EFFECTS OF PLYOMETRICS PERFORMED DURING WARM-UP ON 20 AND 40 METER SPRINT PERFORMANCE.

by Ceith Creekmur

The purpose of this study was to investigate the effects of a plyometric exercise performed during a typical sprint warm up on subsequent 20 and 40 meter sprint performances. Testing was conducted in two testing sessions on consecutive Mondays. Subjects were randomly selected to either an experimental group or control group for the first testing session, and then groups were switched for the second testing session. The test consisted of a warm up followed by three 40 meter sprint trials with splits recorded at 20 and 40 meters. The experimental group performed the same warm up, but prior to the sprint trials, performed 2x8 plate jumps. Results showed a 1.15% decrease in average 20 meter sprint time and 1.24% decrease in 40 meter sprint time with the experimental group. (p<0.05). Results indicate that incorporating a plyometric into your warm up may enhance sprint performance.
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In sprint races, tenths of seconds can make the difference between winning and losing. That is why people are constantly searching for various ways to drop fractions of time in order to optimize performance. Traditionally, this has been done via improvements in athletic gear (speed suits and improvements of athletic shoes) or in athletic training (weight training). Recently, however, coaches and academics alike have been looking for ways to improve performance on that given day (improvements in pre competition preparation). Sports drinks have been created, supplements are taken, and static stretching is being replaced by dynamic stretching. Another method for improving performance that has made a come back in the past few years is the use of complex training. Complex training takes advantage of the benefits of post activation potentiation (PAP). Post activation potentiation is the preloading of the muscle concentrically, eccentrically and/or isometrically, which can lead to acute increases in power output and decreases in sprint time (Kilduff et al. 2007 and Hilfiker et al 2007). It has been shown that a resistance stimulus can lead to performance improvements when exercises involving the same movement patterns are performed prior to the performance.

In a 1998 article titled Acute enhancement of power performance from heavy load squats, Young et al. (1998) found a 2.8% increase in weighted counter movement jump height when it was preceded by the back squat exercise. Ten subjects with experience with the squat exercise performed two loaded counter movement jumps using 19 kilograms (approximately 42 pounds) followed by 1 set of 5 reps at 100% of the subjects’ 5-rep back squat max. After four minutes rest the subjects performed another set of counter movement jumps. Results showed no difference between the two jumps preceding the squat, but a 2.8% increase in performance was found following the heavy squat. Such results indicate that the squat lead to an improvement in the squat jump.

The PAP effect is also seen in upper body exercises. Daniel Baker (2003) reported that subjects performing the bench press for 6 reps at 65% of their 1 rep max increased their bench throw performance 4.5%. Baker’s subjects were split into two groups. In the experimental group, the participants did 5 consecutive reps of bench press throw using a smith machine. The subjects then did 6 reps using 65% of their 1 rep max bench followed 3 minutes later by another bench press throw using a mass of 50kg (approximately 110 pounds). The control group did the same protocol, minus the 6 reps at 65% of 1 rep max bench. The experimenters were measuring the
peak height of the bar after it was released during the bench throw, and what they found was a 4.5% increase for those subjects that had performed the heavy load bench.

Post activation potentiation effects both competition and practice alike. Imagine if you could train using a technique that can improve your performance output in practice by 2-4%. How much of an impact that could have over a long term? Since the post activation potentiation phenomena has come about, people have been examining various other aspects to see if it carries over to enhance exercises that are more sports specific. What they have found is that benefits of PAP seem to extend beyond exercises directly related to the movement patterns of the heavy resistance stimulus. Research has also shown that pre-loading the body using squats with medium to heavy weight can improve movements that use the same muscle groups, but have different movements patterns such as cycling or sprinting.

In The effects of high intensity exercise on a 10 second sprint cycle test, Chadwick Smith et al (2001) tested if PAP would work on a sprint cycle test like it had on vertical jump performance. The control group in this study simply warmed up and then did a 10 second sprint cycle test. The first experimental group performed the same warm protocol as the control group. They then performed a squat exercise of 10 sets of 1 rep at 90% of 1 rep max, followed 5 minutes later by the 10 second sprint cycle test. The second experimental group mimicked the first, but waited 20 minutes before they performed the sprint cycle test. Results showed that the group that performed the sprint cycle test 5 min post heavy squat significantly increased their average power output and their average power output relative to body weight while the other two groups did not significantly improve performance. These results showed that PAP could translate to exercises that don’t directly mimic the pre-load stimulus exercise.

In addition to cycling, PAP has been found to work with sprinting as well. Dimitris Chatzopoulos (2007) found that performing a half squat at 90% of your 1 rep max decreased 30 meter sprint time 5 minutes after exercise, but not 3 minutes after exercise. Further, Rahman Rahimi (2007) reported that a decrease in 40 meter sprint time is induced using a variety of squat loads. His participants were broken up into 60, 70 or 80% 1 rep max groups and performed 2 sets of 4 reps of the back squat exercise at the given intensity of their respective groups. Four minutes later, the subjects performed a 40 meter sprint. All groups significantly decreased their sprint times relative to baseline measures. However, the 80% of 1 rep max group decreased their time
the most. Additionally Matthews, Matthews and Snook (2004) found similar results. Their participants were broken up into two groups. The control group did a warm up, sprint, 10 minutes rest and then another sprint. The experimental group did the same thing, except during their 10 minutes rest they performed 5 reps at their 5 rep max back squat preceding their second sprint. A significant increase in sprint performance (decrease in sprint time) was found following a 5 rep max back squat compared to baseline measures. These results show a good deal of evidence that a heavy pre-load stimulus can result in increased performance of movements with similar movement patterns as the stimulus exercise. However the PAP effect doesn’t seem to be limited to a heavy pre-load stimulus.

The exercises that induce the PAP effect are not limited to heavy resistance exercises consisting of loads of 60% or greater. The PAP effect is also seen when a more dynamic/plyometric type of exercise is used. Hilfiker et al. (2007) found that pre activating muscles with a drop jump during a warm up protocol increase power output by subjects performing counter movement jumps. In the study, 13 subjects were randomly assigned to two groups. Group one did 1 set of 5 drop jumps from a height of 60cm followed by 3 single counter movement jumps and 3 single squat jumps. One hour later, group one performed the same routine without the 5 drop jumps. Group two did the same set up, but in reverse order, performing the 3 single counter movement jumps and 3 single squat jumps first, then coming back an hour later to perform those same exercises preceded by 5 drop jumps from a height of 60cm. The aim of the study was to see if the drop jumps from 60cm had any effect on the counter movement or single squat jumps. Result showed an improvement with added drop jumps to the warm up routine compared to warm up without the drop jumps. These last few studies show that pre activating muscles using a heavy load, moderate load or a high intensity plyometric can acutely increase power output in sprinting and jumping exercises.

Rest and Level of fitness:

The difficulty in achieving a positive effect from post activation potentiation is balancing fatigue. The goal is to do just enough to elicit a response, without making the athletes tired. There are two main factors that come into play when trying to maintain this balance; rest interval, and level of fitness of the subjects.
When trying to include PAP in your training, rest is of upmost importance. If you group your exercises too close together in time, then you end up fatiguing the athlete instead of eliciting an excitatory response. Kilduff et al. (2007) performed a study that used 23 professional rugby players as subjects. The experiment consisted of performing a baseline counter movement jump. Ten minutes later they completed the squat exercise as a pre load stimulus. Immediately following the preload (within 15 seconds) and every 4 minutes after the squat up to 20 minutes, the subjects performed a single counter movement jump. On the second testing day, the subjects did a similar protocol, but using the upper body exercises of bench and bench press throw using 40% of 1 rep max weight. The study showed that when performing the counter movement jump or bench throw every 4 minutes, it took between 8 and 12 minutes before a significant difference was found. Though 8-12 minutes was needed to find a significant difference in this particular study, many other studies have found significant difference while using rest intervals of 3-5 minutes (Chatzopoulos et al 2007, Duthie, Young, Aitken 2002, Rahimi 2007, Smith et al. 2001, Young, Jenner, Griffiths 1998. For instance, as mentioned before, Chatzopoulos (2007) found that when his subjects performed half squats at 90% that 3 minutes was not enough time to elicit a positive response. His subjects took 5 minutes before a significant improvement could be found. Such examples show that following a high intensity exercise, it takes time for the body to recover, and that fatigue wears off before the excitatory response of PAP do.

Additionally, a subject’s fitness level has an impact on fatigue during a post activation potentiation type of exercise routine. A study by Loren Chiu et al. (2003) demonstrates the point. Her study consisted of 24 subjects, 7 athletes and 17 recreationally trained individuals. The protocol had the subjects test their 1 rep max on the first testing day. They were then divided into either a control or a post activation warm up group which consisted of 5 sets of 1 rep at 90 percent of the subjects already determined 1 rep max. Then, two series of max effort rebound jumps or concentric only jumps with 30, 50 and 70 percent of 1 rep max was performed. When the analysis was performed with all subjects combined, no significant difference was found. However, when the athletes were separated out from the recreationally trained subjects, results showed a significant difference in average force, average power, and peak power at 30 percent load for the concentric only jumps. Additionally, average force for rebound jump was also found to be significant, suggesting that the higher trained athletes were better able to recover from the load. Similar results were found in a study by Vassilios Gouroulis (2003). His study called for half
squat’s at 20,40,60,80 and 90 percent of 1 rep max followed by a vertical jump. The average increase in vertical jump following the squat was 2.39 percent. However, when Vassilios separated the subjects by level of strength (and inferred more trained), the increase jumped to 4.01 percent.

In some recent studies, researcher protocols that did not find significant differences when using PAP could be explained by one or both of these factors limiting PAP. The subjects used in many of the studies that found no significant difference were “active male subjects” (Hrysomallis, Kidgell 2001) and “physically active” (Scott, Docherty 2004). The potential reasoning behind this phenomenon is that subjects that are not adapted to the exercises being performed will become fatigued rather than potentiated when performing an exercise they haven’t done before, or haven’t done in a long time (Chiu et al. 2003).

Many studies have shown that preloading the muscle concentrically, eccentrically and isometrically can lead to acute increases in power output and decreases in sprint time (Young, Jenner, Griffiths 1998, Baker 2003, Kilduff et al. 2007, Hilfiker et al 2007). Previous studies have shown that preloading muscles using various weight lifting exercises can lead to both increase in power output (by demonstrating improved counter movement jump height) (Kilduff et al. 2007), and decrease in sprint time (Chatzopoulos et al. 2007). One recent study showed that adding plyometrics to a warm-up can also act as a preload to muscle and lead to increases in power output (Hilfiker et al. 2007). It is unknown if adding plyometrics to a warm-up would also extend to improving performance in a short burst sprint (20-40m) by decreasing overall sprint time. To the best of my knowledge, it is unknown if a plyometric will improve sprint performance. The purpose of this study is to test the effects of a plyometric added to a sprint warm up on sprint performance over 20 and 40 meters. A secondary purpose of this study is to find an easier way for coaches and athletes to induce the PAP effect on the practice or competition field.

METHODS
Experimental Approach to the Problem

The study is of repeated measures design, with each subject acting as their own control. Testing was conducted on 2 consecutive Mondays in the AM to equalize any negative effects of training performed the previous Friday. Subjects were randomly selected to use the plyometric
warm up (PWU) or the control warm up (CWU) on the first testing day, and then use the opposite warm up on the second testing day. Following the warm up, subjects then performed three sprints over a 40 meter distance with laser timing gates set up at 20 and 40 meters. Average time from start to 20 and start to 40 meters was analyzed for each subject using both warm up protocols.

Subjects

The subject sample for this study consisted of 10 athletes from the Miami University men’s track and field team. Subjects were limited to only those athletes who regularly sprinted 40 meters in either training or competition (Sprinters, Jumpers, Hurdlers and multi event athletes). To recruit subjects for participation, the Head Men’s track and field coach was contacted, briefed on the study and asked permission for his athletes to volunteer. Once his permission was granted, I explained the study procedures to the potential participants and compiled a list of volunteers. Informed consent was obtained for all subjects according to the University policy regarding use of human subjects in research.

Procedures

Figure 1 shows a diagram of the testing protocol for both the PWU and CWU groups. A random number generator was used to randomly assign the participants to either the PWU group or CWU group. Upon arrival to the testing site, all subjects completed the same general warm up designed to represent a typical warm up for athletes who will perform sprinting movements. The warm up consisted of light jogging, dynamic stretching, dynamic exercises and some sprint drills. Once the warm up was finished, subjects were allowed 2 block starts to make any adjustments to block settings before 40 meter trials began. Once blocks were set, they were not allowed to be changed during the testing trials.

Following the standardized warm up and block starts, subjects in the PWU group performed 2 sets of 8 plate jumps (Fig. 2) with 3 minutes recovery between each set and then rested an additional 5 minutes following the plate jumps before starting the 3 x 40meter sprints. Previous research has shown that rest intervals of 4-12 minutes are optimal for eliciting a post activation potentiation response (Chatzpoulos et al. 2007, Kilduf et al. 2007, Matthews, Matthews and Snook 2004, Rahimi 2007, Smith et al. 2001, Young, Jenner and Griffiths 1998).
For those subjects in the CWU group, 8 minutes of rest was given following the warm up and block starts prior to the sprints in order to equalize the rest given to the PWU group (3 minutes rest between plate jump sets, and 5 min rest prior to sprint trials).

A plate jump was chosen because it is a weighted counter movement jump that directly targets the muscles utilized during sprinting and it also does not require a barbell or a squat rack to perform. It is essentially an exercise that is feasible to perform in a setting outside the weight room. Subjects were instructed to perform each jump in a continuous sequence, and to jump as high as possible on each jump.

Once the PWU and CWU group had finished their warm up, everyone performed 3 sets of 40meter sprints with 5 minutes rest between each sprint. Laser timing gates were set at 20 and 40meters. The timer was started via a pressure sensitive pad that would start once the subject took their finger off of it. Splits were then recorded onto a remote timer when the laser timing gates at each distance were tripped.

The following Monday, the testing protocol was followed exactly the same, with the CWU group and PWU groups switched.

Statistical Analysis
The subjects’ average time of the three trials for each condition was calculated. A paired samples t-test was used to compare each subjects average PWU time with their average CWU time. Additionally, due to the small sample size, a wilcoxon signed ranks test was also performed. Testing was set up so that a given subjects average PWU 20 meter time was compared to their own average CWU 20 meter time, and a subjects average PWU 40 meter time was compared to their own average CWU 40 meter time.

RESULTS
Statistical analysis showed a significant decrease in sprint time when a plyometric was performed during the warm up for both 20 and 40 meters. The paired samples t-test showed a significant difference over 20 meter (p<0.05) and the 40 meter (p<0.01) distances. The wilcoxon signed ranks tests also showed a significant difference over 20 meter (p<0.01) and 40 meter (p<0.05) distances.
There was an average decrease over 20 meters of 1.15% and an average decrease of 1.24% over 40 meters.

DISCUSSION

The main finding of this study was that sprint time over a 20 and 40 meter distance was faster when the subjects performed plyometrics during their warm up rather than performing the same warm up without plyometrics.

These findings are similar to other studies that found that performing weighted and/or dynamic exercises can improve sprint speed and increase power output (Baker 2003, Chatzopoulos et al. 2007, French, Kraemer, Cooke 2003, Gourgouliset al. 2003, Kilduff et al. 2007, Matthews, Matthews, Snook 2004, Rahimi 2007, Smith et al. 2001, Young, Jenner and Griffiths 1998). Those studies accredited their findings to the influence of PAP. Though all participants saw an improvement in either 20 or 40 meter sprint performance, individual differences were evident. Five of the ten subjects showed average decreases in sprint time of .09 -.17 seconds over 40 meters.

The use of trained subjects was intentional because previous research has shown that a subjects level of training may influence the potential benefits of PAP. Chiu et all (2003) initially found insignificant results when the subjects were analyze together. However significant improvements in average force, average power and peak power during a squat jump using 30% of 1 rep max following a squat were found when the athletes in the study were separated out from the other subjects. Similar results were found by Gouroulis et al. (2003). Vertical jumping performance was increased from 2.39% when all subjects were included in data analysis to 4.01% when the strongest and more trained subjects were separated out from the other subject population.

Five minutes rest was given after the weighted plyometric prior to the sprint trial because previous research has found significant results when using 5 minutes rest (Chatzopoulos et al. 2007, Kilduff et al. 2007, Matthews, Matthews and Snook 2004, Rahimi 2007, Smith et al. 2001, Young, Jenner and Griffiths 1998). Less than 5 minutes may not be sufficient enough time to negate the effects of fatigue, Chatzopoulos et al. (2007) showed that sprinting speed was improved 5 minutes post squat but not 3 minutes post squat using 90% of 1 rep max. A similar
study showed that the dynamic activity effect may extend out to 12 minutes post exercise (Kilduff et al. 2007) and increases in isometric rate of force development have been found to last out to 20 minutes (Gilbert, Lees 2005).

The mechanisms in which PAP works are still not completely understood. One possibility is that PAP increases the Ca+ sensitivity of actin-myosin, because PAP is related to the phosphorylation of myosin light chains (Baudry et al. 2004). Another such mechanism could be the result of neuronal factors via the H-Reflex (Guillich, Schmidtbleicher 1996).

Further research on the effects of various other plyometric exercises using various other distances and including females is needed. Additionally, studying the inclusion of a dynamic plyometric on other movements such as baseball swing, golf swing, or shot put throw should be studied.

In summary, the results from this study show that inclusion of a plyometric to a sprint warm up could improve performance of sprints of distances of 20 to 40 meters. A higher probability of the methods effectiveness will be attained if adequate rest is given following the plyometric and the sprint performance. Additionally, the level of training must be adequate enough to produce a PAP effect instead of a fatigue effect.

PRACTICAL APPLICATIONS

These results indicate that adding a weighted plyometric to a warm up when a sprint will be performed may improve said sprinting performance. Previous research has shown the potential benefits of improving sprint performance using traditional strength training means. However, a weighted plyometric is much more applicable to most training and competition settings because performing a plate jump 5 minutes prior to a sprint is more feasible than a squat at 90% of 1RM.
400m Jog

Dynamic Stretch:
High Knee - Lunge
Hamstring - quad
Side Lunge
Spiderman
Angle Grab - lateral lunge

Dynamic Drills:
100m Skips (Front/Back/Side
Fence Swings
Caricces

Sprint Drills: 1x20m each
Duck, Pigeon, Heal, Toe walk
High Knees
Butt Kicks
A Skips
B Skips
High Kick
Fast Leg
Knee Dribble to run
High Step to run

Block Set up - 2 practice starts

1x8 Plate Jump            8 Min Recovery
3 Min Recovery
1x8 Plate Jump
5 Min Recovery
40m Dash
5 Min Recovery
40m Dash
5 Min Recovery
40m Dash
5 Min Recovery
40m Dash

Figure 1.
Figure 2.
REFERENCES


