. If the athletes are starting to reach values below PPO as the weigh load increases, then it would suggest they are reaching their maximum power levels and need to decrease the load in order to again reach PPO during their lifts.

This conclusion conflicts with other studies investigating peak power including Dayne *et al*. (2011), who found peak power was reached at 0% of 1RM. The use of unloaded jump squats has been shown to have no improvement on strength, power, speed or agility in athletes. Hoffman et al. (2005) investigated the effects of unloaded and loaded jump squats and found that loaded jump squats provided an enhanced training stimulus, whereas unloaded jump squats did not provide a training stimulus. This may result in athletes being unable to maintain peak power during a given period of training or competition. The results of the study also showed that unloaded jump squats do not improve maximal strength or power clean performance. It may also be argued that performing unloaded jump squats falls under the velocity end of the force – velocity curve, whereas muscular peak power can be identified closer to the speed – strength portion (Figure 1) of the curve (Peterson, Alvar & Rhea, 2006).

Kilduff *et al*. (2007) concluded that peak power was reached at 80% 1RM during the hang power clean in professional rugby players. From these results, and the conclusion made by Cormie, McCaulley, Triplett and McBride (2007), who investigated PPO during three lower – body exercises, and found that PPO was reached in the jump squat at 0% 1RM, 56% of 1RM in the squat and 80% 1RM in the power clean, a conclusion can be made that PPO is reached at different percentages of 1RM depending on the exercise selection.

2.2.2 Rate of Force Development

RFD is a strength quality that has been defined as the development of maximal force in minimal time, which is used as an index of explosive strength (McLellan *et al*. 2011). RFD is a fundamental strength characteristic in sports that require fast and forceful muscle contraction, with movements such as sprinting and striking within boxing involving contraction times of 50 – 250 milliseconds (ms) (Aagaard, Simonsen, Andersen, Magnusson & Dyhre- Poulsen, 2002). Such short contraction times may result in maximal force not being reached. Therefore, increasing contractile RFD would result in reaching maximal force within a shorter period of time, increasing the effectiveness of various sporting movements (Aagaard *et al.* 2002).

RFD Is affected by different physiological parameters, including muscle fibre type, muscle cross- sectional area, the muscle- tendon complex and efferent neural drive to the muscle fibres (Andersen, Andersen & Angaard, 2009). A study conducted by Anderson *et al*. (2009) tested the response of early and late RFD to resistance training protocols. Participants performed fourteen weeks of training, consisting of four machine exercises: leg press, hack squat, knee extension and hamstring curls. During the fourteen weeks, the intensity ranged from 12% 1RM to as low as 6% 1RM. The results of this study showed that late phase (> 200ms) RFD increased with maximal muscle strength, whereas early phase (up to 140ms) RFD, along with decreased type IIX muscle fibre. The findings show that using resistance training alone, without including explosive exercises, increases maximal strength and late phase RFD, however may decrease performance due to the fact that early phase RFD is negatively affected. This is supported by the fact that sporting movements, such as sprint running and long jump, allow for 80 – 120ms and 110 - 160ms to produce force (Anderson *et al*. 2009).

The role of RFD within sporting movements such as vertical jumping has been researched in recent literature (McLellan *et al*. 2011). McLellan *et al.* (2011) investigated the role of RFD on vertical jump performance due to conflicting research stating that there was no correlation between the two, despite Cronin, Hing, & McNair (2004) suggesting that RFD is a better predictor of athletic ability and performance compared to other variables, such as peak power and average power. The results of the study suggested that RFD had a significant correlation with vertical jump performance during the counter movement jump. This is important to address because vertical jumping is specific to many athletic skills (Otto, Coburn, Brown, & Spiering, 2012) including the acceleration phase of sprinting, as both movements require maximal concentric actions of the lower – limb extensor muscles (Requena, Garcia, Requena, Saez – Saez de Villarreal, & Cronin, 2011).

The rate at which RFD can be reached during variations of the Olympic lifts was investigated by Comfort, Allen and Graham – Smith (2011), who found that RFD was significantly ($p < 0.001$) greater during the mid- thigh power clean and mid-thigh clean pull when compared to the power clean and hang power clean. These values are similar to those found by Kawamori *et al*. (2006) who concluded that peak RFD was reached in a shorter period of time during loads of 30% to 120% of 1RM in the power clean than in the countermovement jump (263.3 ± 63.5 ms) and the vertical jump (194.7 ± 27.0 ms). The shortest time to peak RFD was reached at 30% 1RM during the mid – thigh clean pull and took 99.8 ± 14.0 ms. These findings would suggest that Olympic lifts and their derivatives would be more beneficial to use when training for RFD rather than countermovement and vertical jumping exercises.

The need to increase RFD is linked with improvements in movement velocity. In order to improve maximal RFD, limb acceleration time must also be shortened. Murray *et al*. (2007) suggested that actual movement velocity during training may be the variable that is the most effective in creating adaptations so that an athlete can move more quickly. By increasing PV in movements such as sprinting and jumping, athletic performance can be improved. This suggests that improving muscular power via velocity training, as opposed to overall strength, may be more beneficial when seeking to improve athletic performance (McBride, Triplett – McBride, Davie and Newton, 1999).

2.3 Optimal Loading

Varying weight load is an important characteristic that S&C coaches have to consider when deciding the outcome of training sessions. It has been accepted that loads ranging from 70% - 100% 1RM are needed when the training goal is to increase strength and between 80% - 85% 1RM are needed to produce further neural adaptation (Kraemer & Ratamess, 2004). However, the optimal training load needed to train PPO and RFD is inconsistent throughout recent literature, despite research indicating that training with a load that maximises power output improves maximal power production (Chiu, 2008).

Conflicting results among literature may be due to differences in methodologies, as the optimal load for PPO is influenced by a range of variables, such as; exercise selections, training age, muscle mass, age and gender (Jandacka & Vaverka, 2008). Studies conducted by Zink, Perry, Robertson, Roach and Signorile (2006) and Harris *et al*. (2007) investigated power output at different loads during squat based exercises. Whereas, Jandacka and Vaverka (2008) conducted a study to determine the optimal load for PPO during a countermovement squat and bench press. The squat based results of Zink, *et al*. (2006) concluded that PPO was produced at loads of 40% and 50% 1RM, but without any significant difference between loads. Harris *et al*. (2007) reported PPO being produced at much lower loads of 21% 1RM, while Jandacka and Vaverka (2008) concluded that PPO was reached between 50% and 70% for both the bench press and countermovement squat. A similar study investigated by Bevan et al. (2010) found that PPO was found at 30% for ballistic bench press throws, and 0% for jump squats in professional rugby players. With regards to the bench press exercise, Jandacka and Uchytil (2011) found that among high performance football players, 30% - 50% 1RM was the optimal load for mean maximal power output.

Zinc *et al*. (2006) chose to use the squat exercise with participants who had at least two years of resistance training experience, whereas Harris *et al*. (2007) used the machine squat – jump with national level rugby players as participants.

Jandacka and Vaverka (2008) used fifty – five male and forty – eight female physical education students, who were instructed to perform the countermovement squat and bench press. Therefore, this could suggest that the optimal load to maximise power output may differ between training age and exercise selection (Kawamori *et al*. 2005). Due to the variety of participants and exercises used in these studies, it is difficult to form a conclusion on the underlying variables affecting optimal loading for PPO. Comparison studies would need to be investigated between subjects of different training ages, competition levels, gender and sport in order to form a more complete understanding of how to truly maximise PPO.

As stated previously, the use of the Olympic weight lifting movements and their derivatives are considered highly effective in producing PPO and RFD for sporting performance as they involve large muscle mass, multi - joint movements and fast movement velocity (Comfort, Fletcher, & McMahon, 2012).

Three studies have directly examined PPO for derivatives of the Olympic lifts. Kilduff *et al*. (2007) examined seven loading intensities; 30, 40, 50, 60, 70, 80 and 90% of one repetition maximum (1RM) in the hang power clean among professional rugby players. It was found that peak power output was obtained at 80% of the subjects 1RM, highlighting the importance of the relative load. However it was concluded that there was no significant difference between loads ranging from 40% - 90% 1RM, and relative load had no effect on peak RFD.

Kawamori *et al*. (2005) and Comfort *et al*. (2012) conducted studies to identify the optimal load for PPO during the hang power clean and the power clean from floor. Both studies reported similar findings with PPO occurring at 70% 1RM. However, both studies reported no significant difference between loads of 50% to 90% 1RM.

The highest load that can be deemed optimal was 93%, which was found by Comyns, Harrison, Hennessy and Jensen (2007), who investigated the optimal load for complex training in professional rugby players. The study found that 93% 1RM in the back squat resulted in reduced contact time and increased leg stiffness in drop jumps performed straight after. These findings could suggest heavier loads are optimal if the focus is to increase the theoretical rationale of increased neural excitability for post – activation potentiation (Comyns *et al*. 2007).

The findings of the current literature suggest that an optimal load does not exist, and varies depending on methodological differences such as maximal strength levels and exercise selection. Recent literature highlights that loading for upper and lower body exercises would be optimised between 30% and 70% 1RM, and full body movements such and power cleans, at loads closer to 80% 1RM. With consideration to the results found within these studies, it would suggest that it would be appropriate for the present study to test at loads ranging from 60% to 95% 1RM in order to acquire PPO and PV within the data collection.

2.4 Psychological Strategies, Effort and Perception

2.4.1 Psychological Strategies

Psychology is an important aspect when elite sporting performance is concerned, and has therefore become an important consideration for S&C coaches.. It has been stated that the use of psychological techniques is a scientific foundation required by S&C coaches to enhance the training and performance of athletes (Strength and Conditioning Journal, 2009). It is also highly valuable for S&C coaches to be familiar with the field of psychology as coaches without a psychology title are often identified as the favoured provider of psychological support, making it an ideal position for S&C coaches as they have regular contact with the athletes (Radcliffe, Comfort & Fawcett, 2012).

Radcliffe *et al*. (2012) investigated the psychological strategies used by S&C coaches. The study used questionnaires and measured the frequency of eleven subscales which consisted of goal setting, imagery, self – talk, mental toughness, attention control, relaxation, stress management, adherence, activation, self – confidence and ego management. The results of the study showed that goal setting was the most frequently used strategy, with mental imagery being the least used, while confidence and motivation were considered the most important.

Selection of goal setting strategies are the most frequently used due to the fact that they are highly successful and setting short term goals is the most common method used within physiotherapy and athletic training (Radcliffe *et al*. 2012). By setting short term goals, it allows the athlete to strive for and reach them within a short space of time, helping to keep and raise intrinsic motivation levels (Wilson &

Brookfield, 2009). This is an important consideration as a lack of motivation has been considered as one of the most debilitating factors of athletic performance (Radcliffe *et al*. 2012).

Radcliffe *et al*. (2012) also reported that imagery was the least used strategy. Many reasons for this have been stated, including; lack of time coaches have to teach athletes how to correctly use the strategy, and that athletes may feel it does not work and respond in a negative manner. This is problematic as the use of imagery has been shown to be effective in improving strength in complex and multi- joint movements (LeBon, Collet, & Guillot, 2010), along with increasing muscle activation (Wilson, Smith, Burden & Holmes, 2010).

2.4.2 Effort and Perception

Physical load related attention has been categorised into two broad areas; association and dissociation. Association is defined as turning focus inward and towards bodily sensations, whereas dissociation is described as focusing outward and away from bodily sensation (Tenenbaum & Connolly, 2008).

Tenenbaum and Connolly (2008) investigated how attention allocation and effort perception are affected by workload in rowers. The conclusion of the study was that during low to moderate workload, the attention was more categorised as dissociation, suggesting that this was due to the fact that the workload was not overwhelming and therefore did not require as much attention. However, as the workload increased, the results showed that there was a shift from dissociation to association. The findings of this study could suggest that when athletes are performing power based exercises with intensities that are considered low to moderate, despite being instructed to perform the exercise as explosively as possible, the athlete would still know that the weight is not overwhelming and subconsciously not perform the movement within their capabilities. This could result in PPO and peak RFD not being reached and therefore would not aid in increasing these power characteristics. By not knowing the load the athlete is expected to lift explosively, it may aid in keeping the athletes attention within the association category. Reasons for this would be that they would be unaware of whether or not the workload is overwhelming or low to moderate, and therefore would be unable to be in a state of dissociative attention. If they were in a state of dissociation and the load was heavy, it would most likely cause the athlete to be unprepared for the lift and unable to perform the movement explosively, therefore it would be appropriate for the athlete to be in a state of associative attention during all the lifts to enable them to perform the lift explosively as they are unaware of the demands of the task.

Self – efficacy is described as the belief in one's capabilities to organise and execute the courses of action required to produce given attainments, therefore self – efficacy is a crucial characteristic in deciding how much effort will be expended during an activity (Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008).

It has been shown that manipulating levels of self – efficacy can significantly affect perception levels and sustained effort (Hutchinson *et al*. 2008). A study by Hutchinson *et al*. (2008) manipulated levels of self – efficacy and concluded that higher levels resulted in lower perceptions of aches and pains, and an enhanced affective response to exercise. The implications from these results make it unclear how the present study will affect the self – efficacy of the participants as it will be difficult for them to judge their capabilities when the weight load is unknown.

Effort perception is influenced when signals arising in the sensory cortex are matched with the perceptual – cognitive reference filter. As neural signal passes through the reference filter it is fine – tuned, and the individual modulates the intensity according to their past and present events (Hutchinson, & Tenenbaum, 2006). This implies that when an athlete is presented with a load that is far below their physical capabilities and asked to perform a movement maximally, they may subconsciously perform a submaximal effort due to their judgement of the stimulus.

2.5 Conclusion

When reviewing recent literature, the majority focuses on finding the optimal load needed to train for PPO. A conclusion can be made that there is no optimal load and that a variety of loads should be use, as well as manipulation of other variables, such as; exercise selection. The present study will look at the effect unknown loading has on PPO and PV due to the importance they have within athletic success. This research aims to investigate how unknown loading affects these variables through psychological uncertainty. It has been highlighted that athletic performance can be manipulated through self – efficacy, effort and perception. By manipulating self – efficacy and perception, this research aims to answer the question; How does unknown loading affect PPO and PV during the second pull? This study will inform strength and conditioning professionals of the effects of unknown weight loading and whether or not there is a significant application to training for PPO and PV. If more consistent results can be obtained for PPO and PV then prescribing unknown loading lifts will allow athletes to train for PPO and PV regardless of the intensity being used.

2.6 Hypothesis

2.6 Hypothesis:

Having researched extensively the surrounding areas related to the question, the following hypotheses can be made.

- HO 1: Known values will be greater at 80% when compared to unknown values.
- HO 2: There will be no significant difference in PPO and PV values between 60% - 90% when loads are known.
- HO 3: No significant difference in PPO and PV values will be found at 60% and 70% when loads are unknown.
- HO 4: There will be a significant difference in PPO and PV values between 60% and 90% when loads are unknown.

2.6.1 Null Hypothesis:

- HI 1: Known values will not be greater at 80% when compared to unknown values.
- HI 2: There will be a significant difference in PPO and PV values between 60% - 90% when loads are known.
- HI 3: There will be a significant difference in PPO and PV values between 60% and 70% when loads are unknown.
- HI 4: There will be no significant difference in PPO and PV values when loads are unknown between 60% and 90%.

CHAPTER III

METHOD

3.0 METHOD

3.1 Experimental Approach to the Problem

This study aimed to investigate the effect of unknown loads on PPO and PV during the second pull of the clean pull from blocks across varying loads. The second pull position was standardised so that the bar was just above the subjects' patella when on the blocks and the participants were in their start position (Figure 2). A multiple comparisons research design will be employed.

A pilot study was conducted on 3 male participants. All 3 subjects were asked to perform the full protocol with the required warm up, intensities and rest periods. The TENDO linear transducer was set up to ensure that it collected data for all lifts and intensities.

3.2 Participants

Ten male participants from Cardiff Metropolitan University (CMU) volunteered to take part in the study. All participants were involved in sports that required explosive power and therefore all were familiar with weight lifting lifts and their derivatives, and had at some point used them within their training programme or are currently using them. Stature 176.85 ± 8.05cm; Mass 84.43 ± 30.7kg. Prior to testing, all participants read signed the consent form (Appendix A) and read the information sheet provided (Appendix B).

3.3 Instrumentation

The TENDO linear transducer (Tendo Sports Machines, Trenic, Slovak Republic) was used to record data during the study. The TENDO unit has been reported as an accurate measure of PPO (R= 0.97), and is designed to measure vertical velocity and power (Pennington, Laubach, De Marco and Linderman, 2010). The TENDO linear transducer collects data for peak power, mean power, peak velocity and mean velocity. For the purpose of the study, only peak power and peak velocity was used for every test lift that was recorded.

Weight lifting bars that allow for heavy free weight exercises, such as cleans and snatches to be performed (Chiu, 2010), and rubber bumper plates were used for the study, along with safety collars. Lifting blocks were also used and set just

Figure 2 – Start Position and Finish Position

above the participants' patella for the start of the lift. Sleeves made of black material were used to cover the rubber bumper plates, which had a draw string at each end so that the discs could be as covered up as much as possible. All testing was carried out on weight lifting platforms.

3.4 Anthropometric Measurements and 1 Repetition Maximum

Anthropometric measurements of the participant's structure and mass were taken, along with 1 repetition maximum for the second pull from blocks, for the purpose of the study. It was important to record the participant's structure so that the lifting blocks could be placed at the correct height. Subject mass was measured using SECA digital scales (Model 770, Vogel & Halke, Hamburg, Germany), with structure being measured using a wall mounted stadiometer (Model Holtain, Holtain Ltd, Pembrokeshire, United Kingdom).

3.5 Testing Protocols

3.5.1 Warm Up

A standard warm up, following the guidelines of the revised Raise, Activate and Mobilise, Potentiate (RAMP) method (Jeffreys, 2007) was used to prepare the athletes for both the 1RM testing session and the data collection session, as can be seen in table 1. It has been suggested that an effective warm up will improve an athlete's range of motion, produce a higher oxygen uptake, lower lactate accumulation, improve the speed and force of muscle contraction, increase the speed of transmission of nerve impulse and increase muscle pH (Swanson, 2006).

Table 1. Standardised RAMP warm – up performed by participants

Exercise	Repetitions	Intensity/Rest
Back Squat	10	Barbell/ 40 seconds
Squat and Press	10	Barbell/ 40 seconds
Second Pull from Hang	10	Barbell/ 40 seconds

3.5.2 One Repetition Maximum Testing

In order to obtain results for 60%, 70%, 80% and 90%, it is necessary to test for the participants 1RM. Due to the second pull from blocks being a derivative of the weight lifting lifts, it is considered appropriate to use the 1RM protocol outlined by Baechle & Earle (2008) for the power clean. A weight lifting barbell with revolving sleeves, rubber bumper plates, safety locks and lifting blocks to a height that would ensure the bar was set just above the subject's patella. The testing was carried out on weight lifting platforms with weight plate selections of 2.5kg, 5kg, 10kg, 15kg, 20kg, and 25kg, to allow for 2.5kg graduations in weight. After the standardised warm up, the participants performed a warm up set of 5 to 10 repetitions with a light to moderate load. A 1 minute rest was provided, followed by a minimum of two heavier warm up sets of 2 to 5 repetitions. The participants were then instructed to attempt a 1RM. If they were successful then a 2 – 4 minute rest was provided before the participants attempted another 1RM with load increments of 4 – 9kg. The participants were given a maximum of 4 attempts to record a 1RM. Weight lifting straps were used for every 1RM attempt.

3.5.3 Known and Unknown Load Testing

The participants were first instructed to perform the standardised warm up (Table 1). They were then instructed to perform a total of 4 lifts without the weights being covered. The four loads used were 60, 70, 80, and 90% 1RM. Each lift had a load selected at random and the participants were allowed 2 minutes rest between repetitions. The participants were instructed to set up their starting position so that there was no bar slack and they were in a starting position ready to lift maximally. They were also instructed to perform the lift as maximally as possible to ensure PPO and PV readings.

After the four known loads were lifted, the participants were instructed to leave the room so that they were unable to see what weight was being loaded onto the barbell. One of the four intensities (60, 70, 80, or 90% 1RM) was then selected and loaded onto the barbell. Black sleeves (Figure 1) were then placed over the rubber bumper plates. To ensure subjects were unable to guess the load, the bumper plates were placed so that they appeared to reach both ends of the barbell sleeve for every unknown lift. Once the barbell was loaded and the black sleeves fully covered the rubber bumper discs, the participants were then instructed to re- enter the room and perform a maximal lift, being given the instructions used for the known lifts. This procedure was repeated after every lift until all 4 maximal efforts were completed.

3.5.4 Material Sleeves and Lifting Blocks

When the material sleeves were placed over the plates, it was important to ensure that the material was tight enough to not reveal which plates, or what load was on the bar. It was also important that the covered plates appeared to take up the majority of the barbell sleeve during each lift, which can be seen in Figure 3.

Figure 3 - Material Sleeves to Cover Rubber Bumper Plates

The height of the weight lifting blocks was also a highly important consideration. The blocks were placed at a height that ensured the barbell rested just above the participants' patella when they were in a position to perform a maximal lift and the barbell was loaded. If the height of the blocks were set when the participant was standing upright, it would result in the bar resting at a mid – thigh position as they got into their starting position. Therefore it was important that the barbell was at a position just above the patella when the subjects were in their starting position.

3.6 Variables Measured

For each known and unknown lift, the values were collected via the TENDO linear transducer, and were recorded onto a Microsoft spreadsheet.

3.7 Data Analysis and Statistical Analysis

All anthropometric data, 1RM, PPO and PV values were recorded on Excel 2010 for each lift. Mean values were calculated for all lifts (separately for known and unknown loads) so that a comparison could be made for the highest value when the loads were known and unknown. A one – way repeated measures ANOVA was used to determine existence of statistically significant differences between mean percentages of known and unknown loads. This testing procedure was used to compare the intensities in the known condition, and also the intensities when conditions were unknown. The different percentages for both conditions were then compared (e.g. 60% known compared to 60% unknown) to discover whether there was any significant differences. Significance was set at $p \leq 0.05$.

Descriptive statistics were generated using Microsoft Excel 2010, while descriptive statistical analysis was conducted using SPSS v.20. (SPSS Inc, Chicago, IL, USA).

3.8 Ethical Considerations

Ethical approval for the study was granted by the School of Sport Ethics Committee at Cardiff Metropolitan University. The participants were informed that their identity is strictly confidential and would not be used within the study; they were also informed that they were able to leave the study at any point.

CHAPTER IV

RESULTS

4.0 RESULTS

The study compared the effects unknown loading would have on the second pull from blocks when compared to known loading. Ten male subjects took part in the study, with anthropometric and 1RM data displayed in Table 2. PPO and PV values were recorded, and mean ± standard deviation (SD) was calculated for all intensities and variables. The means and SD were calculated for the intensities used and for both conditions (known and unknown).

Comparative statistics are provided in the figures 2 and 3, illustrating the effects of the test conditions (known and unknown).

Table 2. Anthropometric and 1 Repetition Maximum Data of 10 Subjects

	Mean Stature (cm)	Mean Mass (kg)	1RM (kg)
Mean ± SD	176.9 ± 8.1	84.4 ± 13.3	162.5 ± 30.7

4.1 Intensity Comparisons

Mean values show that unknown values for all intensities (60, 70, 80 and 90%) were lower than all known values in both PPO and PV (Table 3). Peak values for PPO were found at 80% 1RM for both known and unknown conditions, with no significant difference ($p > 0.05$), Peak values for PV being found at 60% 1RM for both conditions, with no significant difference ($p > 0.05$).

Table 3. Mean Values for 4 Intensities

Load (% 1RM)	PPO Known (W)	PPO Unknown (W)	PV Known (m/s)	PV Unknown (m/s)
60%	1336.1 ± 212.2	1298.7 ± 263.4	1.402 ± 0.256*	1.375 ± 0.237*
70%	1327.3 ± 239.4	1318.2 ± 260.4	1.217 ± 0.248	1.207 ± 0.233
80%	1382.7 ± 194.6*	1357.3 ± 205.8*	1.108 ± 0.224	1.08 ± 0.179
90%	1368.9 ± 210.1	1351.6 ± 170.0	0.981 ± 0.203	0.967 ± 0.171

*Peak power and peak velocity values were obtained.

4.2 Peak Power Output Results

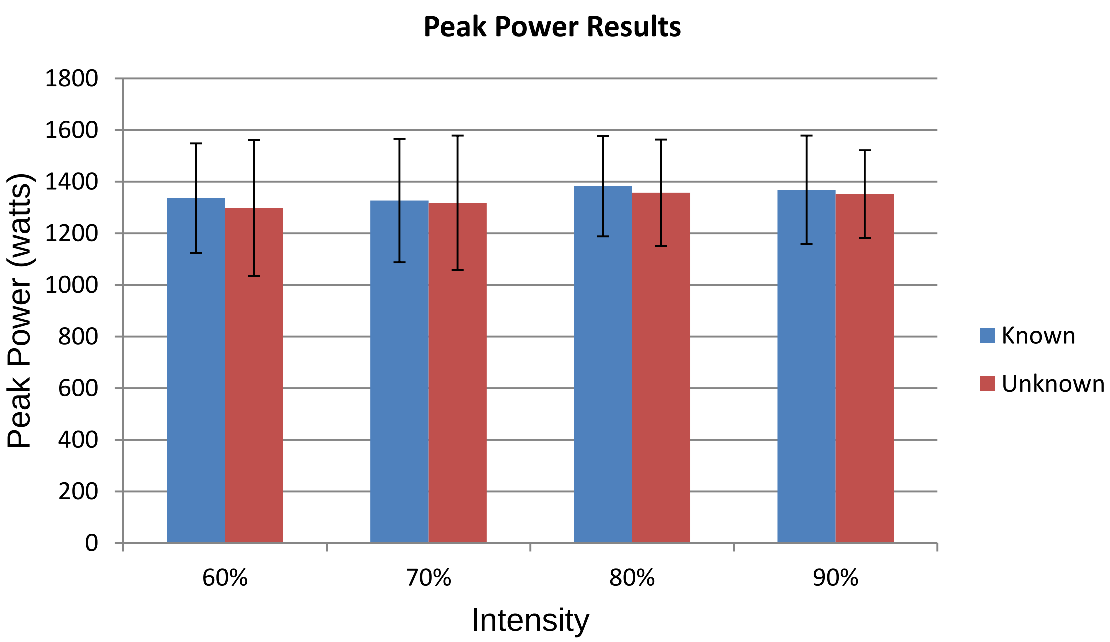

Figure 4 - Comparison of PPO when Loads are Known and Unknown

Statistical analysis revealed that relative load (%1RM) had no significant difference (p > 0.05) on PPO regardless of whether the load was known or unknown between percentages (60%, 70%, 80% and 90%). Figure 4 shows mean ± SD values for all intensities, with the greatest mean for known loading occurred at 80% 1RM (1382.7 ± 194.6 W), which was also the case for unknown loading (1357.3 ± 205.8 W).

4.3 Peak Velocity Results

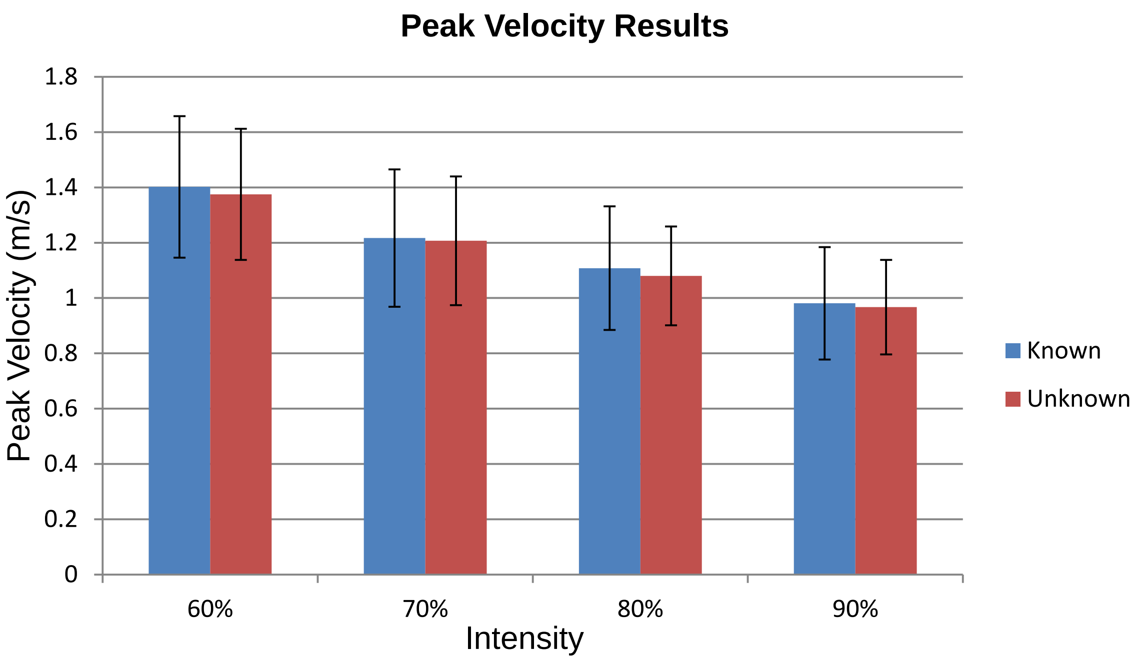

Figure 5 - Comparison of PV when Loads are Known and Unknown

The results of the statistical analysis showed that relative load (%1RM) had a significant difference ($p \leq 0.05$) when all known loads were compared against each other, apart from between 70% and 80%, which showed no significant difference ($p > 0.05$). However, when loading was unknown, there was a significant difference ($p \leq 0.05$) between all percentages of 1RM. Mean peak velocity occurred at 60% 1RM for both known (1.402 ± 0.256 m/s) and unknown (1.375 ± 0.237 m/s) conditions, as can be seen in Figure 5.

CHAPTER V

DISCUSSION

5.0 DISCUSSION

The aims of the study were to investigate the effect unknown loading would have on the second pull from blocks at varying intensities when compared to known loads. The study was completed by 10 male athletes, who all completed eight lifts in total, the first four were known and then the second four were unknown. Loads were selected at random regardless of whether the load was known or unknown. The participants used lifting straps for every lift, and the bar was set just above the patella. PPO and PV were recorded for each of the eight lifts, with means and standard deviation collected for each of the percentages.

5.1 Peak Power Output

One of the primary findings of the present study was that PPO had no significant difference ($p > 0.05$) between loads of 60, 70, 80 and 90% during the second pull from blocks, regardless of whether the load was known or unknown. The results showing that there was no significant difference between loads when conditions were known supports part of the original hypothesis and also extend the results found by Kawamori *et al*. (2005) and Kilduff *et al*. (2007), who also reported no significant difference in PPO between loads of 60, 70, 80 and 90% 1RM during the hang power clean. Kilduff *et al*. (2007) suggested that this similarity in results indicate large intra- individual responses to optimal loading for PPO and may also be due to strength training levels in participants.

The fact that there was no significant difference in PPO between loads when conditions were unknown does not support the hypothesis that there will be a significant difference between loads of 60% and 90% 1RM unknown. This finding is surprising as it was hypothesised that the subjects would perceive the unknown 60% load to be heavier than it was and produce a more explosive lift than would typically be performed at 60% known. The results obtained actually show quite the opposite, with 60% 1RM unknown being the lowest mean value (1298.7 ± 263.4 W) calculated out of all PPO values recorded.

Despite 60% 1RM unknown being the lowest mean value, it recorded the highest single value (1924 W) for PPO. This single value may suggest that the perception caused by the unknown loading would produce a more explosive lift, and therefore higher PPO at 60% 1RM. The reason for this anomaly may be due to competence of Olympic style lifts and their derivatives. However, further research would need to be in order to investigate this suggested finding on subjects who are competitive weightlifters.

Mean PPO was maximised at 80% during known loading, which directly supports the results found by Kilduff *et al*. (2007), who reported maximum PPO at the same percentage of 1RM during the hang power clean in professional rugby players. With the pull from blocks also having mean PPO values reached at 80% 1RM, it would be a valuable training consideration if an athlete is not competent enough in a power or full clean and the S&C coach does not have enough time to teach the athlete to become proficient in these lifts.

Interestingly, 80% was also the maximum value found for PPO when loads were unknown. Even though PPO was found at 80%, a difference, although not significant, was found in the mean values when loads were known (1382.7 ± 194.6 W) and unknown (1357.3 ± 205.8 W). This would suggest that although unknown loading is effective at reaching near maximal values at 80% 1RM for the second pull from blocks, using known conditions is more effective.

In regards to the lower intensities, the current study found that 60% and 70% values were not greater when conditions were unknown for PPO values. It may be hypothesised that perceived effort would enable participants to produce higher power outputs at lower intensities during the unknown condition as the protocol stated that; the bags must cover all of the load and it must reach the end of the collar regardless of how much weight has actually been loaded. By using this method, the participants would not know the load on the bar and therefore must perform a maximal voluntary contraction for every lift. This would then enable that participants to recruit high – threshold motor units, typically composed of type II muscle fibres (Kawamori and Haff, 2004), and produced a maximum voluntary contraction on a load that is 60 – 70% of their 1RM. However, as the results showed that loads of 60% and 70% 1RM were not greater when loads are unknown proves this hypothesis incorrect.

Reasons for this conclusion are unclear and may be due to a number of theories. Psychological methods such as imagery have been shown to increase muscle activation (Bakker, Boschker, and Chung, 1996). During the study, participants were unable to imagine themselves lifting the load as explosively as possible simply because they did not know what weight was on the bar. As image is a functionally organised set of prepositions (Bakker *et al*. 1996), this allows a subject to prepare for a given situation and respond. By not knowing the load on the bar, the participants were unable to prepare for the given load and therefore may have become apprehensive about producing a maximal voluntary contraction.

Attention allocation and effort perception could also have affected the current findings. Tenenbaum and Connolly (2008) found that as intensity increased from 30% to 75% in rowers, dissociative attention strategies would shift to associative attention strategies due to the high levels of effort perception. By using associative strategies during higher intensity, the rowers would focus inward and towards bodily sensation rather than outward (dissociation). Due to the focus of the present study, during unknown loading the participants may have an altered sense of effort perception, focusing their attention in a more dissociative manner. This would cause the participants to switch attention between multiple sources of information rather than only focusing their attention towards producing a maximal voluntary contraction (association). This theory could explain not only why loads of 60% and 70% unknown did not reach greater values, but also why there was no significant difference between all intensities when conditions were unknown. However, further research into the psychological elements involved when comparing unknown and known loading would need to be investigated in order to form a more complete conclusion.

The starting position may also have been a factor in determining why there was no significant difference in PPO between known and unknown loads regardless of intensity. As the starting position was above the patella and therefore below mid – thigh, participants were able to perform a partial lift into a mid – position to then produce a maximal effort second pull. The partial lift may have given an indication to the participant as to how much load was on the bar. If this were the case, then it would allow the subject to replicate the effort needed to perform each lift that was exerted when the load was known. Starting position comparison research would need to be explored in order to confirm this suggested finding.

Finally, the use of then Tendo unit may contribute to the results of the present study. The Tendo unit may not have recorded true PPO values as the unit calculates PPO through a combination of calculations using the acceleration values and mass of the barbell. A more accurate measurement of PPO could be recorded with the use of a force plate or BMS.

5.2 Peak Velocity

For the present study, null hypothesis 1 can be accepted, as mean values for 60% and 70% unknown were lower than known values in PV and PPO, however PV was found at 60% 1RM for both known (1.402 ± 0.256 m/s) and unknown (1.375 ± 0.237 m/s) conditions. There were also significant differences ($p \leq 0.05$) between all loading intensities when conditions were unknown, with significant differences ($p \leq 0.05$) between all loading intensities apart from 70% and 80% when loads were known, which showed no significant difference ($p > 0.05$).

The fact that 60% and 70% produced the highest mean values directly supports the force – velocity relationship. As it is evident that as velocity production is increased, maximal force is decreased and *vice versa*, it is unsurprising that the highest peak mean values for PV were found at 60% and 70% regardless of whether the condition was known or unknown. Toji and Kaneko (2004) highlighted the importance of enhancing velocity of muscle contraction as well as strength for power development. Therefore, the results of the present study may suggest that when training specifically for PV in order to enhance the development of power, using the second pull from blocks at 60 – 70% would be optimal. However, due to the present results concluding that unknown values are in fact lower than known values in all four intensities, using known loading would be the more favourable method.

Hypothesis 5 can be considered correct for PV as there was a significant difference between unknown loads of 60% and 90%, with the same being true for known loads. This hypothesis also directly relates to the force – velocity relationship and supports the results obtained by Zink *et al*. (2006) who found significant differences in PV between loads of 60% and 90% during the squat exercise, with no significant difference ($p > 0.05$) between loads of 70% and 80%. However, the current study found a significant difference ($p \leq 0.05$) between loads of 70% and 80% when conditions were unknown. The present study overall found significant differences between all intensities when loads were unknown, forming a more linear relationship with the force – velocity curve. This could be due to the intention to move explosively. It has been suggested that performing movements with the intention to move explosively will positively affect adaptations in RFD (Kawamori and Newton, 2006). Therefore, the fact that significant differences were found between all loads when conditions were unknown may suggest subjects intended to move explosively on a more consistent basis when conditions were unknown, and this could prove to be a useful method for developing RFD.

However, with these PV values, it may also be suggested that training with unknown loading is not effective when the goal is to increase RFD. The exercise used in the current study is similar to the mid – thigh clean pull, which has been reported as having the shortest time to peak RFD when compared to the countermovement jump and vertical jump (Comfort *et al*. 2011), the only difference being the current study used the clean pull from just above the patella, as opposed to mid – thigh. Despite significant differences being found between all loads when conditions are unknown, as opposed to no significant difference between 70% and 80% when loads are known, known conditions still obtained higher mean and maximal values across all intensities. It would be interesting to note that the results of studies investigated by Kilduff *et al*. (2007) and Kawamori *et al*. (2005) concluded that peak RFD was unaffected by relative load for all intensities higher than 25% of maximum force, suggesting that increases in RFD development are optimised at lower percentages of 1RM.

Consideration for RFD development should also be placed on maximal force development. Aaagaard *et al*. (2002) found that contractile RFD was increased 17 – 26% after a period of heavy resistance training. The study concluded that this increase in RFD may be due to increases in efferent neural drive. However, Aagaard *et al*. (2002) stated that the subject population had not previously participated in systematic resistance training, suggesting a low training age. This proves counterproductive as any strength training programme will enhance strength in a novice participant, making the results of this study misleading (Siff, 2003). A study on subjects with a more advanced training age to determine the role of resistance training on maximal RFD would be more appropriate.

If the focus is on developing PV, then it would be a considerable option to use the current results to expand on an investigation into velocity specific training. If the current study was taken into consideration to train for velocity specificity, the results would suggest that 60% known would be the optimal intensity and condition as this is where the highest value was obtained (2.00m/s).

Hatfield *et al*. (2006) concluded that velocity specific training elicits higher peak power, force, and volume at 60% and 80% 1RM.

5.3 Loading Intensity

A number of recent studies have been conducted to discover an optimal load for power training. A conclusion can be made that peak power is reached at different intensities depending on exercise selection. The present study hypothesised that PPO will be reached at 80%, due to findings by Kilduff *et al*. (2007), who found that PPO was found at this percentage in the hang power clean, a similar exercise to the one used within the current study. Four loading percentages were used; 60, 70, 80, and 90% 1RM due to the mixed results found in recent literature that suggest PPO is found anywhere between 0% - 80% 1RM. Kilduff *et al*. (2007) found that PPO was reached at 80%, with Kawamori *et al*. (2005) concluding that PPO was found at 70% 1RM, however both studies found no significant differences between loads of 60 – 90% 1RM. Therefore, these loading parameters were used in order to investigate the effects unknown loading would have on PPO and whether or not PPO can be reached at a lower percentage for a weightlifting derivative.

Low intensity loads, such as 60%, were also used to test for PV, as lower loads are necessary in order to reach PV values. This relates back to the force – velocity relationship shown in Figure 1 which expresses the point that as velocity is increased, force is decreased. Therefore, by using lighter loads, greater velocity values can be obtained. However, PPO values will only be obtained when the maximum potential product of strength and speed is demonstrated (Peterson *et al.* 2006).

5.4 Application of Findings

The results of this study, along with recent literature, highlight the validity of the force – velocity relationship and the importance to train strength and velocity in order to enhance power development. With PPO being reached at 80% 1RM and PV being reached at 60% 1RM, it would suggest that training at both ends of the force – velocity continuum need to be considered in order to train power development.

In terms of unknown loading, the current findings suggest that using unknown loading is not an optimal training method for either PPO or PV development. The only consideration may be the use of 60% unknown for PPO development. Currently this would be considered illogical due to the fact that the results of this study reported 60% unknown had the lowest mean PPO for both known (1336.1 ± 212.2 W) and unknown values (1298.7 ± 263.3 W). However, this percentage and condition also reached the highest single value for PPO (1990 W). Although a minimal consideration and anomaly, it would be advantageous to investigate further into this anomaly with competitive weightlifters or athletes with a high competency level in Olympic style weight lifting lifts and their derivatives, to see if the effects of unknown loading are more apparent when compared to known loading when the lifting ability of the participants is a primary consideration.

5.5 Limitations and Further Research

Throughout the course of the study, a number of weaknesses arose in the research process. With regards to subject population, participants who volunteered to take part in the study had to be playing in a sport that had a high demand for power output, with the inclusion of Olympic style lifts and their derivatives in their training programme. However, despite the inclusion of these lifts, competency levels were no assessed. The participants were competent enough to be able to perform the second pull from blocks; however an analysis assessment of their full clean pull would have been a worthwhile measure to test the participants' skill level. Another change in subject population would be to use competitive weightlifters, or subjects with a substantial weight lifting history, as subjects. This would provide a more accurate testing protocol as a weightlifter's training is specified to be able to produce maximum PPO and PV during the second pull.

Equipment selection should be rectified in future studies in order to improve validity and also variable measurements. The TENDO unit was used in the present study, which only allowed for PPO and PV values to be recorded due to the focus of the study. By using the ballistic measurement system (BMS), RFD could be measured, which would provide a more complete comparison between known and unknown loading when power development is the primary focus.

In order to form a more comprehensive study in the future, the psychological aspect should be researched in more depth. Sport psychology is extensively researched in current literature and within the present study, perception had to be utilised in order to extract the best outcome from the testing procedure. The current literature analysing the links between performance and perception have not researched how perception of load affects performance.

Within the present study, the blocks were set so that the subject was lifting from below mid – thigh, just above the patella. This would allow for a slight lift and transition before performing the explosive second pull. This partial lift may have given the athlete an indication of the load on the bar when conditions were unknown. It would be beneficial for a future protocol to have subjects perform the lift with the bar positioned at mid – thigh. This would ensure that the participant would only be able to perform an explosive vertical lift from the blocks, cancelling out the potential for a partial lift at the beginning of the movement, providing more validity that the lift will involve a maximum voluntary contraction against an unknown load.

CHAPTER VI

CONCLUSION

6.0 CONCLUSION

The current study has investigated whether there is a need for a new training modality in order to optimise the development of peak power and peak velocity. The use of unknown loading was compared with known loading to discover whether an athlete reaches peak power and peak velocity values at different intensities despite having the intent to move the given load as explosively as possible.

The current study concluded that there was no significant difference ($p > 0.05$) between loading intensities for peak power output when unknown conditions are used, with peak power output being found at 80% for both known (1382.7 ± 194.6 W) and unknown (1357.3 ± 205.8 W) conditions. The use of unknown conditions resulted in a significant difference ($p > 0.05$) between loads of 70% (1.207 ± 0.233 m/s) and 80% (1.08 ± 0.179 m/s) for peak velocity, which was not found when conditions were known. Despite this difference being found, mean peak velocity was found at 60% 1RM for both known (1.402 ± 0.256 m/s) and unknown (1.375 ± 0.237 m/s) loading.

For both peak power and peak velocity, unknown mean values were lower than known mean values for all intensities tested, from this it can be concluded that using unknown loading is ineffective when the objective is to maximise these values from the second pull off blocks. However, the results obtained gives strength and conditioning coaches an indication of the percentages that need to be used if they choose to include the second pull from blocks to develop either peak power output or peak velocity, as weightlifting movements and their derivatives have become increasingly popular in recent training programmes.

CHAPTER VII

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CHAPTER VIII

APPENDICES

APPENDIX A

CARDIFF METROPOLITAN PARTICIPATION CONSENT FORM

CSS Reference Number: st09003648
Participant name or Study ID Number:
Title of Project: A Comparative Study Between Known and Unknown Loading
Name of Researcher: Henry Applegate

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet for the above research project. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to stop taking part at any time, without giving a reason. ☐
3. I agree to take part in the above research project ☐

Name of Participant Date:

Signature of Participant…………………………………………..

Name of person taking consent……………………………………..Date:

Signature of person taking consent…………………………………….

APPENDIX B

Cardiff Metropolitan reference number: XXXXXX

Title of Project: A Comparative Study Between Known and Unknown Loading

Participant Information Sheet

Background

This study will be investigated by myself, an undergraduate student at Cardiff Metropolitan University.

The project will be studying the effects of unknown loading peak power output and peak velocity during the second pull from blocks when compared to known loading. The results of this study will aid in understanding if there is a place for unknown loading as a training method when the focus is power development.

What will be expected of me?

You will be asked to attend two data collection sessions. The first session will be to determine your one repetition maximum (1RM) for the second pull from blocks. Your height and weight will be measured, and then the blocks will be set to a height so that when the bar is loaded and on the blocks, it will rest just above your patella when you are in your starting position. You will then be taken through a standardised warm up and then a number of repetitions to determine your 1RM. Lifting straps will be a requirement for every 1RM attempt and follow up testing sessions.

On the second test day you will be required to perform the same standardised warm up as the 1RM testing day before having to perform 8 total lifts. The first four lifts will be known to you, and will be selected at random, ranging from 60 – 90% 1RM. For the last four lifts, you will be asked to leave the room so that a weight between 60 – 90% 1RM can be selected at random, loaded onto the bar and then covered using black material sleeves. You will then be asked to enter the room again and perform a maximal lift each time with the use of lifting straps. A 3 minute rest will be given between each lift.

What are the risks of the study?

We do not believe there are any significant risks to you taking part in this study; however as for the last 4 attempts the load will be unknown to you, we strongly advise that you are prepared to lift maximally for each attempt. If you are injured before any of the testing days this will prevent you from taking further part in the study. No prejudice will be held against you if you decide to stop participating within this study at any time as you are free to do so.

Your rights:

No legal rights will be given up if you choose to participate in this study. If in the unlikely event something goes wrong during the study, Cardiff Metropolitan University fully indemnifies its students and all participants are fully covered by its insurance.

What happens to the results of the study?

All information will be coded so that names are removed and anonymity is maintained. I will need to keep a record of the codes until the research has been completed. All data collected will be securely stored in a filing cabinet in Cardiff Metropolitan University, with all digital information being stored on a computer with a secure password. All the information about the participants will be produced together; however there will be no reference or description that will identify the participant. The research will be presented as a dissertation project and may be used for publication.

What happens next?

An information sheet and a consent form will be included within this letter for you to give permission for you to participate in this study.

How we protect your privacy:

Any participant information used within the study will have no reference to the participant's name or any information that will identify them. If individual participants are mentioned within the text, a code will be used as opposed to their name to protect their confidentiality. Only participant consent forms will be kept as verification, which will be kept in a secure filing cabinet by Cardiff Metropolitan University. Any data collected will not have participant names within them as they will be replaced with a code. Raw data will be kept on a laptop with a secure password, and will then be destroyed after the research process has ended.

Further Information

If you have any further questions about the study or how we intend to conduct it, please feel free to contact us on:

✉ St09003648@outlook.cardiffmet.ac.uk

Henry Applegate