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Title: The effects of an isometric potentiation protocol in the warm-up of elite rowers

Running head: Potentiated warm-up for rowing

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ABSTRACT

The main purpose of this research was to compare two warm-up conditions (normal and potentiated) on 1000 m rowing ergometer time trial performance. Another purpose of this research was to compare warm-up conditions by assessing mean power output, mean stroke rate, blood lactate, and rating of perceived exertion from the 1000 m rowing ergometer time trial. Ten Australian national level rowers from the Australian Institute of Sport were required to perform the two warm-up conditions in a counterbalanced order on separate days. The normal warm-up condition (NWC) involved rowers performing their own preferred warm-up, followed by a four minute recovery that preceded the 1000 m rowing ergometer time trial. The potentiated warm-up condition (PWC) was similar to the NWC, except for the inclusion of a series of isometric muscle actions on the ergometer, which were conducted between the optimal warm-up and the 1000 m rowing ergometer time trial. The PWC produced a reduction of 1000 m time by 1.4 seconds or 0.8% ($p = 0.166$), improved mean power output over 1000 m by 2.6% ($p = 0.134$), and improved mean stroke rate over 1000 m by 4.6% ($p = 0.001$), when compared to the NWC. The PWC reduced 500 m time by 1.7 seconds or 1.9% ($p = 0.009$), improved mean power output over 500 m by 6.6% ($p = 0.007$), and improved mean stroke rate over 500 m by 5.2% ($p = 0.003$), when compared to the NWC. The isometric potentiation protocol in the PWC may have induced a net-potentiated state in the muscles required for rowing. Future research should trial these two warm-up conditions on the typical rowing race distance of 2000 m.

KEY WORDS

Preloading, Acute Enhancement, Rowing, PAP

INTRODUCTION

A warm-up prior to an athletic event is generally considered to be beneficial in improving subsequent performance (10). The design of the warm-up may be enhanced by including a component to exploit the postactivation potentiation (PAP) phenomenon. Postactivation potentiation refers to the acute enhancement of the neuromuscular system following muscular activity (21). The primary mechanisms of PAP have been suggested to be the phosphorylation of myosin regulatory light chains (19) and the increased recruitment of higher order motor units (8). Postactivation potentiation is typically measured by eliciting electrical impulses to a muscle and assessing variables such as twitch peak torque, time to twitch peak torque, half-relaxation time, and M-wave amplitude (11). The M-wave has been used previously to measure membrane excitability and to detect changes in the effectiveness of the action potential transmission / propagation in muscle fibres (5). For example, Hamada et al. (11) found that a 10-second maximal isometric knee extension produced a larger twitch peak torque and M-wave amplitude following the isometric knee extension for up to a five minute period, indicating that an isometric potentiation protocol is effective for eliciting PAP in the knee extensors.

Previous research investigating the effects of potentiation (assumed effects of PAP, where PAP is not directly measured) on dynamic performance has focussed on explosive events such as sprinting (16), countermovement jumping (8, 20), depth jumping (8), and throwing (17). Rixon et al. (20) found that three sets of three-second isometric back squats displayed improvements in countermovement jump height of 2.9% and 1.2% for males and females respectively. Similarly, Gullich and Schmidtbleicher (8) found that three sets of five-second isometric unilateral leg press resulted in improvements of countermovement jump height of

4.7%. These studies provide support for the use of an isometric potentiation protocol on eliciting improvements in explosive dynamic performance.

There is a lack of research investigating the effects of an isometric or dynamic potentiation protocol on dynamic performance lasting longer than 5-10 seconds. Bishop et al. (1) compared two kayaking warm-up conditions on two-minute maximal kayaking ergometer performance. One warm-up condition consisted of kayak ergometer work for 15 minutes at an intensity of 65% $\dot{V}O_{2max}$. The other warm-up condition consisted of kayak ergometer work for 10 minutes at an intensity of 65% $\dot{V}O_{2max}$, followed by kayak ergometer work for five minutes comprising five sets of 10-second sprints at 200% power output at $\dot{V}O_{2max}$ with a 50-second recovery at 55% of $\dot{V}O_{2max}$ after each sprint. Bishop et al. (1) reported that the sprint-based warm-up significantly increased mean and peak power output by 7 and 28 W respectively ($p < 0.05$), despite no significant differences reported between peak $\dot{V}O_2$, total $\dot{V}O_2$, or the accumulated O_2 deficit. Bishop et al. (1) concluded that the increase in power output may have been attributable to the mechanisms of PAP, but this was not measured directly. Grodjinovsky and Magel (7) found that the inclusion of a 160.9 m run at near maximal speed to a warm-up comprising a five-minute jog was superior in improving 1609 m run performance, when compared to a warm-up only consisting of a five-minute jog. These studies may provide support for enhanced neuromuscular activation, which is a mechanism underpinning PAP, and may also indicate that a potentiation protocol added to the warm-up could be effective in improving dynamic performance lasting longer than 5-10 seconds. However, research has provided equivocal findings on protocols designed to elicit PAP on improving subsequent dynamic performance (6, 23). There appears to be many factors that need to be considered if dynamic performance is to benefit from a protocol designed to elicit

PAP; including muscle fibre type composition (11, 12), relative strength (15), and the design of the protocol to induce PAP.

A typical rowing race requires submaximal muscular contractions over a distance of 2000 m, approximately taking between six to seven minutes at the elite level to complete (24). Aerobic energy system contribution has been reported to be 70% after a six minute row (9), indicating that rowing requires a well developed aerobic capacity. This is further highlighted by the dominance of Type I muscle fibres in national and international rowers of 70% and 85% respectively (24). Hamada et al. (11) reported that subjects with a Type I muscle fibre dominance can elicit PAP following an isometric potentiation protocol, but not to the same magnitude as subjects with a Type II muscle fibre dominance. The importance of power output to rowing performance can be seen by the strong positive correlation between maximal power output during a five-stroke rowing test to rowing speed during a 2000 m rowing ergometer time trial (14). The aforementioned studies may support the notion that elite level rowers can elicit PAP and perhaps improve rowing performance through greater elicitation of power output. To the best of the author's knowledge, there has been no research investigating the effect of a potentiated warm-up protocol on rowing performance. Therefore, the aim of this study was to compare two warm-up conditions (normal and potentiated) on 1000 m rowing ergometer performance.

METHODS

Experimental Approach to the Problem

This study utilized a randomized within-subject design where participants were assessed on two testing occasions: a) self-selected rowing warm-up followed by a 1000 m rowing ergometer time trial on the rowing ergometer (Concept II, Model E, Morrisville, Vermont, USA) (normal warm-up condition or NWC), and b) self-selected rowing warm-up combined with an isometric potentiation protocol followed by a 1000 m rowing ergometer time trial (potentiated warm-up condition or PWC). Both testing occasions were separated by 7 days and were performed in a counterbalanced order, with each testing occasion taking place before structured training to ensure fatigue was not going to significantly impact performance. During the time of testing, the rowers were preparing for a major international regatta, and therefore were not willing to perform a 2000 m time trial (typical rowing distance), as this was deemed to be too fatiguing to incorporate into their preparation. However, an investigation into the Concept II ergometer online rankings website (<http://www.concept2.com>) revealed a significantly strong positive correlation between 1000 m and 2000 m rowing ergometer time ($r = 0.918$, $p < 0.01$, $n = 18$), highlighting that 1000 m performance is predictive of 2000 m performance on a rowing ergometer, and thus an appropriate test to use in this study. This result was found by selecting verified times (year 2010 and below) from subjects who had rowed both a 1000 m and 2000 m ergometer time trial within a four-week period. To be included in the analysis, the subjects had to have achieved times that placed them in the 90th percentile (standards used were for year 2010) for both the 1000 m and 2000 m distance, which were set at 03:17.4 and 06:45.7 respectively (times provided by Concept II).

Rowers were instructed to not consume alcohol or caffeine in the 24 hours prior to testing. They were also encouraged to maintain a hydrated state before testing began. Prior to the two testing occasions, rowers were familiarized to the isometric potentiation protocol and timings

within the study. The temperature in the rowing shed ranged from 14.9-24.2°C and the humidity ranged from 59-72.6% between the two testing occasions (i.e., there was one cold day of testing and one warm day of testing). As there was a randomized within-subjects design used in the study, rowers performed both conditions on each testing day. Therefore, the difference in temperature conditions would not have biased either testing occasion. We hypothesized that the PWC would reduce 1000 m rowing ergometer time to a greater extent compared to the NWC. We also hypothesized that the PWC would display a larger mean power output and a faster mean stroke rate throughout the 1000 m time trial when compared to the NWC.

Comment [UoB1]: Why? You just said temp would not bias any one warm-up? Delete?

Subjects

Ten Australian elite level rowers (9 male, 1 female) volunteered to participate in this study (age range: 20-30 years, mean weight: 91.2 ± 7.1 kg). All were of a heavyweight class (i.e., >72.5 kg for males, >59 kg for females). All rowers were scholarship holders at the Australian Institute of Sport and had a resistance training background of more than five years. The rowers were informed that non-participation would not affect selection for future Australian rowing squads. Informed signed consent was obtained from all rowers prior to testing to comply with the University Human Research Ethics Committee.

Procedures

Before the commencement of the warm-up, rowers were randomly assigned to either the NWC or PWC for the first testing occasion, which allowed the testing to be completed in respective groups. The rowing shed was set up with five ergometers side by side and was mirrored with another five ergometers side by side across the room. One side of the room was

for the PWC, and the other side was for the NWC to allow efficient coordination. Rowers who performed the PWC were informed of the start time of the isometric muscle actions so they could be completed together and thus replicate a team environment at testing, similar to on-water rowing performance. Rowers who performed the NWC were informed of the start time of the 1000 m rowing ergometer time trial to allow this test to be completed together for the same reasons mentioned above. A 25-minute period was given for the rowers to perform their self-selected warm-up before the start of either the isometric potentiation protocol (PWC) or the 1000 m rowing ergometer time trial (NWC). This procedure was repeated for the second testing occasion for all rowers. Rowers who were in the PWC were required to have the adjustable nylon strap fitted before the commencement of their self-selected warm-up. The adjustable nylon strap was fitted around the rowing ergometer and taped down, with it looped through the metal portion of the rowing ergometer handle. The length of the nylon strap was adjusted so that the rower was in a position that enabled $\sim 100^\circ$ knee flexion (eye-ball measurement) whilst allowing the trunk to remain relatively upright with the elbows slightly flexed. The nylon strap was fitted without obstructing air flow in and out of the flywheel and thus did not affect stroke resistance (Figure 1). Heavyweight men and women were assigned to drag factor settings of 115 and 105 respectively. The drag factor number is designed to account for weight and gender differences and to also simulate on-water rowing resistance as much as possible. This meant that rowers were required to adjust their resistance during the first few strokes of their warm-up (by moving the resistance lever up or down on flywheel) to ensure that the drag factor number reported on the performance monitor matched the drag factor number that was prescribed to each rower.

INSERT FIGURE 1 ABOUT HERE

The rowers were required to perform their self-selected warm-up before both testing conditions began. The rationale behind allowing the rowers to perform a self-selected warm-up was twofold: 1) it was felt that it would closely resemble a pre-race warm-up thus being specific, and 2) an individualized approach is important to performance as each rower knows from experience what to include and exclude from the warm-up to make it effective. The rowers were encouraged to replicate their race-day warm-up, with any on-water rowing to be substituted with ergometer rowing. For the first testing occasion, and upon immediate completion of their preferred warm-up, each rower was required to record it so it could be accurately reproduced on the next testing occasion.

After the completion of their self-selected warm-up, rowers in the PWC performed the isometric potentiation protocol, which consisted of five sets of five-second isometric muscle actions (justification of protocol explained further on). The rowers were permitted to be in bare feet or in shoes, as long as this was consistent for both testing occasions. Each five-second isometric muscle action was performed by building up the "pulling" force gradually for two seconds (to minimize the risk of injury through any "jerky" movements) where maximum force was developed and maintained for a further three seconds. A 15-second recovery period was prescribed between isometric muscle actions. The rowers did not receive any encouragement and were asked to remain seated throughout the isometric potentiation protocol.

A pre-recorded voice on a CD allowed the rowers to perform the isometric potentiation protocol to correct timing. A five-second countdown preceded the first isometric muscle action followed by "go, one, two, three, four, stop (5th second)". The rower started the isometric muscle action on "go", and aimed to be at peak muscle activation at "two", and then completely relaxed on "stop". After a ten-second recovery, the rower was given a further five-second countdown before the commencement of the next isometric muscle action. This process was repeated until a total of five isometric muscle actions were completed. A four-minute passive recovery commenced immediately after the five sets of isometric muscle actions. The rowers were to remain seated on the rowing ergometer during this recovery period.

Comment [UoB2]: Put the close of quotation marks before 5th second. The reason is that the actual statement was "go, one, two, three, four, stop"

Rowers were encouraged by their coaches to perform their best 1000 m rowing ergometer time. The rowers were very familiar with the 1000 m time trial distance as it is used frequently in training. Each rower could use any pacing strategy they desired in order to replicate race tactics. During the 1000 m ergometer time trial, the performance monitor on the rowing ergometer was set to countdown from 1000 m, and all other data on display was covered with tape to ensure rowers and coaches could only view the distance. The rowers received encouragement during the 1000 m time trial for both testing occasions. Average power output and time taken to complete each 100 m split was measured by the performance monitor on the rowing ergometer. Accumulated time after each split and average power output over multiple splits were analysed. The rowing ergometer contained an inbuilt self-calibrating electronic performance monitor to measure the above variables. After the completion of the 1000 m time trial, data was obtained from the performance monitor of the rowing ergometer and recorded by hand.

Immediately and four minutes after the 1000 meter rowing ergometer time trial, a homogenised cold blood sample was taken from the earlobe to measure blood lactate concentration (Lactate Pro, Arkray Inc. Shiga, Japan) as an indicator of fatigue. This was performed by two trained physiologists from the Australian Institute of Sport. Immediately after the 1000 meter rowing ergometer time trial, rowers were required to rate from “6-20” their rating of perceived exertion (RPE) (3). The rowers were able to provide their rating based from a visual scale with subjective ratings at various numbers (3). A score of "six" represented "no exertion at all", and a score of "20" represented "maximal exertion". This measure was used as a subjective indicator of effort for the 1000 m rowing ergometer time trial.

Justification of Potentiation Protocol

An isometric muscle action was selected for its practicality as it could be transferred to the race boat. This type of muscle action has been found to be less metabolically fatiguing than an isotonic concentric contraction (4), which may serve to reduce the accumulation of fatigue during a rowing race to a better extent than a series of isotonic concentric contractions. This study employed five sets similar to what has been used in previous research (8), as this was felt to be sufficient in eliciting a net-potentiated state, as it has been established that subjects with a Type I muscle fiber dominance (like rowers) generate PAP to a lesser extent than subjects with a Type II muscle fibre dominance (11). Three seconds of maximal isometric intensity was prescribed as this has been used in previous research (20), and the low duration may act to minimize the accumulation of fatigue throughout the isometric potentiation protocol, which would counteract PAP. A maximal isometric intensity was selected as this

would be expected to allow greater motor unit activation than a submaximal intensity; possibly by activating a greater percentage of Type II muscle fibres and eliciting a greater PAP response. A 15-second recovery interval was prescribed between sets as it was assumed that the elite level rowers would have developed a resistance to fatigue due to the possible dominance of Type I muscle fibres. A four-minute recovery interval was employed after each warm-up as this is believed to allow sufficient recovery of the central nervous system (2), which should allow optimal force production to occur during the 1000 m rowing ergometer time trial. Previous research has found that the four-minute recovery is beneficial in improving sprinting performance (16, 18) and loaded countermovement jump performance (25).

Statistical Analyses

All statistical analysis was conducted using a software package (SPSS for Windows, version 17.0.0; SPSS, Inc., Chicago, IL). As there were less than 30 participants, normality was tested for by using a Shapiro-Wilk test, and it was concluded that the normality and normality of difference scores assumptions were not violated. Paired samples t-test with α of .05 was used to compare all dependent variables between the two warm-up conditions. Pearson correlations were conducted to determine the relationships between dependent variables on 500 m and 1000 m time for each respective warm-up condition. To determine the magnitude of difference between the warm-up conditions, effect size (ES) calculations were performed. Modified effect sizes (13) were classified as: 0.0-0.19 = "trivial", 0.2-0.59 = "small", 0.6-1.19 = "moderate", 1.2-1.9 = "large", 2.0-4.0 = "nearly perfect". To see how many boat-lengths the PWC may save or add to the NWC in the 1000 m time trial, the absolute 1000 m time for the PWC was subtracted from the NWC and was multiplied with the mean speed of the PWC

1000 m time trial (in meters per second). This number was then divided by 8.2 to calculate the number of single scull boat lengths (one boat length = 8.2 m).

RESULTS

When comparing the PWC to the NWC, the PWC resulted in a non-significant reduction of 1000 m rowing ergometer time ($p = 0.166$, Table 1). However, the PWC reduced 1000 m rowing ergometer time by a mean of 1.4 seconds or 0.8% (small effect size). The PWC displayed a faster mean split time over the first seven splits, of which the first four splits were significantly faster (Figure 2). Eight of the 10 rowers managed to reduce their 1000 m rowing ergometer time to a greater extent when undertaking the PWC (Figure 3). The absolute mean difference of 1.4 seconds in favour of the PWC resulted in a mean advantage of one single scull boat length (8.2 m, Figure 3). The PWC resulted in a non-significant increase in mean power output over the 1000 m of 14.1 W or 2.6% ($p = 0.134$, Table 1). The PWC was superior in generating larger mean power outputs per split for the first seven splits, of which the first four splits were significantly larger (Figure 4). The correlation between mean power output over 1000 m and time to complete 1000 m was significantly strong for the NWC and PWC ($r = -0.997$; $r = -0.992$ respectively, $p < 0.01$). Therefore, it appears that 98% of the variance in 1000 m time witnessed from the PWC is attributed to mean power output over the 1000 m. The PWC resulted in a significant increase in mean stroke rate over the 1000 m by 1.8 strokes/minute or 4.6% ($p = 0.001$, Table 1), with significant differences occurring on splits three, five, seven, and eight (Figure 5). The PWC displayed significant reductions in 500 m time of 1.9% or 1.7 seconds ($p = 0.009$, Table 1). The PWC produced significant increases in mean power output of 36.6 W or 6.6% ($p = 0.007$, moderate effect size) and

stroke rate of 2.1 strokes/minute or 5.2% ($p = 0.003$, small effect size) over the 500 m distance.

INSERT TABLE 1 ABOUT HERE

INSERT FIGURE 2 ABOUT HERE

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DISCUSSION

The main purpose of this research was to compare the time taken to complete 1000 m on a rowing ergometer between two warm-up conditions (normal and potentiated). Another purpose of this research was to compare mean power output, mean stroke rate, blood lactate, and RPE between two warm-up conditions over the 1000 m rowing ergometer time trial. The primary finding of this research was that the PWC resulted in an overall reduction in 1000 m rowing ergometer time by 1.4 seconds when compared to the NWC, despite its statistical non-significance (small effect size, Table 1). The PWC had a significant effect on reducing the time to complete 500 m when compared to the NWC ($p = 0.009$, moderate effect size).

As approximately 98% of the variance in the 1000 m time could be explained by the mean power output from the 1000 m time trial, it highlights the importance of mean power output

to 1000 m rowing performance. The non-significant increase in mean power output over the 1000 m for the PWC may be attributed to the mechanisms of PAP; despite the limitation that PAP was not directly measured. The PWC produced significant differences in mean split time and power output over the first four splits when compared to the NWC, with non-significant differences in mean split time and power output observed for splits five, six, and seven in favour of the PWC (Figure 2 and 4 respectively). This indicates a possible level of potentiation that may have been induced from the isometric potentiation protocol in the PWC. This may be further supported by the superior mean stroke rate displayed throughout all 10 splits by the PWC (Figure 5). Eight of the ten rowers displayed a faster 1000 m time from the PWC than from the NWC (Figure 3). Whilst the absolute mean difference in 1000 m time was not statistically significant, it resulted in an absolute mean difference of 8.2 m in favour of the PWC (or one single scull boat length, Figure 5). This means that the PWC cut one single scull boat length off the 1000 m distance when compared to the NWC, which is quite substantial in a rowing race.

Comment [UoB3]: Fig 3?

The PWC displayed slower mean split times and lower mean power outputs in the last three splits when compared to the NWC (Figure 2 and 4 respectively), which may indicate the effects of fatigue in the PWC during this time period. The lowest mean power output from the PWC occurred at split eight, with larger power outputs observed in split nine and 10 (Figure 4). The rowers may have adopted a pacing strategy and may have been aiming to finish the race with a greater intensity by developing larger power outputs. A similar trend appeared for the NWC, except that the increase in power output during these final stages was of a greater magnitude than the PWC (Figure 4). In examining the mean power output for the final split within the two warm-up conditions, the PWC displayed a mean power output that was the fifth largest overall, and the NWC displayed a mean power output that was second

largest overall (Figure 4). This indicates that the NWC may have displayed lower levels of fatigue than the PWC towards the end of the 1000 m time trial. This may be supported by the “small” but non-significant difference in blood lactate concentration measured four minutes after the 1000 m rowing ergometer time trial (Table 1); possibly indicating a greater level of fatigue for the PWC than the NWC. The PWC displayed slightly greater RPE values than the NWC (Table 1), indicating that rowers may have expended more “effort” during the PWC. Maximal mean RPE values were non-existent in both warm-up conditions, suggesting that some of the rowers did not reach “maximal effort” during the time trial, which may be indicative of an ineffective execution of the pacing strategy during the 1000 m time trial.

Secher (22) calculated that rowers use approximately 39% of their maximal isometric rowing strength during an on-water race. Although the prescription of a maximal isometric muscle action for three seconds was employed in this study to activate as many Type II motor units as possible, and thus elicit a greater level of PAP, the isometric muscle actions in this study may have been performed at a higher than required intensity. The recruitment of a greater percentage of Type II motor units may have resulted in higher levels of fatigue for the PWC. This may have been a possible cause of fatigue towards the end of the 1000 m time trial, where the final burst in mean power output would have required energy to be produced by the anaerobic energy system, but due to the significant increase in mean power output from the PWC in the first four splits, it is quite possible that less energy may have been able to be produced via anaerobic pathways and thus could explain the difference between the NWC and PWC during the final three splits.

There has been a lack of published research relating to the effects of a protocol designed to elicit PAP and its effects on dynamic performance consisting longer of 5-10 seconds.

Previous research has found that supplementing a section of a continuous warm-up on a kayaking ergometer with five sets of 10-second sprints has been shown to increase mean and peak power output over a two-minute maximal kayaking ergometer test (1). Unfortunately, the test used by Bishop et al. (1) was of a fixed duration and did not measure the distance achieved from the two-minute maximal kayaking ergometer test; therefore, the increase in mean and peak power output could not be related to kayak ergometer performance, unlike the current study. Running performance over 1609 m has been shown to benefit from a warm-up consisting of a five-minute jog supplemented with a near maximal sprint of 160.9 m, when compared to a warm-up consisting of only a five-minute jog (7). The aforementioned studies may provide support for the possible elicitation of PAP from the high intensity sprint (s), which could be considered a dynamic potentiation protocol. The current study differed by attempting to elicit PAP through an isometric potentiation protocol, to allow possible implementation into the boat for future rowing events. We found no published research that was of similar design to the current study to allow comparison. Future research should investigate the effects of an isometric potentiation protocol on 2000 m rowing ergometer performance.

PRACTICAL APPLICATIONS

As the research into potentiated warm-ups and rowing is relatively new and unexplored, it is not recommended at this stage to implement an isometric potentiation protocol on the typical “on-water” race distance of 2000 m, due to the possible effects of fatigue at the end of the 1000 m rowing ergometer time trial. However, the PWC was very encouraging in reducing 1000 m race time as shown by the reduction of one single scull boat length compared to the

NWC, and may be an effective method for the possible augmentation of power output in training and races of a short distance and duration. The isometric muscle actions can be implemented to a race situation, because an adjustable strap and a rigid point on the boat are all that is required to allow the body position adopted by this study (Figure 1). The timings of the isometric potentiation protocol may be implemented by recording an electronic version of the timings onto an mp3 player where rowers can listen to and follow the protocol properly in the boat before the race. The coxswain may be able to administer the timings of the isometric potentiation protocol if participating in the race itself.

REFERENCES

1. Bishop, D, Bonetti, D, and Spencer, M. The effect of an intermittent, high-intensity warm-up on supramaximal kayak ergometer performance. *Journal of Sports Sciences* 21: 13-20, 2003.
2. Bompa, TO. *Periodization of strength*. Toronto, ON: Veritas Publishing, 1993.
3. Borg, G. *Borg's perceived exertion and pain scales*. Champaign, IL: Human Kinetics, 1998.
4. Cady, EB, Jones, DA, Lynn, J, and Newham, DJ. Changes in force and intracellular metabolites during fatigue of human skeletal muscle. *The Journal of Physiology* 418: 311-325, 1989.
5. Girard, O, Carbonnel, Y, Candau, R, and Millet, G. Running versus strength-based warm-up: Acute effects on isometric knee extension function. *European Journal of Applied Physiology* 106: 573-581, 2009.
6. Gossen, ER, and Sale, DG. Effect of postactivation potentiation on dynamic knee extension performance. *European Journal of Applied Physiology* 83: 524-530, 2000.
7. Grodjinovsky, A, and Magel, JR. Effect of warm-up on running performance. *Research Quarterly* 41: 116-119, 1970.
8. Gullich, A, and Schmidtbleicher, D. MVC-induced short-term potentiation of explosive force. *New Studies in Athletics* 11: 67-81, 1996.
9. Hagerman, FC, Connors, MC, Gault, JA, Hagerman, GR, and Polionski, WJ. Energy expenditure during simulated rowing. *Journal of Applied Physiology* 45: 87-93, 1978.
10. Hajoglou, A, Foster, C, De Koning, JJ, Lucia, A, Kernozek, TW, and Porcari, JP. Effect of warm-up on cycle time trial performance. *Medicine and Science in Sports and Exercise* 37: 1608-1614, 2005.

11. Hamada, T, Sale, DG, MacDougall, JD, and Tarnopolsky, MA. Postactivation potentiation, fiber type, and twitch contraction time in human knee extensor muscles. *Journal of Applied Physiology* 88: 2131-2137, 2000.
12. Hamada, T, Sale, DG, MacDougall, JD, and Tarnopolsky, MA. Interaction of fibre type, potentiation and fatigue in human knee extensor muscles. *Acta Physiologica Scandinavica* 178: 165-173, 2003.
13. Hopkins, WG. A new view of statistics. Available at:
<http://www.sportsci.org/resource/stats/effectmag.html>. Accessed September 20, 2010.
14. Ingham, SA, Whyte, GP, Jones, K, and Nevill, AM. Determinants of 2,000 m rowing ergometer performance in elite rowers. *European Journal of Applied Physiology* 88: 243-246, 2002.
15. Jo, E, Judelson, DA, Brown, LE, Coburn, JW, and Dabbs, NC. Influence of recovery duration after a potentiating stimulus on muscular power in recreationally trained individuals. *Journal of Strength and Conditioning Research* 24: 343-347, 2010.
16. Linder, EE, Prins, JH, Murata, NM, Derenne, C, Morgan, CF, and Solomon, JR. Effects of preload 4 repetition maximum on 100-m sprint times in collegiate women. *Journal of Strength and Conditioning Research* 24: 1184-1190, 2010.
17. Markovic, G, Simek, S, and Bradic, A. Are acute effects of maximal dynamic contractions on upper-body ballistic performance load specific? *Journal of Strength and Conditioning Research* 22: 1811-1815, 2008.
18. Matthews, MJ, Matthews, HP, and Snook, B. The acute effects of a resistance training warmup on sprint performance. *Research in Sports Medicine* 12: 151-159, 2004.
19. Metzger, JM, Greaser, ML, and Moss, RL. Variations in cross-bridge attachment rate and tension with phosphorylation of myosin in mammalian skinned skeletal muscle fibers.

- Implications for twitch potentiation in intact muscle. *The Journal of General Physiology* 93: 855-883, 1989.
20. Rixon, KP, Lamont, HS, and Bemben, MG. Influence of type of muscle contraction, gender, and lifting experience on postactivation potentiation performance. *Journal of Strength and Conditioning Research* 21: 500-505, 2007.
 21. Sale, DG. Postactivation potentiation: Role in human performance. *Exercise and Sport Sciences Reviews* 30: 138-143, 2002.
 22. Secher, NH. Isometric rowing strength of experienced and inexperienced oarsmen. *Medicine and Science in Sports* 7: 280-283, 1975.
 23. Smith, JC, and Fry, AC. Effects of a ten-second maximum voluntary contraction on regulatory myosin light-chain phosphorylation and dynamic performance measures. *Journal of Strength and Conditioning Research* 21: 73-76, 2007.
 24. Steinacker, JM. Physiological aspects of training in rowing. *International Journal of Sports Medicine* 14: S3-10, 1993.
 25. Young, WB, Jenner, A, and Griffiths, A. Acute enhancement of power performance from heavy load squats. *Journal of Strength and Conditioning Research* 12: 82-84, 1998.

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Figure Legends

Figure 1. Body position for the isometric potentiation protocol.

Figure 2. Mean time and SD per 100 m split for the NWC and PWC. *denotes $p < 0.05$.

**denotes $p < 0.01$.

Figure 3. Boat length difference as a result of the PWC. A positive boat length value indicates that the PWC was superior to the NWC in saving distance to complete the 1000 m time trial. A negative boat length value indicates that the PWC was inferior to the NWC in saving distance to complete the 1000 m time trial. One boat length = 8.2 m, which represents the length of a single scull boat.

Figure 4. Mean power output and SD per 100 m split for the NWC and PWC. *denotes $p < 0.05$. **denotes $p < 0.01$.

Figure 5. Mean stroke rate per 100 m split for the NWC and PWC. *denotes $p < 0.05$.

**denotes $p < 0.01$.

Table Legends

Table 1. Descriptive statistics of the two warm-up conditions on 1000 m rowing ergometer performance. SD = standard deviation. NWC = normal warm-up condition. PWC = potentiated warm-up condition. SR = stroke rate. BL - Immediate = blood lactate concentration measured immediately after 1000 m time trial. BL - 4 Minutes Post = blood lactate concentration measured four minutes after the 1000 m time trial. RPE = rating of perceived exertion. % change NWC = % difference in favor of PWC. Absolute difference = PWC mean minus NWC mean. *denotes $p < 0.01$.