Effects of Back Squat Post Activation Potentiation Protocol on 30 Meter Sprint Performance

Amongst male Crossfit athletes

Viktoria Sandra Stefanescu

Bachelor's Thesis In Exercise Biomedicine, 15 credits

Halmstad 2016-05-23
Effects of Back Squat Post Activation Potentiation Protocol on 30 Meter Sprint Performance
Amongst male Crossfit athletes

Viktoria Sandra Stefanescu

2016-05-23
Bachelor Thesis 15 credits in Exercise Biomedicine
Halmstad University
School of Business, Engineering and Science

Thesis supervisor: Sofia Ryman Augustsson
Thesis examiner: Emma Haglund
Acknowledgments

I would like to thank Crossfit Halmstad for allowing me to use their facility and equipment to execute all of the tests and I would also like to thank the subjects for participating in this study. Without Crossfit Halmstad and the subjects that volunteered, this study would have been impossible to execute.
Abstract

**Background:** Post activation potentiation (PAP) is an increased muscular performance that occurs after maximal voluntary contraction. Previous studies have shown a significant increase in explosive movements, such as sprint and jump performance, as an effect of these maximal contractions.

**Aim:** The aim of this study was to analyze if PAP, in terms of heavy squats, has a performance enhancing effect on 30 meter sprint, with a hypothesis that the maximal effort in the squat has a performance enhancing effect on 30 meter sprint.

**Method:** Twelve healthy male Crossfit athletes from Crossfit Halmstad, age between x-x, volunteered to participate in the study, eleven of these completed all of the test sessions in this cross-sectional study. During the first test session, the subjects attempted to set a one repetition max (1RM) in the back squat. During the second and third test session, the subjects were randomly divided into two groups and the subjects got to perform both the non-PAP and the PAP protocol during different sessions, depending on which group they were in. The sprint time was measured with a handheld stopwatch. Wilcoxon Signed Rank Test was used to determine significant differences between sprint time after the two different protocols, and the level of significance was set at $p < 0.05$.

**Result:** The result showed that there was no significant difference between PAP and non-PAP protocols ($p = 0.679$). With a median value of 4,78 seconds, a minimum value of 4,59 seconds and a maximum value of 5,54 seconds for the sprint trials after PAP and a median value of 4,82 seconds, a minimum value of 4,59 seconds and a maximum value of 5,31 seconds for the sprint trials without PAP, the results did not confirm the hypothesis.

**Conclusion:** As an effect from the low number of participants, the result could be deceptive. The study could have show a different result if the number of participants would exceed at least 25 subjects. There are no performance enhancing effects in the sprint after PAP, in this study. Further research is required, to determine possible performance enhancing effects from PAP.
Background

According to Galloway and Jokl (2000) both males and females, regardless of age, can benefit from regular exercise. Exercise in itself has shown to be a method to reduce premature mortality by reducing the risk of stroke, diabetes, several forms of cancer and coronary artery disease. Furthermore, the human body is constructed to be in movement, therefore, exercise has positive effects on bones, joints and muscles. In many countries all over the world, physical inactivity is a major health-related problem to the world population (Galloway et al., 2000). To have an active lifestyle is of assistance to physical, cognitive and brain health as well as academic performance for children (Chaddock-Heyman, Hillman, Cohen & Kramer, 2014).

Functional training

The term functional training is defined as movements that expand human beings ability to complete their daily activities or to achieve a certain goal (DeFransesco & Inesta, 2012). Functional training should be used to increase performance in activities of daily living, and therefore be stabilizing, strengthening and have an improvement on the neuromuscular interaction (Da Silva-Grigoletto, Brito & Heredia, 2014). Exercising in machines is appeared to be inefficient, because of the fact that the resistance is only moved alongside a fixated axis, which limits the body. Furthermore, the machines can create reduced motor patterns amongst human beings, since the functional strength transfer to real life situations is eliminated whilst using the machines (DeFrancesco et al., 2012). According to DeFrancesco et al., (2012) it is essential to perform functional movements when trying to build muscle strength, joint integrity, balance and flexibility in all planes of the human motion. Therefore, it is of great importance to include multi-joint exercises, since it leads to proper function in the nervous system which makes sure that all body parts are used fluently with correct muscle interactions (DeFrancesco et al., 2012).

The concept of functional training is originally an idea from physiotherapy and rehabilitation, where people who are injured or have physical limitations perform rehabilitation where everyday situations are simulated in the workouts (Stasinski & Dyall, 2015). This aims to prepare them for real life situations like standing up from a chair, walking the stairs or carrying large and heavy objects. Furthermore, functional training is believed to focus on the interaction between the muscles in the body and practicing on making the muscles work
together instead of isolating them with different machines and therefore inhibit the muscles development (Stasinski & Dyall, 2015).

Crossfit

Crossfit is a strength and conditioning training that is built on functional movements executed at a high intensity (Glassman, 2004). It seems that Crossfit has become one of the biggest fitness trends since the establishment in the year of 2000. During 2014 it was confirmed that there was approximately 6,500 Crossfit affiliates in the United States alone, whilst there was 10,000 affiliates worldwide (Dawson, 2015). Crossfit was established by a former gymnast named Greg Glassman. He felt that his regular training routines wasn’t challenging enough for him, therefore he began searching for a workout schedule that would increase his performance level. Glassman started experimenting with different ways of pushing his body to limits he had never reached before. This resulted in workouts that were varied functional movements performed at high intensity (Dawson, 2015). The workouts are constantly varied and most of the time randomized. The Crossfit workouts are influenced by natural and primal movements of the human being. Furthermore, the movements are a part of our bodies’ designs and consist of standing, sitting, throwing, lifting, pushing, pulling, climbing, running and punching (Glassman, 2004). The basis of Crossfit consist of a combination between weightlifting and gymnastics, which are seen as a powerful representation of the physical abilities needed for human beings to move themselves and other things (Glassman, 2004). Furthermore, the aim of Crossfit is to optimize physical ability in ten recognized areas that consist of; stamina, strength, power, speed, flexibility, cardiovascular and respiratory endurance, agility, coordination, accuracy and balance (Glassman, 2002).

According to Glassman (2002) the time it takes executing some sort of work, also known as power, is said to be crucial in most sports. In Crossfit training, power is the king of performance and power is measured in jumping, throwing, sprinting and punching. To achieve elite athleticism, it is necessary and sometimes sufficient to increase the athlete’s power output ability. Almost every positive characteristic of fitness is linked to power and power is influenced by strength, performance, muscle mass and bone density. The stronger the athlete, the higher the power output ability. Power is considered to be one of the four essential themes in Crossfit training and it is constantly used when performing Crossfit, therefore it is of great interest to examine possible methods to increase the power output amongst Crossfit athletes (Glassman, 2002).
Post activation potentiation

Post activation potentiation (PAP) is an increased muscular performance that occurs after maximal voluntary contraction. Previous studies have shown a significant increase in explosive movements, such as sprint and jump performance, as an effect of these maximal contractions (Xenofondos, Laparidis, Kyranoudis, Galazoulas, Bassa & Kotzamanidis, 2010). It has been shown that PAP is induced by twitch contractions in the muscles and also by phosphorylation of the myosin chains, which has resulted in actin and myosin being more sensitive to calcium, which improves the relationship between actin and myosin and therefore resulting in increased muscle performance (Hodgson, Docherty & Robbins, 2005; Tillin & Bishop, 2009).

Underlying factors of the effects from post activation potentiation

There are different theories regarding the underlying factors causing the effects from PAP (Xenofondos et al., 2010; Hodgson et al., 2005; Tillin et al., 2009; Xenofondos, Patikas & Kotzamanidis, 2014). Furthermore, physiological reactions occur in the muscles, which increases the interaction between actin and myosin, two fundamental functions of a muscle contraction. The neurological reactions result in better recruitment of motor units and an increased number of motor units. The muscles also develop their receptivity to nerve impulses. Previous studies have shown that PAP may be a result of an interaction between physiological and neurological reactions, and to this day, these reactions are not fully understood. Furthermore, it is unclear whether the training level amongst individuals affects the responses from PAP, therefore further research is required to determine primary and secondary factors that influence the effects from PAP (Xenofondos et al., 2010; Hodgson et al., 2005; Tillin et al., 2009; Xenofondos et al., 2014). According to Jensen and Ebben (2003) and Ebben, Jensen and Blackard (2000) there are no differences in how effective PAP is that is related to training experience. Matthews, O’Conchuir and Comfort (2009) and Robbins (2005) conclude that when eliminating factors such as different strength levels or training experience, the time and the extent of PAP appears to be individual.

The effects from post activation potentiation

In comparison to untrained subjects, the effects of PAP have been superior amongst subjects with greater training experience (Robbins, 2005; Rixon, Lamont & Bemben, 2007). According to Wilson, Duncan, Marin, Brown, Loenneke, Wilson, Jo, Lowery and Ungrinowitsch (2013) there are significant differences between how untrained, trained and athletes respond to PAP. The effect from PAP seems to be optimal after performing multiple
sets at moderate intensities and letting the subjects rest for 7 to 10 minutes before performing the explosive movements (Wilson et al., 2013). Furthermore Lowery, Duncan, Loenneke, Sikorski, Naimo, Brown, Wilson and Wilson (2012) found that power increased and peaked, after moderate and high intensity in the back squat, after 4 minutes and returned to normal after 8 to 12 minutes. Therefore, power is considered to increase after performing moderate or maximal effort in the squat exercise (Lowery et al., 2012). On the other hand, the high squat intensity could delay the extent of PAP. This concludes that athletes could benefit from performing moderate or high intensity loads in the squat before explosive movements, with the aim of improving their power output when performing jumps and maximal sprints (Lowery et al., 2012).

The differences amongst the results from the most recent studies regarding the effects of PAP is due to the differences in methods, study design, the length of the rest intervals, type of explosive movement and training history amongst the subjects. The majority of the studies have not used any measures of the twitch responses, which occur in the muscles when potentiated, to determine if the muscles actually are potentiated or not. Furthermore, this type of measurement could be performed with the help of intramuscular electromyography (Hodgson et al., 2005).

Post activation potentiation and sprint

When performing a short and maximal explosive movement such as sprint, recruitment and maximization of all relative motor units are required (Xenofondos et al., 2010). Furthermore, it is documented that elite sprinters have increased their sprint performance by, 20 minutes prior to competition, performing five sets of one repetition back squat with a load of 90 % of their 1RM, with two minutes rest in between the sets (Xenofondos et al., 2010). According to Vanderka, Krčmár, Longová and Walker (2015) PAP has resulted in an increased performance in the acceleration phase, amongst young track and field athletes, in the sprint during the first 0 to 20 meters of the sprint. There are however no documented improvements during the 20 to 40 meters of the sprint (Vanderka et al., 2015).

Tsimahidis, Galazoulas, Skoufas, Papaiaakovou, Bassa, Patikas and Kotzamanidis (2010) have examined the effect of PAP on sprint performance, where the subjects got to perform a training program that consisted of running and complex strength training. The program lasted for 10 weeks and the subjects’ result of their maximal sprint performance was documented before the training program, after the first five weeks and after 10 weeks when the program was completed. The squat consisted of five sets of 5-8 repetitions on a maximum weight of a
half back squat (90 degrees in the knee-joint in the bottom of the squat), followed by a maximal sprint of 30 meters after each set of squats. The final results showed an increased performance amongst the subjects, where their acceleration and maximal speed during the sprint had increased significantly after following the 10 week training program (Tsimahidis et al., 2010). According to Tsimahidis et al., (2010) there are no previous studies that investigate the effect of a combined training program (with sprints after a heavy resistance training session) on running performance, by having the subjects perform the sprint trials after each set of the resistance exercise. They predict that this type of protocol could cause a more effective transfer of PAP from the resistance exercise to running performance.

In a recent study made by Chatzopoulos, Michailidis, Giannakos, Alexiou, Patikas, Antonopoulos and Kotzamanidis (2007) the effects of PAP on sprint performance during a 30 meter sprint, after performing heavy resistance exercise, was investigated. They examined different rest intervals (3 minutes and 5 minutes) after a heavy resistance exercises. The study concluded that the sprint performance increased 5 minutes after the resistance exercise, but not after 3 minutes. Furthermore, the fatigue in the muscles seems to be more dominant than PAP during the first 3 minutes after the resistance exercise. The findings in this study indicate that a 5 minute recovery between the resistance exercise and the sprint trial is sufficient to reduce the fatigue in the muscle and therefore result in a better performance in the sprint (Chatzopoulos et al., 2007).

Comfort, Bullock and Pearson (2012) concluded that sprint performance is one of the most important qualities that athletes need to master, in most sports. The relationship between strength and sprint performance has been examined and the conclusion was that the stronger athletes performed better than the average athletes, during sprint performances. Furthermore, one of the main reasons for this could be an increase in the peak ground reaction forces and impulses, which are strong elements of sprinting (Comfort et al., 2012).

According to Lim and Kong (2013) and Tsimahidis et al., (2010) few studies have been done regarding PAP and its effect on sprint performance. Therefore, it was of great interest to examine how PAP affects performance in a 30 meter sprint after maximal effort in the back squat, since few studies have examined PAP and its effect on 30 meter sprint and PAP in relation to Crossfit athletes.
Aim

The aim of this study was to investigate how post activation potentiation affects the performance in 30 meter sprint amongst male Crossfit athletes, after performing maximal effort in the back squat.

Research questions

Does maximal effort in the back squat, consisting of three repetitions of a half back squat with a load of 85 % of one repetition max (1RM), result in post activation potentiation and therefore increase the sprint performance amongst male Crossfit athletes?

Hypothesis

The hypothesis was that PAP would increase the performance in the 30 meter sprint.
Methods

Subjects

All of the male Crossfit athletes at Crossfit Halmstad were asked to participate in this study, via a post in the Crossfit Halmstad group on Facebook and also private messages, to the members at Crossfit Halmstad, on Facebook. This resulted in twelve healthy male subjects that volunteered to participate in the study. All of them were competitive athletes. Eleven of these completed all tests in the study while one subject was forced to discontinue due to an injury that occurred in the hamstrings muscle during one of the sprint trials. One of the eleven subjects that completed the study also felt some discomfort in the hamstrings muscle after completing all of the sprints, but since the subject completed all of the sprints, his results were not excluded from the study. All of the subjects had to be Crossfit athletes and they were required to have at least one year of experience of strength training, especially performing the squat exercise. Any possible subjects that had been injured for the past six months or suffered from overtraining, were excluded. All of the subjects were provided with information sheets one week before the first test session, which included what shoes and clothes to wear and what to bring to the test sessions. Furthermore, they got some guidelines to follow including information about sufficient sleep and food intake. They also received some restrictions, including no alcohol and training of the legs 24 hours prior to the test sessions and no caffeine or nicotine intake three hours prior to the sessions, see appendix 1 for further information. For reproduction purpose, the subjects age, height and weight were documented, as shown in table 1. Median, min and max are given, as well as mean and standard deviation with the purpose of comparison to other studies in the field.

Table 1. Mean, median, standard deviation, min and max of age, length and weight of the subjects included in the study.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>Standard deviation</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>11</td>
<td>34.5</td>
<td>34</td>
<td>10.9</td>
<td>21</td>
<td>55</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>11</td>
<td>182.9</td>
<td>182</td>
<td>4.1</td>
<td>178</td>
<td>190</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>11</td>
<td>87</td>
<td>88</td>
<td>7.8</td>
<td>75</td>
<td>97.5</td>
</tr>
</tbody>
</table>
Study design

This study was performed as a cross-sectional experimental study (Levin, 2006; Scott & Docherty, 2004) and carried out during spring 2016.

Standardization

During the squats, the subjects had an Olympic 20-kg barbell with extra load, which was different for each subject (Eleiko, Halmstad, Sweden). The barbell was placed on the trapezius muscle, whilst the subjects were holding the bar with a closed, pronated grip (Baechle & Earle, 2008). The subjects’ feet stance was shoulder width apart, with their toes pointing slightly outwards and they had their chest out and up (Baechle & Earle, 2008; Augustsson & Svantesson, 2013; Augustsson, 2013). Subjects then performed the squat and they dropped down to a 90 degree flexion in the knee joint. This position was achieved by having the subjects flex in their knees and hips until they had reached the bottom position of 90 degrees in the knee joint, which was reached when their thighs were slightly above parallel to the floor. The test leader gave a signal to the subjects when they could return from the squat position to the standing start position. Furthermore, for each squat trial, the test leader was responsible for the loading of the barbell (Augustsson & Svantesson, 2013; Augustsson, 2013; Baechle & Earle, 2008).

Equipment

The sprint time was measured with the help of an Asaklitt stopwatch. According to Hetzler, Stickley, Lundquist and Kimura (2008) handheld stopwatches may be used as a possible alternative to electronic timing when collecting group data, but when high degrees of precision are needed, electronic timing should be used, since a reliable correction from handheld stopwatch to electronic timing values is impossible. Furthermore, the test leader counted down accordingly: 3, 2, 1, GO!. When the test leader shouted “go”, the stopwatch started counting and the subject started the 30 meter sprint. The test leader stood right by the finish line and stopped the stopwatch when the subject reached the finish line. To avoid the subjects slowing down too soon during the 30 meter sprint, the placement of the sprint lane was placed in a way that made the braking distance sufficient. During the warm-up, a Concept2 rowing machine (Morrisville, Vermont).
Testing procedures

All of the three test sessions were executed at Crossfit Halmstad. The squat exercise was performed inside the Crossfit box and the sprint trials were performed outside of the Crossfit box, on asphalt. The subjects got to perform the tests with at least five days in between (with a range of five to seven days) the test sessions and they were tested, one at a time, during the afternoon.

First test session – 1RM test

During the first test session, all of the subjects performed a warm-up consisting of five minutes of rowing on resistance eight and then they performed a warm-up in the squat exercise. The subjects estimated their 1RM in the back squat and based on their estimation, the load during the warm-up sets in the back squat were calculated. Each subject got to perform 4 warm-up sets, which is shown in table 2. After the warm-up sets, they got two attempts to set a 1RM in the back squat (Norton, 2015; McArdle, Katch & Katch, 2010; Baechle & Earle, 2008). The best attempt in the 1RM squat was used when calculating how much weight the subjects would have in the back squat during PAP. See appendix 2 for the protocol used during the first test session.

Table 2. Warm-up sets in the back squat, with a one repetition max percentage representing the load in the squat.

<table>
<thead>
<tr>
<th>Warm-up set 1</th>
<th>Warm-up set 2</th>
<th>Warm-up set 3</th>
<th>Warm-up set 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 repetitions at 30 %</td>
<td>4 repetitions at 50 %</td>
<td>2 repetitions at 70 %</td>
<td>1 repetition at 80 %</td>
</tr>
</tbody>
</table>

Second and third test session

During the second and third test session, the subjects were randomly divided into two groups, which resulted in group 1 (n = 6) and group 2 (n = 5). The reason for the subjects being divided was to avoid the learning process from affecting the results (Levin, 2006; Scott et al., 2004). Instead of having all of the subjects perform the non-PAP protocol (sprint) during the second test session and then having them perform the PAP protocol during the third test session, the first group started with the PAP protocol and the second group with the sprint protocol, during the second test session. During the third test session, the first group performed the sprint protocol and the second group performed the PAP protocol. The cross-over design resulted in the subjects performing both sprint and PAP during different sessions, depending on which group they were in, which is seen in figure 1.
The agenda for the different test sessions, where all of the subjects performed the one repetition max trial during the first session, and half of the subjects performed the post activation potentiation trial and the other half performed the sprint trial during the second session and then switched places during the third session.

The protocol for the second test session and the third test session are represented in appendix 3 and 4. The PAP trial included a standard warm-up, a squat warm-up, performing PAP and performing a 30 meter sprint five minutes after each set of PAP (Tsimahidis et al., 2010). PAP consisted of three repetitions in the back squat, with a load of 85% of 1RM (Wilson et al., 2013). According to Chatzopoulos et al., (2007) five minutes of rest after the maximal contraction would be enough for PAP to be higher than the fatigue in the muscles and therefore resulting in a better performance in the sprint. Furthermore, the sprint trial included a standard warm-up and three trials of 30 meter sprint with five minutes of rest in between. Therefore, the only difference in the test sessions were the squat warm-up and PAP. This is presented in figure 2.

Figure 2. Post activation potentiation trial and sprint trial, where one repetition max (1RM) is set to 50 % during the squat warm-up and 85 % during the post activation potentiation.
Ethical and social considerations

Information was provided to the possible subjects during the recruitment. The information consisted of what type of tests they would perform and what the test sessions would require from them. Furthermore, they read and signed an informed consent (appendix 5) which included information about their participation, that it was voluntary and that they could discontinue at any time, without explaining why. The information also stated that their participation would not be any more of an injury risk than what they normally have during their regular training sessions. The subjects were also reassured that the information about them and all of their results would be confidential, these ethical consents were applied for from the local ethics committee at Halmstad University. The subjects were provided with contact information to the test leader and also to the supervisor for the study, if they had any further questions. The findings from this study could possibly result in more awareness of PAP and improve overall performance in the society, especially amongst Crossfit athletes since explosive performance is essential in Crossfit (Glassman, 2002).

Statistical analysis

The subjects got to perform three sprint trials during the non-PAP session and three sprint trials during the PAP session. Furthermore, every subjects best sprint time, in seconds (sec), from each session were analyzed, with the help of Microsoft Excel v.15. The Shapiro-Wilks test was used to check for normality and it showed that the data was not normally distributed. Therefore, the Wilcoxon Signed Rank Test, which is a nonparametric t-test, was used to determine significant differences in sprint performance. Both the Shapiro-Wilks test and the Wilcoxon Signed Rank Test were executed in IBM SPSS v.20. The level of significance was set at \( p < 0.05 \).
Result

The subjects' individual results are illustrated in figure 3, with no significant difference between PAP and non-PAP protocols \((p = 0.679)\). With a median value of 4.78 seconds, a minimum value of 4.59 seconds and a maximum value of 5.54 seconds for the sprint trials after PAP and a median value of 4.82 seconds, a minimum value of 4.59 seconds and a maximum value of 5.31 seconds for the sprint trials without PAP, the results did not confirm the hypothesis. Maximal effort in the back squat, consisting of three repetitions of a half back squat with a load of 85% of 1RM, did not result in post activation potentiation and did therefore not increase the sprint performance amongst male Crossfit athletes, in this study.

![Figure 3. Subjects individual time in the sprint and in the sprint after post activation potentiation (n=11).](image-url)
Discussion

The thesis, which aimed to investigate how PAP affects the performance in 30 meter sprint amongst male Crossfit athletes, after performing maximal effort in the back squat showed that PAP did not increase the sprint performance amongst male Crossfit athletes.

Result discussion

One of the studies in the field has shown that PAP is beneficial for running speed (Tsimahidis et al., 2010). Another study has shown that PAP was beneficial for running speed, after five minutes of rest and not after three minutes of rest (Chatzopoulos et al., 2007). The main difference between their studies and the present study is the age rank, different amount of repetitions, sets and weight in the heavy movement before the sprint. Also, different rest intervals after PAP, compared to this study. Different numbers of repetitions and the load during PAP could possibly result in different effects in the sprint, since the load and the repetitions can fatigue the muscles in different ways and to different extent. Furthermore, longer rest intervals could also result in different effects in the sprint and possibly enhance the performance amongst the individuals, since the fatigue level in the muscles gets lower and lower with longer rest intervals.

Subject nine and subject ten are deviant from the rest of the subjects in the study. The outcome of the results could possibly have been different if their results would have been excluded.

Method discussion

The study was originally going to examine PAP amongst male handball players. A team was chosen several months ahead of the test sessions but with approximately three weeks before starting the sessions, the coach of the handball team decided to not let his players participate in this study due to the fact that they were in the end of the season and had a high training volume and intensity. Furthermore, the coach didn’t want to risk his players being injured. Therefore, the target group had to be changed at short notice and it was changed to Crossfit athletes. This affected the age range and resulted in severe differences in age amongst the subjects, which could be one of the reasons why there was no performance enhancing effect from PAP in this study.

Considering that Crossfit is a very recent kind of training form, it was very hard to find peer-reviewed articles that examine the topic. Therefore, it was hard to find sufficient information
that could have been needed in this thesis. For example, it would have been relevant with a complete requirement analysis for Crossfit athletes.

Twelve male Crossfit athletes volunteered as subjects and eleven of them participated. The subject that had to discontinue his participation fell to the ground in his second sprint trial. He got a partial tear in one of the hamstrings muscle during the sprint, which made him fall down. The subject was 50 years old and he had, at the time, been active in Crossfit for the past four years. Furthermore, he had competed in a couple of Crossfit competitions during the weeks before the test sessions, which the test leader found out after the injury occurred. The competitions and insufficient recovery time could have been a reason behind the subjects’ injury, since he could have easily been exhausted in his body.

Amongst the eleven subjects that participated in the study, one of them felt some discomfort in his hamstrings muscle after all of his sprint trials. Since he performed all of the tests, his results were not excluded from the study. The subject had not been competing as much as the subject that got a partial tear in the hamstring, but his training intensity was rather high at the time. The discomfort he felt turned out to be a severe muscle strain.

The injuries occurred during the non-PAP protocol, which means that PAP was not the reason for the injuries. The reason for the injuries could be fatigue in the muscles, insufficient recovery time and poor running technique.

The final result in this study did not confirm the hypothesis. The results could be deceptive as an effect from the low number of participants. The study could therefore be more dependable and maybe show a different result if the number of participants would exceed at least 25 subjects.

Because of lack of time, limited access to the school laboratory and due to difficulties during scheduling the different trials with the subjects, timing gates were unfortunately not used to measure the sprint times. The timing gates would have been placed on 0, 10, 20 and 30 meters. Although handheld stopwatches are proven to be a somewhat reliable substitute for electronic timing (Hetzler et al., 2008), it would have been interesting to know if the results from both the PAP protocol and the sprint protocol would have been different if the sprint trials would have been measured with the help of timing gates.

The subjects were instructed to refrain from heavy training 24-48 hours before the test session as well as stimulants such as caffeine or nicotine three hours before the test sessions. These restrictions and instructions were followed, except for the one with heavy training. Most of
the subjects did not refrain from heavy training and this could have affected the results.
Considering that the subjects didn’t perform the different test sessions at the exact same time of the day, because of work, studies, transportation and other factors, there could be a possible impact on their performance levels and this could have had some sort of influence on the results in this study.

For further research in the field, it would be of great interest if a higher or lower amount of repetitions and higher or lower weight during PAP could affect the performance in the sprint differently. In this study, it would have been interesting to analyze different parts of the sprint, such as 0-10 meters, 10-20 meters and 20-30 meters to be able to see if there was any difference in the acceleration phase or other differences (Vanderka et al., 2015).

It would also be interesting to see the outcome of performing a heavy explosive movement, for example a clean, and examine if that would have had a performance enhancing effect in the sprint. Further research could examine how heavy deadlifts could affect the performance in the sprint, since the muscles work differently during a deadlift than during a squat. To my knowledge, there are few studies done regarding heavy deadlifts influence on sprint performance. Further studies should also examine more homogeneous groups that include more subjects.

**Conclusion**

There are no performance enhancing effects in the sprint after PAP, in this study. It is unclear what could be the reason for this result and therefore, more research in the field is required and it should include a larger and more homogeneous group, to determine possible performance enhancing effects from PAP.
References


Appendices

Appendix 1 - Test session guidelines

Att tänka på inför samtliga testtillfällen är att se till att ha bekväma kläder, dina vanliga skor som du brukar träna med, vatten och något mellanmål efter testet (exempelvis en banan). Testerna kommer att ske individuellt och uppvärmning sker på plats, precis innan testet.

OBS! Följande regler gäller:

• Bra sömn 24 timmar innan testtillfället

• Du skall ha ätit ordentligt det senaste dygnet, samt äta en stabil måltid ungefär 2 timmar innan testtillfället

• Ingen tobak/nikotin, alkohol eller koffein 3 timmar innan testtillfället

• Normal till låg träning 24-48 timmar innan testtillfället, för att undvika träningsvärk främst i benen

• Bra vätskeintag det senaste dygnet

Hoppas du får en trevlig dag och hör av dig om du har några frågor!

Hälsningar från Viktoria
Appendix 2 – 1RM protocol

<table>
<thead>
<tr>
<th>Namn:</th>
<th>Ålder:</th>
<th>Vikt:</th>
<th>Längd:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Uppvärmning set 1</th>
<th>Uppvärmning set 2</th>
<th>Uppvärmning set 3</th>
<th>Uppvärmning set 4</th>
<th>RM försök 1 på 96-100 %</th>
<th>RM försök 2 på 100-104 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 reps på 30 %</td>
<td>4 reps på 50 %</td>
<td>2 reps på 70 %</td>
<td>1 rep på 80 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3 – Sprint trial protocol

Namn ____________________________________________________________________
Datum ____________________________________________________________________
Tid _______________________________________________________________________

Uppvärmning:
- 5 minuter rodd på motstånd 8

Vila mellan varje sprint:
- 5 minuter

<table>
<thead>
<tr>
<th>Tid (sekunder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint 1 (30 m)</td>
</tr>
<tr>
<td>Sprint 2 (30 m)</td>
</tr>
<tr>
<td>Sprint 3 (30 m)</td>
</tr>
</tbody>
</table>
Appendix 4 – PAP and sprint trial protocol

Namn_______________________________________________________________
Datum____________________________________________________________
Tid_______________________________________________________________

Uppvärmning:
- 5 minuter rodd på motstånd 8
- 2 set x 6 reps på 50 % av 1RM i knäböj

Vila efter varje set PAP (innan påbörjan av sprint):
- 5 minuter

<table>
<thead>
<tr>
<th>Utförande</th>
<th>Vikt på stången</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAP set 1</td>
<td>3 repetitioner på 85 % av 1RM</td>
</tr>
<tr>
<td>PAP set 2</td>
<td>3 repetitioner på 85 % av 1RM</td>
</tr>
<tr>
<td>PAP set 3</td>
<td>3 repetitioner på 85 % av 1RM</td>
</tr>
</tbody>
</table>

5 minuter vila

<table>
<thead>
<tr>
<th>Tid (sekunder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint 1 (30 m)</td>
</tr>
<tr>
<td>Sprint 2 (30 m)</td>
</tr>
<tr>
<td>Sprint 3 (30 m)</td>
</tr>
</tbody>
</table>
Appendix 5 – Informed consent

Information till deltagare

Hej! Mitt namn är Viktoria och jag läser tredje året på Biomedicin - inriktning fysisk träning på Högskolan i Halmstad. Jag skall under följande månader skriva mitt examensarbete och undrar därmed om Du skulle vilja vara med i min studie, som handlar om post aktiverings potentiering och hur det påverkar prestationen i 30 meter sprint. Post aktiverings potentiering innebär att de muskler som används under explosiva moment, utsätts för en maximal muskelkontraktion innan den explosiva prestationen.

Förfrågan om deltagande

Du tillfrågas för att Du är medlem i Crossfit Halmstad. För att delta i studien krävs det att Du har minst ett års erfarenhet av styrketräning, i synnerhet knäböj och att Du under det senaste halvåret har varit skadefri.

Tillvägagångssätt

Studien kommer att innefatta tre testtillfällen med en veckas mellanrum. Under det första testtillfället kommer vi beräkna Ditt 1RM i knäböj (med stången bak på övre delen av ryggen) vilket vi kommer att göra på Crossfit Halmstad. Under de två senare tillfällena kommer Du att få utföra både sprint (30 meter) och post aktiverings potentiering, i form av några set tunga knäböj. Det andra och tredje testtillfället kommer också att ske på Crossfit Halmstad. Uppvärmningen sker på plats och kommer att vara densamma vid samtliga testtillfällen. Ditt deltagande i studien kommer inte medföra några skaderisker eller dylikt, som inte skulle förekomma under dina vanliga träningsspass.

Frivilligt deltagande

Som testperson har Du rätt till att avbryta testet när som helst, utan att ange någon orsak till varför Du vill avsluta Din medverkan. Vidare kommer då redan insamlad data att förstöras, om Du önskar det.

Sekretess

Ansvariga
Viktoria Stefanescu
Biomedicin – inriktning fysisk träning
Högskolan Halmstad
0763-138253
Stefanescu.Viktoria@gmail.com

Handledare
Sofia Ryman Augustsson, lektor vid Högskolan i Halmstad

Samtycke till deltagande i forskningsstudie

Nedan ger Du Ditt samtycke att delta i studien vars syfte är att skildra eventuella skillnader i sprintprestation som ett resultat av post aktiverings potentiering. Läs igenom informationen noggrant och ge Ditt medgivande genom att signera Ditt namn nederst på sidan.

Jag medgiver att Jag:

- Har tagit del av informationen kring studien förstår vad den innebär.
- Har fått ställa de frågor Jag önskar och vet vem som är ansvarig huvudman om Jag har fler frågor.
- Deltar frivilligt i studien och förstår varför Jag har blivit tillfrågad.
- Vet att Jag när som helst kan avbryta Mitt deltagande i studien, utan att ange någon orsak.

Jag intygar att Jag har läst det informerade samtycket och har tagit del av information kring studien. Jag förstår vad deltagandet i studien innebär för Mig och Jag ställer upp frivilligt.

Ort och datum__________________________________________________________

Namn________________________________________Underskrift____________________________________
The author of the bachelor's thesis was born in 1994 and has been interested in exercise and nutrition for several years now. Strength training has been the most interesting type of exercise, until three years ago when the author found Crossfit.