Cardiff School of Sport

DISSERTATION ASSESSMENT PROFORMA:

Empirical [1]

Student name:	Ryan Keates	***Student ID:***	ST10001442
Programme:	SES		
Dissertation title:	The effects of different conditioning contractions on acute potentiation of counter movement jump performance		
Supervisor:	Dr. Joseph Esformes		

Comments	Section
	Title and Abstract (5%) 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 (25%) 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 (15%) To include: details of the research design and justification for the methods applied; participant details; comprehensive replicable protocol.
	Results and Analysis (15%) [2] 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.

[1] This form should be used for both quantitative and qualitative dissertations. The descriptors associated with both quantitative and qualitative dissertations should be referred to by both students and markers.

	Discussion and Conclusions (30%) [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.
	Presentation (10%) To include: academic writing style; depth, scope and accuracy of referencing in the text and final reference list; clarity in organisation, formatting and visual presentation

[2] There is scope within qualitative dissertations for the RESULTS and DISCUSSION sections to be presented as a combined section followed by an appropriate CONCLUSION. The mark distribution and criteria across these two sections should be aggregated in those circumstances.

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CARDIFF SCHOOL OF SPORT

DEGREE OF BACHELOR OF SCIENCE (HONOURS)

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TITLE

THE EFFECTS OF DIFFERENT CONDITIONING CONTRACTIONS ON LOWER BODY ACUTE POTENTIATION OF COUNTERMOVEMENT JUMP PERFORMANCE

(Dissertation submitted under the discipline of Strength and Conditioning)

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THE EFFECTS OF DIFFERENT CONDITIONING CONTRACTIONS ON LOWER BODY ACUTE POTENTIATION OF COUNTERMOVEMENT JUMP PERFORMANCE

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Acknowledgements

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Abstract

The present study investigated the effects of different conditioning contractions (CC) on lower body acute potentiation of counter movement jump (CMJ) performance. Acutely enhancing muscle performance through the use PAP would allow complex training to be implemented within programmes designed by strength and conditioning coaches. A total of 8 male university rugby union players (Height 178.6±9.6cm; Weight 89.6±12.6kg; 1RM 170kg±40kg) took part in 3 separate trials in which they performed either a 90%, 30% or plyometric (PLYO) CC in a repeated measures design with a baseline performance measure and post-CC performance measure present with a total of 10mins rest utilised between baseline performance measure and CC and a 7min rest period utilised between CC and post-CC performance measure. The performance measure consisted of 3 CMJ with 1 minute rest between each measure. There was no significant difference in P_{peak} (Peak force) among the PLYO, 30% and 90% trials (p= 1.000, p=1.000, p=1.000 respectively), again no significant difference in d_{max} (maximal displacement) among the PLYO, 30% and 90% trials (p=1.000, p=0.097 and p=1.000 respectively). Likewise there was again no significant difference in RFD (rate of force development) across the PLYO, 30% or 90% trials (p=1.000, p=1.000, p=1.000 respectively) and again finally there was no significant differences in RelF (relative force) in the PLYO, 30% or 90% trials (p=1.000, p=0.326, p=1.000 respectively). These findings suggest that neither the PLYO, 30% or 90% has no effect on lower body acute potentiation of counter movement jump in trained male university rugby players.

CHAPTER 1

INTRODUCTION

1. Introduction:

Athletes spend much of their own time and effort in various training sessions trying to improve certain aspects of their performance. These aspects could potentially be physiological performance variables which could possibly give the athlete or performer an edge over the competition. These performance variables may differ from sport to sport. In general sports are not exclusive to just one performance variable. These variables may include; acceleration, speed, anaerobic/anaerobic capacity, maximal strength and jump height. Jump height and acceleration are both important physiological components that can be beneficial in many sports/athletics events and sporting situations; an enhancement in this area is likely a result of an enhancement in overall power production by the working muscles. The search for ways to increase muscular power is an on-going one and many strength and conditioning specialists are currently taking advantage of one such method known as postactivation potentiation (PAP). PAP is a phenomenon known to exhibit acute muscular responses which ultimately have been shown to increase power output and rate of force development (RFD), both in the short term and in terms of chronic adaptations (Robbins, 2005), essentially the enhancement of subsequent force generation. This improvement in power production lends itself to several physiological and biomechanical pathways; increased recruitment of higher order motor units, regulatory light chain phosphorylation (Sale, 2004) and with conflicting research a change in pennation angle has been suggested it can benefit performance post conditioning contraction. The increased recruitment of higher order motor units increased excitation potential across the spinal cord, resulting in improved post synaptic potential ultimately leading to increased force generation potential for several minutes post conditioning contraction. Evidnece suggests that regulatory light chain phosphorylation improves the interaction between the actin-myosin to the Ca2+ sarcoplasmic reticulum (SR), leading to alteration in the shape of the myosin heads, ultimately translating to a larger force production state for the myosin cross-bridges (Kilduff et al, 2007). Finally the resultant changes in pennation angle can be linked as a beneficial mechanism for power performance by creating a more structurally advantageous angle over which a larger force can be produced i.e. the smaller the angle the more force can be produced. This being said rest periods should be a very important variable when it comes to eliciting the best from the acute muscular responses; this is simply because too short a rest period and fatigue becomes a major factor and too long a rest period will see the benefits of the pre conditioning contraction go to waste.

CHAPTER 2

LITERATURE REVIEW

Review of literature:

2.1 Introduction to PAP:

Due to the fact that strength and the rate that this force can be applied are usually considered essential for athletes across the board in terms of anyone sport and/or an event, the previous studies are usually aimed at individual athletes or team athletes due to the need for power and strength improvement. A number of strategies can be implemented to improve power within a training programme, these include plyometric exercises, near maximal back squats and squat jumps at a percentage of 1RM as well as others. To highlight the importance of these training methods Kilduf et al., (2007) decided to try and assess the use of plyometric exercises and its effect on PAP. Whereas, Sale (2002) used varying intensities of 1RM and attempted to find the optimal load at which a greater actute response in the muscle is found. As stated earlier both these training methods are widely used in order increase power and if they can produce gains in RFD and power within a training programme why can't they elicit a short term increase in power output e.g. PAP. The importance of this could be highlighted in sports where an athlete has to exert large amounts of force at a high rate against contrasting external loads (Kilduff et al, 2007). The acute muscular response is therefore an important variable for athletes as it can be used in a practical setting to improve an athlete's power output in the short term e.g. a high jumper could potentially use a near maximal squat, plyometric exercise or even a weighted jump squat in order to try and better his/her performance due to the short term effects of PAP. However this being said the ideal conditioning contraction has to be found in order to elicit the best response to the individual.

2.2 Mechanism of PAP

Contractile proteins and skeletal muscle can be acutely affected by their contractile history. There is one such way in order to bring about these changes in the muscle; Post-activation Potentiation (PAP). Post-activation potentiation refers to the phenomena by which muscular performance characteristics (essentially the rate of force development) are acutely enhanced as a result of their contractile history (Tillin NA & Bishop D, 2009). Meaning a forceful contraction of the muscle can elicit increased rate of force development (RFD) for several minutes afterwards. This enhancement has been predominantly credited to 2 main pathways; regulatory light chain phosphorylation and increased recruitment of motor units. Regulatory light chain phosphorylation has been shown to increase the sensitivity of the actin-myosin interaction to the Ca^{2+} released from the sarcoplasmic reticulum and alter the structure of the myosin head, resulting in a higher force-producing state for the myosin crossbridges (Rassier, D & Macintosh, B., 2000). Increased motor unit recruitment is suggests that previous contractions increase the excitation potential across central nervous system (CNS), resulting in increased postsynaptic potentials and, subsequently, increased force generation capacity (Güllich, A & Schmidtbleicher, D., 1996). This being said, the myosin light chain kinase is responsible for generating a greater amount of ATP (adenosine tri-phosphate) at the actin-myosin complex ultimately increase the rate of actin-myosin cross bridging (Xenofondos et al, 2010). Essentially explaining how the conditioning contraction/stimulus may help to increase the power output and RFD at the cross-bridges, ultimately meaning improved performance in explosive movements such as jumping and sprinting (Hodgson, M et al., 2005). As stated previously the second theory proposes that the conditioning contraction provides a stimulus by which higher threshold motor units are recruited (Chiu L, 2003), essentially meaning this increased neural drive and activity may be due to this motor unit recruitment and the synchronisation of these motor units (Aagaard, 2003). Consequently PAP could be a resultant from both muscular and neural pathways that are not totally understood at this moment in time by sports scientists (Xenofondos et al, 2010). PAP is therefore defined as “a short term increase in muscle performance after a conditioning contraction” (Hamada et al, 2000). These conditioning contractions may vary and include but are not limited to a maximal voluntary contraction (MVC) (Hamada et al, 2000), as well as a plyometric contraction, maximal dynamic contraction and an isometric contraction. It should be noted that using the above mentioned stimuli an acute response can be observed in the muscle therefore increase a number of performance enhancing variables such as rate of force development (Xenofondos et al, 2010). This being said it should be noted that an additional study into the area of post-activation potentiation and varying conditioning contractions is needed to aid understanding of how and when PAP can be utilised in order to improve performance in athletes. Also

Moreover, pennation angle is also sometime potentially thought to elicit an acute muscular response following a conditioning contraction. Pennation angle is the angle between the muscle fibres and a fictional line drawn between a muscles origin and insertion, meaning it is specified by the orientation of muscle fibres in relation to the connective tissue e.g. tendons (Folland and Williams, 2007). Muscles equipped with superior pennation are thought to contain more sarcomeres in parallel and less in series, meaning that this particular muscle is able to generate more force (Beachle and Earle, 2008). Pennation angles essentially provide a more biomechanically beneficial angle at which a larger potential for force can be generated and transferred through the tendon (Folland and Williams, 2007; Fukunaga *et al*., 1997). Despite this the pennation angle and its contribution to the acute muscle response is in need of further analysis (Tillin NA & Bishop D, 2009). Despite this, it should be noted that Mahlfield et al. (2004) stated that the vastus lateralis' pennation angle had not changed immediately following a maximum voluntary contraction. Nevertheless, there was an apparent significant decrease in pennation angle ($p<0.05$) following a rest period of 3-6 minutes. Therefore from these findings it could be said that this alteration in pennation angle could ultimately contribute to PAP.

The main reason why PAP has been researched and assessed by researchers in the strength and conditioning field is to find out whether it can be used and incorporated in a way to increase power in athletes. Among the majority of studies they seemed to have looked at lower limb power and assessed this through the use of either sprint tests of a counter movement jumps with the goal of determining significant correlations between the performance measure and the conditioning contraction used.

There have been a few studies that looked at the effect of a loaded back squat on counter movement jump performance. These previous studies have proven that PAP certainly has a positive effect on RFD and jump performance (Boullosa, Daniel A., 2013.; Cameron J. Mitchell & Digby G. Sale., 2011.; McCann, Matthew R & Flanagan, Sean P., 2010). In a number of the mentioned studies it has been found that the MVC in the form of a back squat certainly produced a greater power output when compared to a dynamic squat movement (Rixon et al., 2007). Therefore, suggesting that a maximal contraction at a high intensity/percentage of 1RM is needed to elicit the best PAP response possible. Strength and conditioning specialists could potentially use this information when designing training programs and warm-up protocols in order to get the best from their athletes in terms of the CNS being fully efficient before the event/training session as well as pre-determining loads within a training program to elicit the best strength and power gains from his/her athletes. This being said the combination of speed and intensity under a maximal contraction was not assessed i.e. bodyweight plyometric exercise or weighted jump squat at a percentage of 1RM. For example, if the assessment was to be carried out this way, a number of training and RFD training protocols would be covered e.g. Strength, Strength-speed and Speed strength (plyometric exercises).

2.3 Rest period

A number of studies have attempted to look at the effect of recovery/rest periods on the PAP phenomenon (Tillin and Bishop, 2009). Despite the fairly large amount of research in this area it is not yet clear at which rest interval the PAP response is optimal (Kilduff et al., 2007) making it difficult reasonably difficult to implement a standardised recovery time with the purpose of limiting fatigue whilst eliciting the best PAP response possible.

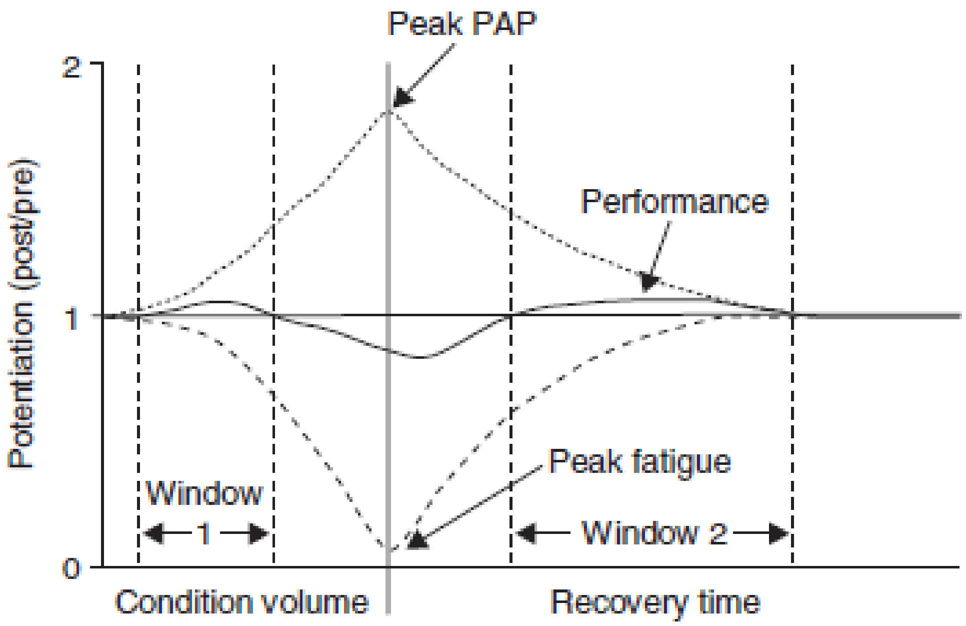

Figure 1. *The theoretical relationship between PAP and recovery following a conditioning contraction (Sale 2002).*

The variant in rest periods have also proven to be incredibly important, as for example Hansen et al., (2007) found increases in vertical jump performance when relatively near max. (80%) back squat loads where used in conjunction with long rest periods (5min seated recovery) between the counter movement jumps (CMJ) and near maximal back squat. Likewise Kilduff et al., (2007) found that CMJ heights were significantly raised compared the baseline results due to the use of relatively long recovery times (4mins) between the squat and the CMJ itself. In comparison to this, within the same study Kilduff et al., discovered that the shorter rest periods they also employed significantly reduced jump height and performance. From this it could be determined that the recovery period used between the conditioning contraction and CMJ can significantly impact the results and effect of PAP. Jensen (2003) found no significant changes or increases in jump performance after a 4 minute recovery period was used and in fact stated there was a large decrease (13%) in performance when only 10 seconds was employed. Again this evidence reinforces the fact that rest periods are significantly important when addressing the PAP response and what potential effects or bonuses it could have on athletic performance for both male and female athletes.

Despite the debate on recovery periods it could be suggested that the prime recovery interval is potentially down to the individual involved (Kilduf et al.,(2007). For example in their findings it was seen that 70% of their participants recorded their highest peak power output, jump height and RFD after an 8 minute time frame of recovery. In comparison to this 15% of the remaining 30% were found to slicit their best peak power output, jump height and RFD after a 12 minute recovery and lastly the remaining 15% were found to produce their optimal PAP response after a recovery period of just 4 minutes, ultimately suggesting that a recovery period of at least 5 minutes should be utilised in order for PAP to influence performance enhancement within the active muscle (Kilduff et al., 2007). This evidence is also backed up by previous studies as they believe the optimal time frame at which acute responses within a muscle are achieved lies between 5-10 minutes (Young *et al.*, 1998; Hamada *et al.*, 2000; French *et al.*, 2003; Hanson *et al., 2007*).

2.4 Conditioning Activity and type:

There have been limited studies on what type of conditioning contraction best elicits the PAP response. Rixon et al.,(2007) found that an isometric contraction provided an enhanced PAP effect when compared to a dynamic contraction. In comparison to this Esformes et al.,(2011) took this study a stage further and examined the use of concentric, eccentric, isometric and dynamic conditioning contractions on PAP in the upper body. Ultimately they found, like Rixon et al., that the isometric contraction produced a significantly higher peak power output compared to the other varying contractions. In a further study by Esformes et al.,(2010) the effect of a lower body plyometric movement and a maximal voluntary contraction (MVC) in the form of a 3RM half squat were used in order to see which is more efficient at inducing a PAP response and its effect on counter movement jump (CMJ) performance. Here, it was concluded that a greater displacement was achieved with the MVC (squat 3RM) compared to rest or plyometric (explosive contraction). However with peak power output, vertical power, RFD and relative force no significant differences were evident.

Tillin & Bishop (2009) have stated that the application of a conditioning contraction as a result of current literature is varying as a result of the lack of consistency in experimental methodologies, ultimately leading to varied findings and research conclusions with reference to the 'correct' volume, intensity and conditioning contraction in order to find out a greater deal of information in regards acute muscular responses. Intensities of conditioning activities have been largely speculated on; Sale (1987) recommended the use of heavy resistance type activities such as 3RM squat, because of its ability to recruit the high threshold motor units of the type II fibres ultimately producing a greater PAP response, this was also reinforced by Luscher et al., (1983) and Gossard et al., (1994). Despite this other authors argue that a lighter load is a required as it allows for maximum power output at a greater speed of movement.

The type of activity is said to have an effect on the amount of potentiation achieved by a muscle i.e. conditioning activity and contraction type (Tillin & Bishop., 2009). The same study by Tillin & Bishop found that any type of contraction is likely to produce the desired responses in PAP but at varying degrees. In relation to both dynamic and isometric contractions research advocates the use of dynamic conditioning contractions at near maximal effort are most likely to induce the sought after responses with regards to PAP in the performance test, here maximal refers to effort given so can translate to maximal loads and/or movement velocity *(Gourgoulis et al., 2003; Rahmi, 2007).* This being said Jenson & Ebben (2003) and Hanson et al., (2007) would indicate that there is either very little or no PAP as a response to a maximum voluntary contraction and would ultimately indicate that isometric contractions are more benficial for eliciting an acute muscular response. This conflicting evidence suggests that there is not yet a clear relationship between conditioning contraction and PAP response (Tilling &Bishop., 2009).

Tillin & Bishop (2009) state that due to the large variances in testing protocols and methodologies it should be unreliable to suggest comparisons as to the efficacy of contraction types and conditioning contractions. This being said it has been stated by a number of research protocols and authors that the conditioning contraction volume should be kept low in order to lessen the onset of fatigue and ultimately an attempt to improve the PAP response via the reduction of fatigue. This is supported by the findings of French et al., (2003) and Behm et al., (2004), however coupled with the low conditioning contraction volume should be assessed in conjunction with recovery time when trying to elicit the best gains possible in regards to PAP and the power response in the performance measure.

In relation to the research it is evident that Isometric conditioning contractions could essentially result in a greater amount of central fatigue but could alternatively assist the peripheral mechanisms of PAP. In conjunction with this dynamic conditioning contractions could in fact produce a greater amount of peripheral fatigue but are deemed more successful at activating the central mechanisms related to PAP (Tillin & Bishop., 2009).

2.5 Exercise selection:

The squat and its variations are some of the most extensively used exercises that are usually a staple in any strength and conditioning coaches training programmes. Largely due to the fact that the prime movers of jumping and sprinting are used in the squat as well as a very biomechanically similar motor pattern, especially present in the squat and the CMJ. Therefore it could be said that improving strength and power in these muscles in a biomechanically similar movement pattern a great improvement in jump performance and running performance could be witnessed in untrained as well as trained athletes (McLaughlin et al., 1984). This being said it was said by Beachle (1994) that the squats ability to produce strength and develop hypertrophy in the lower limbs it is largely a favourite amongst conditioning coaches.

2.6 Subject characteristics:

Recent literature present in PAP suggests that there are a number of subject characteristics that affect the value of PAP on acute responses within the muscle on explosive activities (Gullich and Schmidtbleicher, 1996; Chiu et al., 2003; Gourgoulis et al., 2003, Hamada et al., 2003). It has been stated that this may be due to a positive linear relationship between any one individual's muscular strength and his/her percentage of type II (fast-twitch) muscle fibre type distribution (Aagaard and Andersen, 1998). Muscle fibre type distribution is said to have a huge role in PAP performance as type II muscle fibres exhibit the greatest amplification of in regulatory light chain (RLC) phosphorylation following a conditioning activity beforehand (Moore & Stull, 1984). It has also been found that a larger percentage of type II muscle fibres frequently results in a larger proportion of high order motor units which are stimulated through decreased transmitter failure as a prerequisite to the conditioning activity (Tillin & Bishop). As a result of the combination of the mentioned phenomena a greater PAP response should be present.

Chui (2003) made an attempt to assess the impact of training status on the acute muscular response following a conditioning contraction in athletes involved in explosive strength activities as well as individuals who participate in recreational training (whether it be resistance or general exercise). They had 12 men and 12 women perform jump squats at 5 minutes and 18.5 minutes following a moderate intensity or high intensity PAP intervention over a total of four sessions. Chui (2003) noted that recreationally trained athletes showed little or no acute response at 5 minutes with the high intensity stimulus, largely due to fatigue. In contrast to this, the athletically trained individuals exhibited significantly enhanced power production after both 5 and 18.5 minute rest intervals following the stimulus. Therefore they established that the PAP response is likely to be greater and enhance strength and performance in specifically trained individuals, this is likely to be a result of their greater resistance to fatigue and high level of conditioning. In relation to this study Tillin & Bishop (2009) promote the idea that the study failed to take into account the fibre type distribution of the individuals. Ultimately this could result in the possibility that a greater type II fibre type percentage in the resisted trained subjects could aid the acute response observed in Chui's study.

In addition it has been stated that certain individuals who fail to successfully translate their strength levels into appropriate power levels were at a greater advantage of benefitting from PAP, that being said it appeared as though there was a clear defined threshold at which subjects beyond it didn't seem to profit from PAP. Ultimately meaning individuals with a larger muscular strength, larger percentage of type II muscle fibres, higher level of resistance training activity and a smaller power-strength ratio benefit more readily and effectively from the PAP phenomenon (Schneiker et al., 2006). This being said; Tillin & Bishop (2009) state that further research is required in order to explore a greater number of subject variables/characteristics that may have an effect on the PAP response.

2.7 PAP in application:

As research suggests the phenomenon of PAP is validated by the theory that a muscle ability to produce force can be influenced for the greater as a result of its contractile history (Baudry and Duchateau, 2007; Ferrauti and Bastiaens, 2007; Kilduff *et al., 2008)*. The application of PAP is thought to have the potential to enhance short term power performance or chronic adaptations through specific training techniques such as complex training, thus leading to enhanced chronic adaptations (Gullich and Schmidtbliecher, 1996; Young et al; Duthie et al., 2002). Complex training involves the utilisation of high intensity loads (e.g. 3RM) to excite the CNS and ultimately the body's excitation potential before performing an explosive activity such as a plyometric exercise i.e. heavy 3RM squat before jump squats, the same muscles must be utilised or a similar movement pattern in order to elicit the best results (Docherty and Hodgson, 2007).

CHAPTER 3

METHOD

Method:

3.1 Experimental Approach:

The aim of this study was to evaluate the PAP effects prompted by maximal weight, plyometric exercises and a weighted squat jump. The baseline performance measure (CMJ), conditioning contraction and post conditioning contraction (CC) were all performed on the same day with 10 minutes rest between base line performance measure and CC and a further 7 minutes rest between CC and post-CC performance measure (CMJ). 3 CMJ's were performed with 1minute between each jump for both the base line performance measure and the post-CC performance measure. The conditioning stimuli used were a maximal resistance exercise, plyometric exercise and a dynamic weighted resistance exercise. The resistance exercise consisted of one set of a 3RM (repetition maximum) squat, the plyometric exercise consisted of 4 different exercises totalling 24 foot contacts and finally the dynamic conditioning stimulus consisted of 2 sets of 5 repetitions of jump squats at 30% of the subjects 1RM. Number of variables were measure; maximal displacement (d_{max}), peak force (F_{peak}) all measurements were taken from a force plate, in accordance with this rate of force development (RFD) and relative force (F/body mass) in bodyweights were calculated for each individual subject. All the above mentioned variables were chosen as they are commonly used in order to assess power performance, therefore allowing the comparison between subjects and providing an indication of the potential effects of PAP.

3.2 Subjects:

All participants used were selected through simple availability; however this being said all 8 participants were Rugby Union players that took part in regular resistance training and sports specific training sessions. Height 178.6±9.6cm; Weight 89.6±12.6kg; 1RM 170kg±40kg. All participants were regular users of the back squat and so were familiar with this exercise, but received tuition to avoid any variances in techniques amongst individuals. The 3RM was used as Ritti-Dias et al., (2011) concluded that it was a safer option to 1RM testing to accurately assess muscular strength. Each subject had the research protocol explained to them and informed consent was given to each participant prior to the testing process.

3.3 Procedures:

Each subject visited the laboratory in order to familiarise themselves with the equipment, squat, jump squat and plyometric exercises as well as the CMJ technique. This session was also used to note down each subjects age, height and weight. Weight was recorded down to the nearest 0.01kg with the use of a calibrated balance beam scale (Seca, Birmingham, UK) and height was recorded to the nearest 0.1 cm using a stadiometer (Harpenden, Burgess Hill UK).

All participants were required to complete a series of tests in order to gauge their eligibility to perform the plyometric exercises, these tests included; stabilisation tests, flexibility tests as well as the ability to back squat 1.5 times their bodyweight as a minimum.. Form was monitored for health and safety reasons and was used as a gauge whether or not a lift or movement was successful or not. 3RM was then recorded with the working definition as a load at which a subject reached failure on the third and final repetition with correct technique. In order to establish the 3RM load subjects were required to perform 3 repetitions on a load and if successful the load increased up until failure, adequate rest of 5 minutes was used in between each attempt. Each subject was familiar with the back squat and so was able to recommend an appropriate estimate of where to start load wise. Roughly 3-5 trials were used to gauge the 3RM which was sufficient for reducing fatigue couple with the longer rest periods.

Following these procedures after 3 days of rest the subjects were then required to visit the NIAC (National Indoor Athletic Centre) a further 3 times on non-consecutive days to perform the study. For each visit the same warm up was used; this consisted of 2 laps of the indoor track (400m) and a series of dynamic stretches for a distance of 20 metres. After the warm up was completed the subjects were then put into random groups and were then assigned to perform one of the conditioning contractions, which consisted of the following; 3RM squat, plyometric exercises or the weighted jump squat (30% trial). Following the baseline performance measure (3 CMJ's with 1 minute rest between each) and after 10 minutes rest the 3RM squat group executed a single set of 6 squats (to depth of 90^{o}) at 60% of 3RM followed by 2 minutes rest, then a further warm up set of 85% of 3RM. The plyometric group utilised a single set of the following; 6 vertical jumps, bounds (6 reps), right leg bounds and left leg bounds (6 sets a piece), a total of 20 seconds rest was utilised between each plyometric exercise. The jump squat group then performed 1 set of 5 jump squats at 30% of their 3RM with 3 minutes rest on completion of this specific warm up, the same rest period was given to each of the previous groups also. As stated earlier each subject had adequate rest in order to utilise each conditioning contraction on non-consecutive days to eliminate the variable of fatigue out of the study.

Following the completion of the generic and specific warm-up the post conditioning contraction performance measure was utilised (3 CMJ's with 1 minute rest between each). A schematic diagram of the whole process can be seen below in Figure 2.

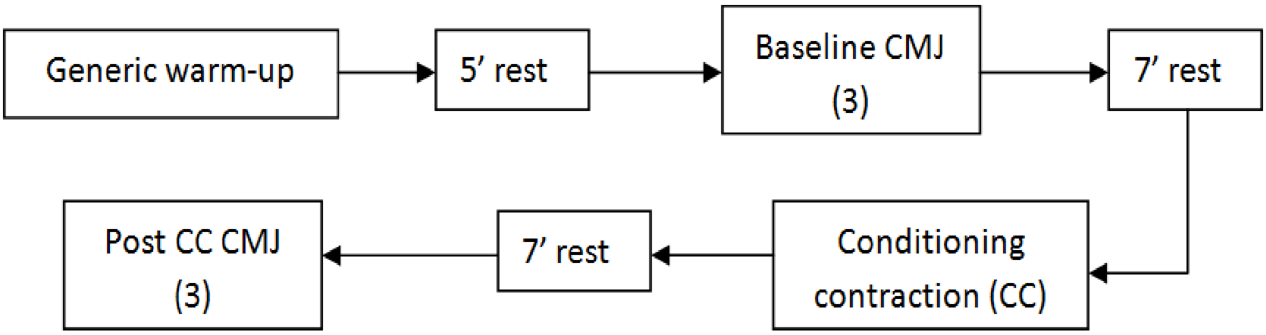

Figure 2. *A diagram depicting the process of each test day. Each Conditioning stimulus box represents each CC used whether it was; SQUAT (3RM), DSQ (dynamic jump squat at 30%) or PLYO (plyometric exercise).*

The conditioning contraction (CC) for the plyometrics was the same as the warm-up but performed at full pace, each subject was told to limit the amount of time spent on the floor i.e. fast foot contacts to promote the use of the stretch shortening cycle as well as the full function of the fast twitch muscle fibres.

The CC for the squat group was 1 set of a 3RM squat (90^{o} knee flexion). Each repetition should have been performed as forcefully as possible, again to elicit the best utilisation of the fast twitch fibres and motor neurone excitement. A standard 20kg Olympic barbell was used as well as weight plates (Ivanko, Reno, NV, USA). Every subject squatted inside a safety cage inside the NIAC within the diagnostics gym, safety bars were present at relevant heights for each subject in the event of failure, it should be noted also that each subject had a number of spotters present.

The variables measured, as stated before, were maximal displacement (d_{max}) and peak vertical force (F_{peak}) and were measure using the AMTI force platform (Model 9287ba, Kistler, Winterthur, Switzerland). The collected force data was collected at 1,000Hz for a total of 6 seconds and ultimately analysed via Geany software (Version 1.23.1). Rate of force development (RFD) was then calculated by dividing the maximum force developed by the amount of time taken for this force to be developed (RFD = P_{peak}/time). Following this relative force was then calculated i.e. the amount of force created relative to bodyweights, the following equation was used; RelF = P_{peak}/Mass. The greatest CMJ was used for each participant (best of three) for each performance measure in order to reduce variability within the study.

3.4 Statistical analysis:

Following the collection of the force data, it was analysed using the IBM's' SPSS statistical package via the use of a one way repeated measures ANOVA. As a result Mean and SD (standard deviation) were then both successfully calculated for each of the CMJ trials in order the gauge the effectiveness of each conditioning contraction. Using these mean and SD scores produced by the one-way repeated measures ANOVA, graphs were created for CMJ performance following each of the conditioning contractions (pre and post conditioning contraction). The graphs were created within Excel software. Error bars were then added to each graph by entering SD scores created by the ANOVA in the SPSS statistics software.

CHAPTER 4

RESULTS

Results

4.1. Peak Force data:

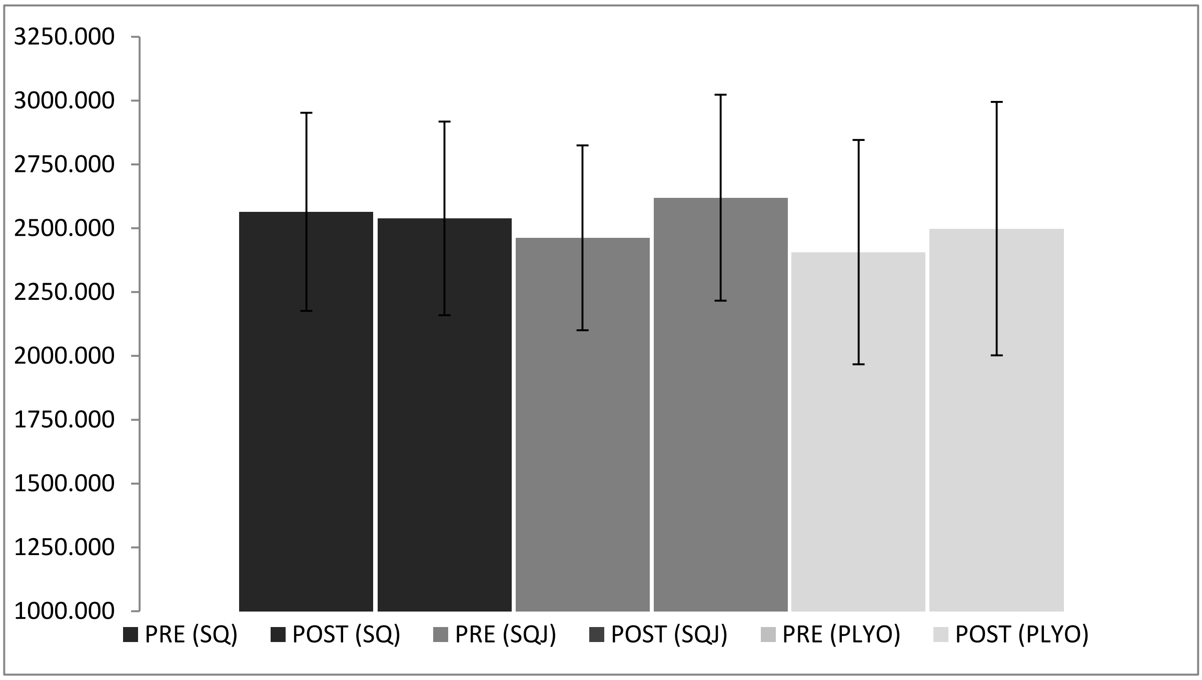

Figure 3. *Shows the Mean P_{peak} (Peak force) and comparisons between the pre/post CC accompanied with SD values (standard deviation).*

Through interpreting the graph in Figure 3 it is apparent that the SQJ (dynamic squat jump) produced the greatest PAP response in comparison to the other conditioning contractions, closely followed by the plyometric exercises. However this being said, the statistical analysis yielded no significant changes in power production ($p>0.05$).

Table 1. *Table showing the significance of the different test variables for Peak force (pre and post CC) in a post-hoc Bonferroni pairwise comparisons test.*

Peak force (P_{peak})	
Conditioning stimulus	Significance
Squat	1.000
Dynamic Squat Jump	1.000
Plyometrics	1.000

*Denotes significance value ($p<0.05$)

As the table presents itself it is clear to see there is far from a statistical significance in regards to the three tested CC's and their effect on P_{peak}.

4.2. Displacement data:

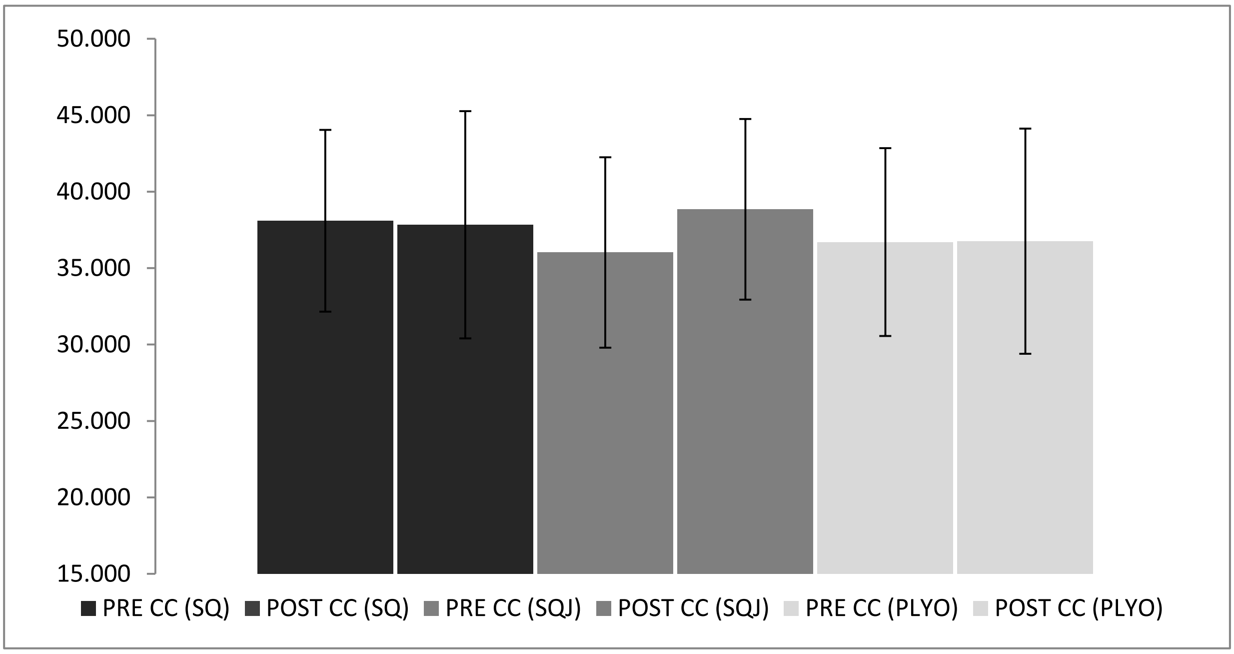

Figure 4. *Shows the Mean displacement (d_{max}) scores both pre and post CC couple with SD bars.*

Figure 4 displays the greatest mean improvement in power (W) with the use of the dynamic squat jump when compared with the other CC's, this ties in with the improvement in peak force, however much like the peak force improvement no significant difference was present.

Table 2. *Table showing the significance of the different test variables for Mean displacement (pre and post CC) in a post-hoc Bonferroni pairwise comparisons test.*

Mean maximal displacement (d_{max})	
Conditioning stimulus	Significance (Sig.[a])
Squat	1.000
Dynamic Squat Jump	0.097
Plyometrics	1.000

*Denotes significance value ($p<0.05$)

From the above table it can be seen that none of the CC's produced significant differences in maximal displacement ($p>0.05$), however the dynamic jump squat appears to yield better results than that of the other conditioning contractions.

4.3. RFD Data:

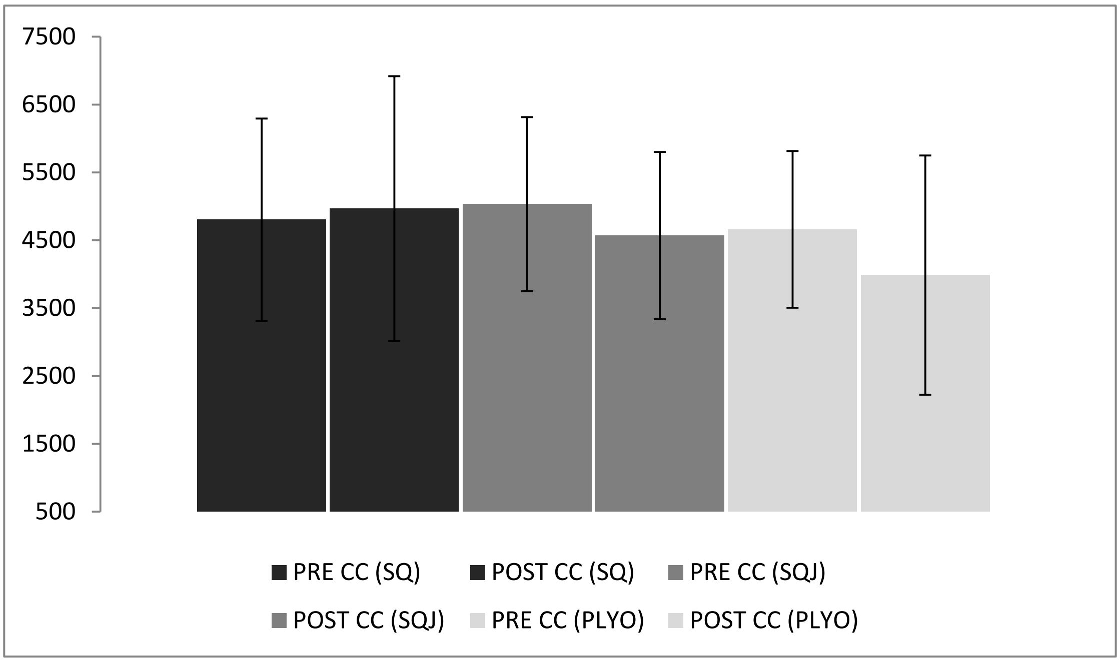

Figure 5. *Shows the mean RFD (rate of force development) scores of both pre and post CC accompanied by SD error bars.*

Unlike the results displayed previous it was apparent that the SQJ had a negative impact on RFD. However the SQUAT was the only CC to yield an improvement on RFD, however again like previous these results were not significant (post SQUAT RFD Sig.[a]= 1.000). Despite this it should be noted that individuals that produced a greater RFD appeared to fatigue at a greater rate and as a result produced a lesser RFD following the CC.

Table 3. *Table showing the significance of the different test variables for Mean RFD (pre and post CC) in a post-hoc Bonferroni pairwise comparisons test.*

Mean RFD	
Conditioning stimulus	Significance (Sig.[a])
Squat	1.000
Dynamic Squat Jump	1.000
Plyometrics	1.000

*Denotes significance value (p<0.05)

It is apparent from looking at Table 3 that neither of the conditioning stimuli produced significant increases in maximal displacement.

4.4. Relative force data (W/Kg):

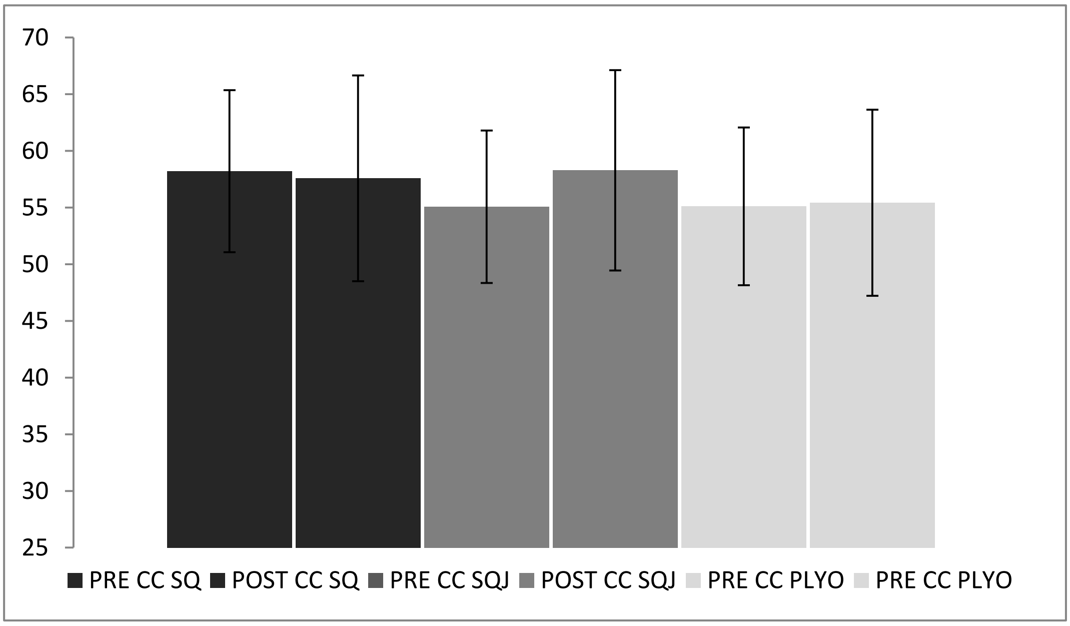

Figure 6. *Shows the Mean relative forces (W/kg) generated both pre and post CC couple with SD error bars.*

The dynamic squat jump (SQJ) again appeared to produce the best improvement in performance in regards to relative force, however it failed to yield a significant difference (post SQJ relative force Sig.[a]= 0.326). In regards to this the results also suggest that individuals with a greater relative force score seemingly react better with respect to PAP when performing the squat jump.

Table 4. *Table showing the significance of the different test variables for Mean relative force (pre and post CC) in a post-hoc Bonferroni pairwise comparisons test.*

Mean relative force (W/Kg)	
Conditioning stimulus	Significance (Sig.[a])
Squat	1.000
Dynamic Squat Jump	0.326
Plyometrics	1.000

*Denotes significance value (p<0.05)

It is apparent from looking at Table 4 that none of the conditioning stimuli were significantly effective for eliciting improvements in relative force. Despite this it is apparent that the squat jump has the greatest effect on displacement, however not to a significant degree.

4.5. Means and standard deviations (SD):

Table 5. *Mean and SD for each CC post conditioning stimulus.*

	Squat	Squat Jump	Plyometric
P_{peak}	2462.74 ± 379.30	2538.43 ± 403.52	2498.57 ± 496.26
d_{max}	37.838 ± 7.43	38.843 ± 5.91	36.763 ± 7.36
RFD	4967.49 ± 1950.83	4568.86 ± 1233.70	3987.25 ± 1763.57
RelF	57.58 ± 9.08	58.29 ± 8.84	55.43 ± 8.21

The above table depicts the mean and standard deviation from each of the performance variables following the conditioning stimuli of the squat, squat jump and plyometric exercises.

CHAPTER 5

DISCUSSION

Discussion:

5.1. Interpretation of results

The results of this present study indicate that neither the 90%, 30% or PLYO trial were sufficient at producing a local acute PAP response within the lower body in relation to; P_{peak}, d_{max}, RFD or RelF in trained university rugby players. Furthermore this study could indicate that the 90% trial could prove to be debilitative in regards to PAP, more specifically; P_{peak}, d_{max} and RelF. Despite none of the CC's producing significant changes in PAP response it was apparent that the low-moderate intensity trial proved to obtain the greatest results in terms of P_{peak}, d_{max} and RelF despite being statistically insignificant. Despite this finding the efficacy of a high intensity CC and PLYO trial in eliciting PAP is unclear and may not have any potentiating effect on CMJ P_{peak}, d_{max}, RFD and RelF. Likewise previous studies have also failed to validate an acute response using a high intensity CC; Till and Cooke (2009) used 5RM deadlifts as a sufficient CC and found no effect on vertical jump performance at rest intervals of 7,8 or 9 minutes post CC in elite level male soccer players. Correspondingly Duthie et al. (2002) used a 3RM squat as a CC and subsequently failed to enhance jump squat performance. Equally as previously mentioned a low-moderate intensity dynamic contraction has often failed to elicit significant PAP response; Hanson et al., (2007) and Lowery et al., (2012) found that 80% and 56% CC intensities had little or no effect on acute responses within the targeted muscles. In comparison to the present study very few previous studies have in fact found a significant negative effect of a moderate CC on PAP using a similar rest time to the current study. A CC of 65% and 80% squats appeared to significantly reduce flight time of the ensuing drop jumps in Comyns et al., (2007) study, also El Hage et al., (2011) found that a 3RM back squat significantly diminished CMJ performance, again backing up the findings of the present study. Both aforementioned studies conducted their studies with a rest time of 4 minutes; this could in fact be too short a rest period therefore not allowing fatigue to diminish effectively (Kildiff et al., 2011). It is difficult to pinpoint why the low-moderate CC in the present study did not have a significant effect on the PAP response given that the intensity was significantly lower than the 90% trial and that a rest period of 7 minutes was used, which should result in less fatigue than that of the 90% trial.

The little significance in gain of P_{peak}, d_{max} and RelF during the low-moderate intensity trial may be explained due to a reduction in muscle temperature during the 7 minute rest period in place between the CC and the CMJ. A decline in muscle temperature can reduce PPO (peak power output) (Davies & Young, 1983; Sargeant, 1987). More specifically the reduction in muscle temperature have been shown to lessen the force productivity of a muscle, especially in the concentric and isometric type contractions, with the eccentric portion of the movement being less affected (De Ruiter & De Haan, 2001). This is applicable to the present study as the force producing capability of the CMJ could be inhibited in the concentric portion of the movement. However for decrease muscle temperature to cause negative effects on PAP performance must drop across the board for all of the CC's, which was in fact the case in this study. This being said it cannot be proved that previous researchers have made an attempt to keep the muscle temperature at an appropriate level during the rest period and how this may affect understanding. In relation to this Comyns et al. (2007) and Chaouachi et al. (2011) did not set a specified rest protocol, while Rahimi (2007) allowed walking throughout the rest period in an attempt to maintain muscular temperature, however in regards to this laboratory temperature was not stated or attempted to be maintained for each subsequent trial. However all the aforementioned studies did demonstrate an acute response post CC meaning perhaps the laboratory temperatures were relatively high or some form of activity during the rest period was what prevented muscle temperature being reduced therefore diminishing the PAP response. On the other hand a study by Lowery et al., (2012) was specific in requiring a seated rest period and still managed to exhibit the PAP response; however much like the studies aforesaid laboratory temperature was not stated and could have played a vital role in maintaining the heat of the working muscles.

It is possible that the discrepancies in P_{peak}, d_{max}, RFD and RelF across the all the CC's were a resultant factor of differentiation in volume. It could be possible that the decline in power performance variables among the high intensity CC that were not present in the low-moderate intensity CC and partially present in the plyometric CC could have been as a result of the lessened volume. The low-moderate trial had the lowest amount of volume and seemed to elicit the best results despite still not being significant. Preceding studies within the same subject area have calculated volume via multiplying weight lifted by the number of repetitions (Lowery et al., 2012) e.g. in the current study a participant with a back squat 1RM of 200kg would be required to lift 60kg (30%) for 4 repetitions in the low-moderate trial and a total of 180kg (90%) for 3 repetitions in the high intensity trial, giving volume loads of 240kg and 540kg respectively which translates to a huge 22% difference between these two trials alone. When this is compared to the weightless plyometric trials which consisted of 24 foot contacts the discrepancies in volume are greater still. Again Lowery et al., (2012) confirmed similar effects in their study when using loads of 70% and 93% as CC's and intended to use the same volume for each CC in order to study their effects on vertical jump height and power. Which could suggest the negative effects of the different CC's in the present study could be a product of differences in volume load as opposed to the intensity of the CC itself.

The findings in the present study, especially in relation to the high intensity trial, are not in line with the findings of the previous research in this literature area, the majority of the previous research as in fact managed to find an increase power response via the PAP pathway. Comyns et al. (2007), Kilduff et al. (2007) and Bevan et al. (2010) found similar findings in a positive PAP response using CC's in excess of 85% of 1RM in elite level male rugby union players with the average (mean) squat value being 2, 1.6 and 1.7x BW (bodyweight) correspondingly. In a study by Crum et al. (2012) it was found that there was little or no significant effect of moderate intensity quarter squats as a CC on CMJ performance. Crum et al. (2012) ventured that because of the little eccentric nature of CC activity very little motor-neuron recruitment took place therefore no excitement of the spinal cord was able to take place and induce a greater PAP response. The eccentric action of the muscle is an important tool in stimulating acute responses within a muscle; this is ultimately because the muscle-tendon unit lengthens during the lowering (eccentric) portion of the lift (or movement) and causes the muscle spindles to deform (Lindstedt et al., 2001), ultimately causing the spinal reflex that has been shown to potentiate the force producing proficiency of the muscle and subsequent muscular contractions (Nicol & Komi, 1998).

Supporting the importance of the eccentric portion of a CC Esformes et al. (2011) discovered no PAP after a concentric only bench press (CC) on bench throw performance, ultimately suggesting that a primarily concentric based movement as CC is not best for potentiation effects, however a primarily eccentric based CC and an eccentric followed by a concentric contraction may also not be optimal for eliciting a PAP response in regards to a bench press throw performance. As a result of these findings it could be said that a supramaximal eccentric may induce a greater power response of a desired muscle. However, generalising these findings in the upper body to the lower body may perhaps not be suitable because of the differences in muscular structure, function and fibre type distribution between the upper and lower body; all of which could lead to different potentiation levels (Behm et al., 2002).

Individual differences have been shown to play a huge role and may cause a great deal of variance in response to a CC (Chiu et al., 2003). Individuals responded differently in this study particularly in the 90% trial whereby five participants verified a positive PAP response, in contrast to this in the 75% trial only two subjects showed a positive response. This data is in agreement with previous literature as some individuals respond better to varying rest times between the CC and performance measure. Bevan et al. (2010) recorded no significant differences of a CC on 5 and 10 meter sprint times using varying rest times of 4, 8, 12 and 16 minutes. However when each participants best sprint time was noted irrespective of rest period it was found that there was a significant augmentation of five and 10m sprint times with Sig.[a] values of p=0.002 and p=0.003 respectively. This information could explain why no significant differences were achieved in the present study as the rest period was generalised for everyone at 7 minutes, some subjects may respond better to 4 minutes and therefor lose the PAP augmentation and some subjects may respond better to a greater rest period of 10+ minutes, therefore resulting in fatigue providing the explanation for the insignificant data. In regard to this different CC's may also require different rest periods as it has been put forward that low-moderate intensity CC's require shorter rest periods as they are less fatiguing on the system as say a high intensity CC (Tillin & Bishop, 2009).

A PAP response has been previously found to effect stronger individuals when strength is assessed in absolute terms; Young et al. (1998) and Kilduff et al. (2007) both found a strong positive correlation between subject strength and PAP response. Duthie et al. (2002) also found a significant strong correlation between participant absolut strength (1RM) and changes in peak power (r=0.66). Mangus et al. (2006) reported that the use of heavy squats prior to CMJ should be individualised for men, with only half of their subjects actually demonstrating and improvement in CMJ performance. Despite this information the present study showed no significant improvement in PAP response following any of the CC's in spite of the fact that everyone in this present study had at least a 1.5x BW squat. It is unclear why the results of the current study propose a significant negative correlation which is the opposite of that previously found. The other studies above-mentioned reported that a significant positive correlation that occurred used performance measures commonly used in strength and conditioning programs such as jump squats (Duthie et al., 2002; Kilduff et al., 2007) and CMJ (Young et al., 1998). It is entirely feasible that the high strength athletes in these previous studies had a greater deal of knowledge or experience in strength and conditioning and therefore more familiar with the performance measures featured in these particular studies, therefore eliciting a greater acute response. This premise is supported by Comyns et al. (2010) who suggested that their subjects learnt to relate their potentiated state to subsequent sprint performance, this was because they had a great deal of continual experience with complex training sessions.

5.2. Advantages of the study

The present study performed each successive CC on separate non-consecutive days with at least 48-hours between each trial. Comyns et al. (2007) compared three different CC intensities all on the same testing day allowing only 6minutes rest between the performance measure and the successive CC. As a result the performance measure, which in this case was a drop jump, may have been effected by the CC which happened prior rather than CC that was used 6 minutes previous, this is because a total of 14-minutes separated the two CC's, this becomes a problem as Gilbert and Lees (2005) found the PAP response to be active for up to 20-minutes post CC. likewise a study by Lowery et al. (2012) carried out a number of different CC trials separated by 72 hours whereby a number of different rest times were examined on any one testing day. Each testing day consisted of three vertical jumps with 2, 4, 8 and 12 minute rest periods post CC, regarding this subsequent vertical jump trials may have been limited by the trials prior and as a result fatigue could have played a large role in the validity of the results. Contrastingly the prior vertical jumps could have infarct improved performance through potential potentiation effects (Burkett et al., 2005). As previously stated the current study required participants to only complete one CC on a given test day, therefore any potential changes in PAP response were as a result of the CC at hand. In further studies it could be recommended that the researchers adopted a similar protocol to Miyamoto et al. (2010) and measure muscle twitch response in order to decipher whether PAP was actually responsible for the changes in performance instead of other variables such as muscle temperature as aforementioned.

5.3. Limitations of the study

The present study used 8 male rugby union players, however as a result of the physiological demands of a rugby match it does not allow for adequate recovery time in order to elicit the best PAP response i.e. fatigue is likely to play a huge factor in limiting the effect of PAP on a rugby players performance during a game. Due to the Physical demands of rugby union it requires short intense bouts of effort over a minimal distance (Crewther et al., 1997) coupled with continuous movement, and unregulated stoppages throughout the game allowing for brief recovery, over a time period of two 40 minute long halves. As a result of these unplanned stoppages it becomes extremely difficult for strength and conditioning coaches to regulate recovery times between a CC in order to induce PAP within/previous to a game.

In addition there are a number of methodological limitations present in the current study that could have potentially hindered the statistical significance. Due to the small number of participants it is inappropriate to generalise these findings to the population as a whole or even the rugby playing population as a contingent. Similarly the study consisted of university level rugby union players, meaning the results again cannot be generalised for elite level rugby union players leading to the connotation that a further study may be required to assess the elite level rugby union player and how they react to different CC's in terms of power production and the PAP response. As aforementioned in the discussion it would potentially be more fitting and applicable to real world application by taking into account the individual differences between participants, these differences may include variances in volume, different CC's and rest periods in order to reveal the full potential augmentation PAP can have on power production.

Future studies investigating PAP and its effects should make an attempt to prevent participants from taking part in any other form physical activities whilst the investigation is taking place. This is because of potential fatigue and hormonal stress on the body that any other forms of activity may cause, these physiological responses by the body could inhibit results further and therefore not give a true representation of the effects of PAP within lower body skeletal muscle and CNS.

5.4 Future Research

Due to the inconclusive findings in the present study further research must be undertaken in order to conclusively know id PAP can be incorporated in a competitive sporting setting in order to amplify performance.

Previous PAP research shows that individual differences play a great role (Young et al. 1998 Kilduff et al. 2007 and Chiu et al., 2003) therefore leading to the reasoning that each individual may respond better to a different rest period or CC or both. In regards to the study at hand it could be said that more variance in rest periods is required in order to find the 'best' rest periods for individuals i.e. rest periods of 4, 7, 10 minutes etc. could be implemented in order to discover appropriate rest periods for certain individuals. Height, weight and strength levels could also be analysed in order to see if there is any correlation present in order to try and make a generalisation for certain populations. Thus becoming possible to identify the specific peak potentiation times relating to each individual, therefore allowing an accurate assessment of what time fatigue begins to detrimentally effect any potentiating effects caused by the CC.

The same could again happen for a number of CC's (e.g. supramaximal eccentric, plyometric, MVC etc.) to make an attempt to find the most effective CC to elicit a

PAP response within certain individuals; again height weight and absolute strength could be taken into account in a further attempt to make generalisations for similar populations.

CHAPTER 6

CONCLUSION

6.1 Conclusion

Much of the previous literature around the area of PAP seems to be varying, despite this it has been shown that there is potential to acutely increase the power production of a muscle following a CC after a prearranged recovery period. This being said the PAP phenomenon appears to be an individual response and may be affected by a number of individual differences such as subject height, subject weight and volume, intensity and load of CC. The augmentation associated with PAP also seems to be reliant on the relationships between fatigue and performance within subject i.e. different subjects may fatigue more and require longer rest periods. The present study does not make any significant findings in terms of which CC is best for producing the PAP phenomenon, although it may suggest that a moderate-low intensity CC could perhaps acutely potentiate P_{peak}, d_{max}, RFD or RelF compared to a low intensity and a high intensity CC, however there is a degree of uncertainty in conjunction with this study as too whether each CC can significantly enhance PAP above the baseline measure scores.

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APPENDICES

APPENDIX A

CARDIFF METROPLOLITAN

INFORMED CONSENT FORM

CSS Reference No:

Title of Project: *The Effect of a High-force versus a High-velocity warm up on the power and velocity characteristics of a clean.*

Name of Researcher: Ryan Keates

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet dated ………. for this evaluation study. 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 it is possible to stop taking part at any time, without giving a reason. ☐

3. I also understand that if this happens, our relationships with the Cardiff Metropolitan University or our legal rights will not be affected ☐

4. I understand that information from the study may be used for reporting purposes, but I will not be identified. ☐

5. I agree to take part in this study on *The effects of different conditioning contractions on lower body acute potentiation of counter movement jump performance.* ☐

Name of Participant:

Signature of Participant: Date:

Name of person taking consent: Date:

Signature of person taking consent: Date:

* When completed, one copy for participant and one copy for researcher's files.

APPENDIX B

Data Collection- Individual Information Sheet

NAME:

D.O.B:

HEIGHT (M):

BODY MASS (KG):

YEAR OF STUDY:

APPENDIX C

Cardiff Metropolitan University | Prifysgol Metropolitan Caerdydd

Date: 14-03-2014

To: Ryan Keates

Project reference number: 10U

Your project was recommended for approval by myself as supervisor and formally approved at the Cardiff School of Sport Research Ethics Committee meeting of 14th of March 2014.

Yours sincerely

Dr Joseph Esformes

Supervisor

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APPENDIX D

Medical PARQ Form

In order for your safety and other people's safety during the study we require you to fill out this quick PARQ (Physical Activity Readiness Questionnaire) so your time during the study will be safe.

Please complete the following questionnaire to the best of your knowledge. Any information proved will be treated as confidential.

	Yes	**No**
1) Do you take part in regular exercise?		
2) Has your doctor/GP advised you against taking part in exercise?		
3) Are you recovering from, or ever had, any serious illness or surgery or injury?		
4) If you ticketed yes, please state the injury, illness or surgery		
5) Are you pregnant?		
6) Do you smoke? If so please state how, many per day. ____________________		
7) Are you under any medication?		
8) If stated yes, please state what.		

Please answer the following:Do you suffer from any of the following? (Please circle

Heart Conditions	High or Low Blood Pressure	Diabetes	Severe Respiratory Illness (Emphysema)	Thyroid Problems	Mild Respiratory Illness (Bronchitis, Asthma)	Back or Joint Problems	Epilepsy

the relevant boxes.)

If other please specify:

Declaration

I declare that, to the best of my knowledge, I know of no reason why I should not participate in a personal exercise programme.

Signed: Date: