The Effect of Including a Series of Isometric Conditioning Contractions to the Rowing Warm-Up on 1,000-m Rowing Ergometer Time Trial Performance

Simon A. Feros,[1] Warren B. Young,[1] Anthony J. Rice,[2] and Scott W. Talpey[1]

[1]*School of Health Sciences, University of Ballarat, Ballarat, Victoria, Australia; and* [2]*Department of Physiology, Australian Institute of Sport, Canberra, Australia*

Abstract

Feros, SA, Young, WB, Rice, AJ, and Talpey, SW. The effect of including a series of isometric conditioning contractions to the rowing warm-up on 1,000-m rowing ergometer time trial performance. *J Strength Cond Res* 26(12): 3326–3334, 2012—Rowing requires strength, power, and strength-endurance for optimal performance. A rowing-based warm-up could be enhanced by exploiting the postactivation potentiation (PAP) phenomenon, acutely enhancing power output at the beginning of a race where it is needed most. Minimal research has investigated the effects of PAP on events of longer duration (i.e. 1,000-m rowing). The purpose of this research was to investigate the effects of PAP on 1,000-m rowing ergometer performance through the use of 2 different warm-up procedures: (a) a rowing warm-up combined with a series of isometric conditioning contractions, known as the potentiated warm-up (PW), and (b) a rowing warm-up only (NW). The isometric conditioning contractions in the PW were performed by "pulling" an immovable handle on the rowing ergometer, consisting of 5 sets of 5 seconds (2 seconds at submaximal intensity, and 3 seconds at maximal intensity), with a 15-second recovery between sets. The 1,000-m rowing ergometer time trial was performed after each warm-up condition, whereby mean power output, mean stroke rate, and split time were assessed every 100 m. Ten Australian national level rowers served as the subjects and performed both conditions in a counterbalanced order on separate days. The PW reduced 1,000-m time by 0.8% ($p > 0.05$). The PW improved mean power output by 6.6% ($p < 0.01$) and mean stroke rate by 5.2% ($p < 0.01$) over the first 500 m; resulting in a reduction of 500-m time by 1.9% ($p < 0.01$), compared with the NW. It appears that the inclusion of isometric conditioning contractions to the rowing warm-up enhance short-term rowing ergometer performance (especially at the start of a race) to a greater extent than a rowing warm-up alone.

Key Words acute enhancement, preloading, power, potentiation, PAP

Introduction

Rowing at an international level requires high levels of muscular strength, power, and strength endurance, because the typical race distance is 2,000 m and takes approximately 6–7 minutes to complete (25). Peak force and peak power measured in a 2,000-m rowing ergometer time trial (RETT) have been strongly correlated to average rowing speed during a 2,000-m RETT ($r = 0.93$, $r = 0.94$, respectively) (19), indicating the importance of developing strength and power for the rower. The initial spurt of the rowing race requires larger peak forces (1,000–1,500 N) and large power outputs per stroke (800–1,200 W) than any other phase of the race, to accelerate the boat quickly to its desired speed (25). Providing rowing technique is constant, a rower with superior strength and power qualities should be dominant over a rower who possesses lower levels of strength and power. From a tactical standpoint, it would also appear advantageous for a rower to have great levels of strength and power, because it could position them to be in the lead of the race, allowing adjustments to their stroke rates and power outputs based upon observation of their competitors.

Although structured strength and conditioning programs focus on the long-term development of strength and power for rowing performance (2), the warm-up can acutely enhance power output (16), benefiting a rower for a race or for training. This acute enhancement in strength or power output after conditioning contractile activity refers to the postactivation potentiation (PAP) phenomenon (22) and is typically elicited by performing high-intensity "conditioning contractions" (i.e., dynamic or isometric exercise) (7). This

Address correspondence to Simon A. Feros, s.feros@ballarat.edu.au

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phenomenon may be exploited in the warm-up to enhance performance before a race or training. The mechanisms of PAP are the phosphorylation of myosin regulatory light chains (17), the increased recruitment of higher order motor units (7), and the change of muscle pennation angle (13). The elicitation of PAP has been shown to improve twitch peak torque (9), twitch rate of force development (9), and twitch half-relaxation time (9). Explosive short-term activities such as sprinting (12), countermovement jumping (7,21), depth jumping (7), throwing (14), and swim starts (11) have all benefited from conditioning contractions designed to elicit PAP while also exploiting the "window of opportunity" where PAP prevails over fatigue after a conditioning contraction (22). Acutely enhancing the power output of the rower may assist in greater acceleration ability at the start of a race. However, it is not known whether events that are longer than sprinting (i.e., 1,000-m rowing) can acutely benefit from eliciting PAP in the warm-up.

Given that international level rowers possess a type I muscle fiber dominance (25) and that subjects with a type I muscle fiber dominance typically elicit lower levels of PAP than subjects with a type II muscle fiber dominance (9), it may be expected that rowers would generally not benefit from PAP to a great extent. However, Hamada (8) postulated that endurance-based athletes (such as rowers) could elicit PAP for 2 reasons: (a) Endurance training can improve the maximum shortening velocity of type 1 muscle fibers, which results in an increased amount of "fast" myosin light chains and therefore could lead to a greater capacity for myosin light chain phosphorylation (a mechanism of PAP); and (b) the enhanced fatigue resistance of endurance-trained athletes would allow PAP to prevail over fatigue, allowing a "window of opportunity" to occur, where submaximal contractions would be potentiated. The elicitation of PAP may temporarily allow endurance-trained athletes to perform a given submaximal contraction with the same amount of force with less effort than before, because PAP should increase the force output of the motor units while decreasing the motor unit firing rate (22). The enhanced rate of force development and relaxation elicited from PAP should allow the rower to gain an early advantage in a race situation.

It is well established that performing a warm-up before competition enhances performance, through faster muscular contractions, facilitated nerve transmission and recruitment of required motor units (16). Incorporating a protocol of conditioning contractions to the warm-up to elicit a net PAP response may further enhance these qualities and thus improve rowing performance. Therefore, the purpose of this investigation is to assess the effectiveness of incorporating a series of isometric conditioning contractions to a rowing-based warm-up on 1,000-m rowing ergometer performance. It is hypothesized that the inclusion of isometric conditioning contractions to a rowing-based warm-up would reduce 1,000-m rowing ergometer time, improve mean power output and stroke rate throughout the 1,000-m RETT to a greater extent than a rowing-based warm-up alone. This investigation aims to provide coaches and athletes with relevant information regarding a novel method of modifying a rowing warm-up to possibly enhance short-term rowing performance.

Methods

Experimental Approach to the Problem

This investigation required subjects to perform 2 different testing protocols on 2 different days: (a) self-selected rowing warm-up followed by a 1,000-m RETT on the rowing ergometer (Concept II, Model E, Morrisville, VT) (normal warm-up condition or NW) and (b) self-selected rowing warm-up combined with a series of isometric conditioning contractions followed by a 1,000-m RETT (potentiated warm-up condition or PW) (Figure 1). To control for order effect, the subjects were randomly allocated to either warm-up condition for their first testing session, and were to perform the remaining warm-up condition for their second testing session. Ultimately, this approach allowed for the comparison of 2 warm-up conditions on 1,000-m RETT performance, thereby assessing the effectiveness of the isometric conditioning contractions on 1,000-m RETT performance.

The independent variables in this investigation were the isometric potentiation protocol and the 1,000-m RETT. The dependent variables in this investigation were mean power output, mean stroke rate, and split time; all of which were recorded every 100 m during the 1,000-m RETT. The Concept II Model E rowing ergometer housed a self-calibrating electronic performance monitor to measure these dependent

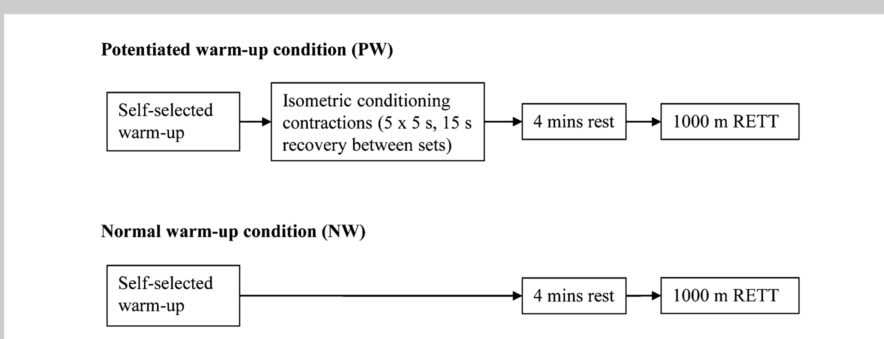

Figure 1. Experimental design of the potentiated and normal warm-up conditions. RETT = rowing ergometer time trial.

variables. Other dependent variables included blood lactate concentration, which was measured immediately and 4 minutes after the 1,000-m RETT as a marker of fatigue, and rating of perceived exertion (RPE) measured immediately after the 1,000-m RETT as a subjective indicator of effort. These dependent variables were chosen as it was felt that they would provide an indirect measurement of PAP and fatigue. The 1,000-m RETT was selected as the subjects were not able to perform the traditional 2,000-m RETT, because of preparation for the World Rowing Championships.

Subjects

Ten Australian elite level rowers (9 male, 1 female) with a mean relative $\dot{V}O_2max$, weight, and age of 68.7 ± 3.1 $ml \cdot kg^{-1} \cdot min^{-1}$, 91.2 ± 7.1 kg, and 24.8 ± 2.6 years, respectively, recruited from the Australian Institute of Sport Rowing Squad, served as the subjects. All the subjects were required to be of a heavyweight class (i.e., >72.5 kg for men, >59 kg for women), with a resistance training background of at least 5 years, and to be free of injury. The University's Human Research Ethics Committee approved the details of this study and all related informational and consent documentation before data collection. In accordance with the Human Research Ethics Committee's policies for use of human subjects in research, the investigator informed all the subjects as to the benefits and possible risks associated with the participation in the study, and all the subjects signed a written informed consent document indicating their voluntary participation.

Procedures

This investigation was conducted during September 2010, and all the rowers were in a strength-power maintenance phase (consisting of 3 sessions per week) in preparation for the World Rowing Championships that were held in New Zealand during November 2010. The subjects were in near peak physical condition. Any external strength and conditioning training was performed after each testing session in this investigation to limit the effects of potential fatigue on rowing performance. No external strength and conditioning training was performed 24 hours before either testing session. In addition, no alcohol or caffeine was allowed to be consumed 24 hours before either testing session. The subjects were encouraged to remain hydrated and nutritionally prepared for each session. Each testing day was separated by at least 7 days to minimize the effects of fatigue. To control for diurnal variation, the subjects were tested at the same time of the day on each occasion.

A familiarization session was conducted on a separate day to educate the subjects on how to perform the isometric conditioning contractions on the rowing ergometer; the subjects were then required to practice this several times until they felt comfortable with the protocol. Afterward, they were then randomly allocated to either the NW or PW for their first testing session. The rowing shed consisted of 10 Concept II Model E rowing ergometers, meaning that all the subjects had their own rowing ergometer to use for this investigation and were tested all at once. A 25-minute window was given to all the subjects to complete their warm-up before the start of either the isometric conditioning contractions (PW) or the 1,000-m RETT (NW). Heavyweight men and women were assigned to drag factor settings of 115 and 105, respectively. The drag factor number represents the rate of deceleration of the rowing ergometer flywheel and changes with the amount of air passing through the flywheel (higher damper setting means that more air will pass through the flywheel and therefore the drag factor number will be higher). The drag factor number accounts for weight and gender differences, which helps to simulate the feel of on-water rowing as much as possible.

The subjects were allowed to conduct their own warm-up because it was felt by the investigators that it would be counterproductive to design a generic rowing warm-up that did not meet an individualized approach. The typical warm-up performed by the subjects consisted of light to moderate intensity rowing, followed by static or dynamic stretches, with minor differences between subjects. The subjects were encouraged to replicate their race-day warm-up as much as possible, with any on-water rowing to be substituted with ergometer rowing. During the warm-up, the subjects were required to adjust the amount of resistance the ergometer provided by moving the resistance lever up or down on the ergometer flywheel (i.e., damper setting); this would alter the drag factor number reported on the rowing ergometer screen, and therefore could match it to the number they were given on the day of familiarization. After performing the warm-up for the first time, the subjects were required to write it down to ensure its reproducibility in the second testing session. Meanwhile, a researcher recorded room temperature, barometric pressure, and relative humidity. Room temperature was recorded at 19.8 ± 3.6° C and 20.0 ± 4.0° C during the first and second testing sessions respectively. Barometric pressure was consistently recorded at 27.93 in Hg during both days. Relative humidity was recorded at 64.4 ± 5.2% for the first testing session, with no data for the second testing session.

Potentiated Warm-Up Condition

Before the warm-up, the subjects were seated on the rowing ergometer and setup in the specific body position required for the isometric conditioning contractions (~110° knee flexion, relatively upright trunk posture, and elbows slightly flexed) (Figure 2). An adjustable nylon strap was looped from the metal ring of the ergometer handle, along the outside of the rowing ergometer and back again, and was fixed down by electrical tape to the sides of the ergometer. The nylon strap allowed the conditioning contractions to be performed isometrically, with the length adjustable to allow each subject to adopt the specific body position for the isometric conditioning contractions. When each subject was set up

Figure 2. Body position for the isometric conditioning contractions. Knees are to be flexed at approximately 110° with trunk as upright as possible and elbows slightly flexed.

correctly, the strap was untied from the ergometer handle at its set length and was moved out of the subject's way, to allow the subject to perform their warm-up.

After completing the warm-up, the subjects passively rested on the rowing ergometer for 1 minute. Meanwhile, a researcher was responsible for hooking the nylon strap to the ergometer handle to allow the isometric conditioning contractions to occur. Another researcher began to play a prerecorded soundtrack of the timings for the isometric conditioning contractions and was made audible via a speaker system set up in the rowing sheds. The isometric potentiation protocol consisted of 5 sets of 5-second isometric conditioning contractions, with 15-second recovery between each set. The first 2 seconds of the isometric conditioning contraction were performed at submaximal intensity (where force was gradually increased), with the final 3 seconds performed at maximal intensity. A submaximal intensity was prescribed to prevent injuries through any "jerky movements." The subjects did not receive any form of encouragement during the isometric conditioning contractions and were permitted to perform the isometric conditioning contractions either in shoes or bare foot, as long as this was consistent across each session. The subjects were required to remain seated on the rowing ergometer during the isometric contractions and recovery periods.

Because the isometric potentiation protocol in this investigation is new, it is important to justify it. The objective of the isometric conditioning contractions is to accumulate PAP while minimizing fatigue, resembling a "staircase effect" of PAP that gradually builds after each set (1). Therefore, the prescription of high-intensity/low-duration isometric conditioning contractions is believed to allow this "staircase effect" to occur for PAP, while minimizing the negative effects of fatigue. Because endurance-trained athletes generate lower levels of PAP than power-trained athletes (18,20), they need to capitalize on any of the PAP that is developed. A maximal intensity was performed to stimulate as many type II muscle fibers as possible, ultimately conferring to a greater PAP response (9). Previous research supports the use of isometric conditioning contractions at maximal intensity for eliciting PAP (7–9); with endurance-trained athletes (triathletes, marathon runners) experiencing greater levels of PAP than sedentary subjects (8), with the associated effects of enhanced twitch peak torque, twitch maximal rate of force development, and relaxation lasting 5–10 minutes for endurance-trained women (20). An isometric conditioning contraction was also selected as it has been found to be less metabolically fatiguing than an isotonic concentric contraction (6), which may be advantageous for rowing performance because it is of longer duration than explosive type activities such as jumping and sprinting. Finally, of practical benefit is that the isometric conditioning contractions can be performed in the boat before a race.

The soundtrack of the isometric potentiation protocol was easy to follow; the subjects were given a 5-second countdown before the first isometric conditioning contraction, followed by "go, 1, 2, 3, 4, stop" (fifth second). The subjects started the isometric conditioning contraction on "go" and aimed to be at peak muscle activation at "two" and then completely relaxed on "stop." After a 10-second silent period of passive recovery, the subjects were given a further 5-second countdown before the commencement of the next isometric conditioning contraction. This process was repeated on the soundtrack until a total of 5 isometric conditioning contractions were completed. A 4-minute passive recovery was then adopted, where the subject remained seated on the rowing ergometer. The 4-minute passive recovery was also used for the NW after the completion of the warm-up. It is believed that a 4-minute recovery allows sufficient recovery of the central nervous system (4) and has been effectively used in previous research (12,15,26). Therefore, force production should not be hindered for the 1,000-m RETT. The nylon strap was unhooked from the ergometer handle by a researcher, to allow the 1,000-m RETT to begin.

Thousand-Meter Rowing Ergometer Time Trial

The subjects were required to set the rowing ergometer screen to countdown from 1,000 m before the 1,000-m RETT. A researcher placed masking tape over the rowing ergometer screen to cover up all dependent variables except distance. The subjects were verbally encouraged before, and during the 1,000-m RETT to provide maximal effort and achieve their personal best time. The subjects could use any pacing strategy they liked during the 1,000-m RETT, because this would occur in a race situation. Immediately after the 1,000-m RETT, the subjects were required to rate from "6 to 20" their RPE (5). The subjects were able to provide their RPE score based off a visual scale with qualitative statements at specific numbers (5); for example, a score of "6" represents "no exertion at all," and a score of "20" represents "maximal exertion." A homogenized cold blood sample was taken from the earlobe to measure blood lactate concentration (Lactate Pro, Arkray Inc. Shiga, Japan) immediately after and 4 minutes after the 1,000-m RETT by qualified physiologists from the Australian Institute of Sport. A researcher was responsible for accessing the data stored by the rowing ergometer from the 1,000-m RETT, whereby mean stroke rate, mean power output, and split time for every 100 m were manually recorded onto a data sheet by a researcher.

Statistical Analyses

Dependent variables from the 1,000-m RETT such as mean power output, mean stroke rate, and split time for every 100 m were entered into SPSS (version 17) and categorized by warm-up condition. Mean power output from 0 to 500 m was calculated by adding the mean power output from the first 5 splits and dividing it by 5. Mean power output from 0 to 1,000 m, mean stroke rate from 0 to 500 m, and mean stroke rate from 0 to 1,000 m were calculated in a similar manner. Time to complete 500 m was calculated by adding split times for the first 5 splits. Time to complete 1,000 m was calculated by adding split times for the 10 splits. These additional variables were entered into SPSS along with RPE and blood lactate data (immediately after and 4 minutes after).

All variables met normality assumptions using a Shapiro–Wilk test ($p > 0.05$). A paired samples t-test was conducted to assess differences of all dependent variables between both warm-up conditions, with significance set at $p \leq 0.05$. Pearson correlations (2-tailed) were performed to assess the strength of the relationships between mean power output from 0 to 500 m and 0 to 1,000 m, mean stroke rate from 0- to 500-m and 0- to 1,000-m, 500- and 1,000-m rowing ergometer time for both warm-ups, with significance set at $p \leq 0.05$. The strength of the Pearson correlations was categorized as follows: trivial ($r = 0.0–0.1$), small ($r = 0.1–0.3$), moderate ($r = 0.3–0.5$), large ($r = 0.5–0.7$), very large ($r = 0.7–0.9$), and nearly perfect ($r = 0.9–1.0$) (10). Effect size statistics were calculated using Cohen's d to determine meaningful effects and were categorized as follows: trivial (0.0–0.19), small (0.2–0.59), moderate (0.6–1.1), large (1.2–1.9), and very large (2.0–4.0) (10).

To assess the effectiveness of the PW, the absolute difference in time to complete 1,000 m between warm-ups for each subject was calculated and converted to a difference represented in meters (based off average speed during the 1,000-m RETT). Test-retest reliability data for any of the dependent variables measured in the 1,000-m RETT was not examined; however, the test-retest reliability correlation for power output during a 2,000-m RETT has been reported to be nearly perfect ($r = 0.96$) (23). The *SD*s will be used in this investigation to indicate the spread of data around the mean.

Results

The primary finding of this investigation was that the PW resulted in a faster 1,000-m rowing ergometer time (Table 1), supporting the hypothesis that this warm-up was more effective than the NW. Although the difference in 1,000-m rowing ergometer time between both warm-ups was statistically insignificant, a small effect size was noticeable ($d = 0.21$). Interestingly, 500-m split time significantly differed between warm-ups ($d = 0.62$, $p = 0.009$); with the PW being 1.9% faster than the NW.

Figure 3 shows the breakdown of time taken to complete each split for both warm-ups. The PW was significantly faster over the first 4 splits than the NW. Although the PW was faster over the first 7 splits, the NW was faster over the final 3 splits. The PW and NW recorded the slowest split time of the 1,000-m RETT at split 7 and 6, respectively; with the last 3–4 splits performed at faster speeds.

Figures 4 and 5 highlight the strong negative relationship between mean power output over the 1,000-m RETT and 1,000-m rowing ergometer time for the PW ($r^2 = 0.984$) and NW ($r^2 = 0.994$). Mean power output over the 1,000-m

Table 1. Results of the 1,000-m rowing ergometer time trial for the PW and NW.*†

	n	PW mean ± *SD*	NW mean ± *SD*	Mean % difference (PW–NW)	p Value	Effect size (d)
500-m Time (s)	10	84.4 ± 2.9	86.1 ± 3.1	−1.9	0.009‡	0.62
Mean power: 0–500 m (W)	10	590.7 ± 59.6	554.1 ± 55.7	6.6	0.007‡	0.64
Mean SR: 0–500 m (strokes·min^{-1})	10	42.3 ± 4.2	40.2 ± 3.5	5.2	0.003‡	0.54
1,000-m Time (s)	10	171.9 ± 6.0	173.3 ± 6.6	−0.8	0.166	0.21
Mean power: 0–1,000 m (W)	10	558.3 ± 54.6	544.1 ± 55.5	2.6	0.134	0.26
Mean SR: 0–1,000 m (strokes·min^{-1})	10	42.2 ± 3.9	40.4 ± 3.3	4.6	0.001‡	0.51

*SR = stroke rate; PW = potentiated warm-up condition; NW = the normal warm-up condition.
†Dependent variables expressed as mean (±*SD*), with the mean difference between PW and NW as a percentage, p value (paired t-test), and effect size (Cohen's d) used to highlight differences between the PW and NW.
‡Denotes significance at $p \leq 0.01$.

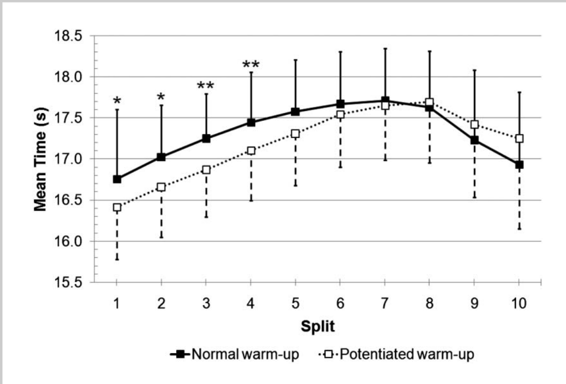

Figure 3. Mean time (±*SD*) for each 100-m split during the 1,000-m rowing ergometer time trial, comparing the potentiated and normal warm-up conditions. *Denotes significance at $p \leq 0.05$. **Denotes significance at $p \leq 0.01$.

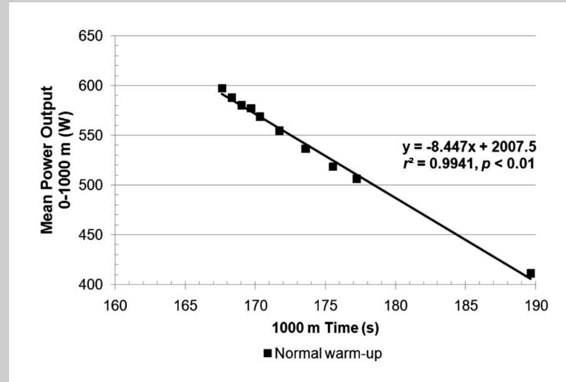

Figure 5. Scatter graph highlighting the strong negative relationship between mean power output throughout the 1,000-m rowing ergomter time trial and time to complete the 1,000-m rowing ergometer time trial, for the normal warm-up condition.

RETT was the only dependent variable that significantly correlated to 1,000-m rowing ergometer time across both warm-ups.

Figure 6 shows the breakdown of mean power output for every split, between both warm-ups. The PW displayed significantly larger mean power outputs over the first 4 splits. The PW resulted in greater mean power outputs over the first 7 splits, with the NW displaying greater mean power outputs in the final 3 splits. The PW and NW showed their lowest power output at split 8 and 7, respectively. Incidentally, the mean power outputs in Figure 6 closely resemble the split times in Figure 3 for both warm-ups.

Although mean stroke rate over the 1,000-m RETT displayed weak coefficients of determination to 1,000-m rowing ergometer time for the PW ($r^2 = 0.001$) and NW ($r^2 = 0.035$), Figure 7 highlights that the PW resulted in faster mean stroke rates per split throughout the 1,000-m RETT; with significant differences in mean stroke rate evident in split 3, 5, 7, and 8. Figure 7 highlights that the subjects adopted a pacing strategy during the 1,000-m RETT, because of the initial (split 1) and final burst (splits 9 and 10) in mean stroke rate across both warm-ups.

To determine the effectiveness of the PW to the NW, Figure 8 shows an individual breakdown of the distance the PW gained or lost by over the 1,000-m RETT in comparison to the NW for each subject. Eight of the 10 subjects gained with the PW; with the largest being 41.2 m for subject 10. The mean result was in favor with the PW with an 8.2-m gain over the NW. Incidentally, this distance gained is equivalent to one single scull boat length; meaning that the PW would beat the NW by an average

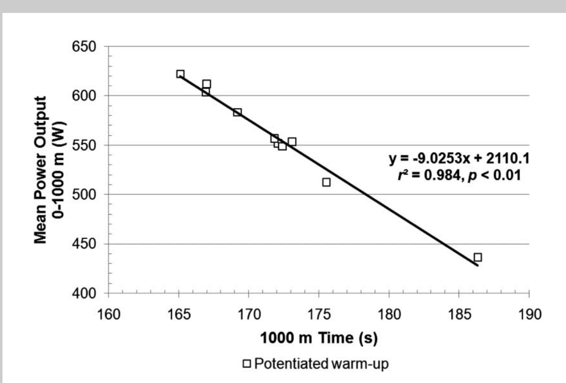

Figure 4. Scatter graph highlighting the strong negative relationship between mean power output throughout the 1,000-m rowing ergomter time trial and time to complete the 1,000-m rowing ergometer time trial, for the potentiated warm-up condition.

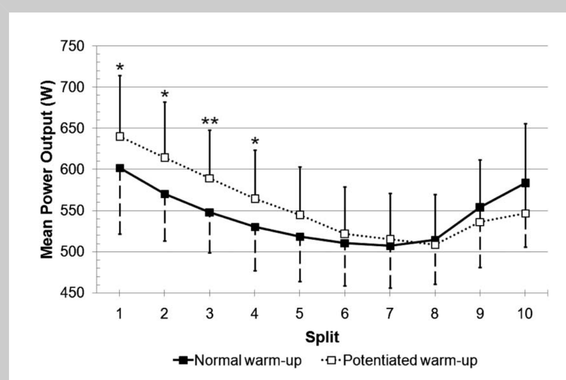

Figure 6. Mean power output (±*SD*) for each 100-m split during the 1,000-m rowing ergometer time trial, comparing the potentiated and normal warm-up conditions. *Denotes significance at $p \leq 0.05$. **Denotes significance at $p \leq 0.01$.

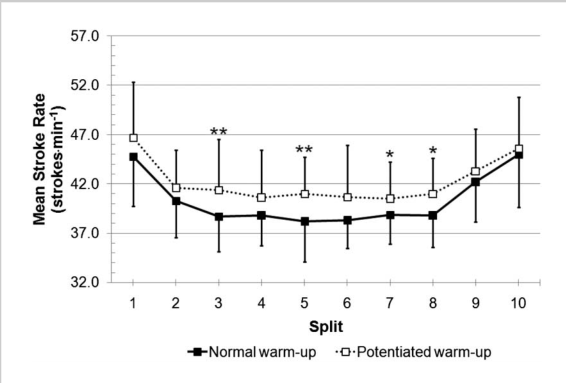

Figure 7. Mean stroke rate (±*SD*) for each 100-m split during the 1,000-m rowing ergometer time trial, comparing the potentiated and normal warm-up conditions. *Denotes significance at $p \leq 0.05$. **Denotes significance at $p \leq 0.01$.

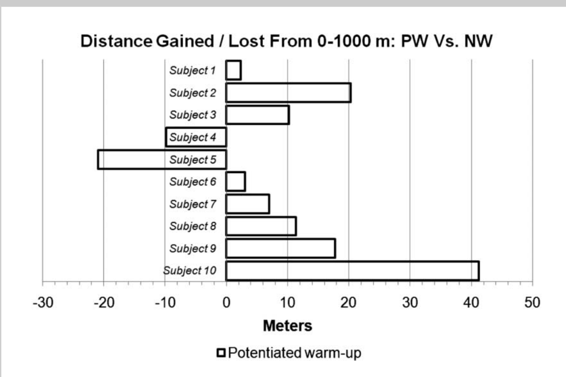

Figure 8. Distance gained or lost from the 1,000-m rowing ergometer time trial as a result of undertaking the potentiated warm-up condition; this is a comparison to the normal warm-up condition for each subject. A positive distance indicates that the potentiated warm-up condition would beat the normal warm-up condition in a 1,000-m rowing race. A negative distance indicates that the potentiated warm-up condition would lose to the normal warm-up condition in a 1,000-m rowing race.

of one single scull boat length in a race situation. This result also supports the hypothesis that the PW is more effective than the NW.

No significant differences were found between blood lactate concentrations of both warm-ups when measured immediately after and 4 minutes after the 1,000-m RETT. Similarly, no significant difference was found between RPE between both warm-ups. However, the PW resulted in a 14.3% higher blood lactate reading immediately after the 1,000-m RETT compared with the NW ($d = 0.34$, $p = 0.306$). The PW also displayed a 2.8% increase in RPE compared with the NW ($d = 0.31$, $p = 0.244$).

Discussion

The main finding of this investigation was that the inclusion of a series of isometric conditioning contractions to the rowing warm-up (PW) reduces 1,000-m rowing ergometer time by 0.8% or 1.4 seconds, compared with a rowing warm-up alone (NW), supporting the hypothesis. Furthermore, this difference in 1,000-m rowing ergometer time could be explained by the significant difference observed in 500-m rowing ergometer time between both warm-ups (1.9% reduction in favor of the PW). From a practical perspective, the PW beat the NW by a single scull boat length (8.2 m) over the 1,000-m RETT.

The significant difference in 500-m rowing ergometer time between both warm-ups was primarily because of the significantly larger mean power outputs developed in the first four splits from the PW. Nevill et al. (19) found that peak power during a 2,000-m RETT nearly perfectly correlated with mean rowing ergometer speed during the 2,000-m RETT ($r = 0.94$). This study indirectly supports the work of Nevill et al. (19) as mean power output over the 1,000-m RETT nearly perfectly correlated with 1,000-m rowing ergometer time for the PW ($r = -0.992$, $p < 0.01$) and NW ($r = -0.997$, $p < 0.01$). The near perfect correlation between mean power output and 1,000-m rowing ergometer time highlights the importance of developing strength and power in strength and conditioning programs, and also the importance of warming up the body before a rowing race to acutely enhance power output. The importance of strength was also highlighted by Secher (24), who found that isometric rowing strength (similar body position to the one adopted in this investigation) distinguished between rowers of international and club level, because international level rowers generated 411 N·seconds more in the isometric rowing strength test than club level rowers. As the initial spurt of the rowing race requires larger power outputs per stroke (800–1,200 W) than any other phase of the race (25), the isometric conditioning contractions employed to the rowing warm-up in this investigation may allow for greater power outputs at the start of a race to accelerate the boat quicker. This may have implications on race tactics, as the rower may be able to get into the lead earlier in the race, permitting the observation of opposition, where adjustments to stroke rate and power output could be made if necessary.

The purpose behind the isometric conditioning contractions in the rowing warm-up was to elicit PAP, which has been shown previously to enhance countermovement jumping performance (7,21) and sprinting performance (12,15). Although PAP was not measured directly in this investigation, its effects were assumed with the observable differences in mean power output for the PW compared with the NW. However, little research has investigated the effects of PAP on events of a longer duration. Previous research has found that adding 5 sets of 10-second sprints to a continuous warm-up on a kayaking ergometer has been shown to increase mean and peak power output over a 2-minute maximal kayaking ergometer test, when compared with a continuous warm-up only (3). Sale (22) postulated that PAP would benefit endurance-trained athletes mainly in periods of low-frequency force, because that is where PAP has its greatest effect, but if the endurance-trained athlete was required to produce high-frequency force during a race, then the effects of high-frequency fatigue would be felt and the effects of PAP would be lost. However, it could still be expected that the rower would benefit from PAP at the start of the race, as Sale (22) suggests that PAP enhances rate of force development at high frequencies of force production.

The enhanced rate of force development that is associated with PAP may have also explained the faster mean stroke rates from the PW throughout the 1,000-m RETT. However, the increased mean stroke rate from the PW may have resulted in fatigue that occurred earlier than desirable. The effects of fatigue are evident in the final 2 splits of the 1,000-m RETT; the NW produced its second largest mean power output overall in split 10, whereas the PW produced its fifth largest mean power output overall in split 10. The combination of larger mean power outputs and faster mean stroke rates witnessed by the PW may have conferred to a greater demand of energy to be supplied anaerobically at the start of the 1,000-m RETT and consequently, led to premature fatigue. This is indicated by the difference in mean power output over the final 2 splits, with the NW producing larger power outputs than the PW. Another indication of fatigue from the PW is the small but insignificant mean increase in blood lactate (14.3%) measured immediately after the 1,000-m RETT. Furthermore, RPE values were insignificantly higher in the PW ($d = 0.31$) after the 1,000-m RETT. A limitation of this investigation is that subjects could not see their stroke rates or power outputs during the 1,000-m RETT, meaning that it was more difficult for them to pace themselves appropriately, as seen by the lower than maximal RPE values obtained. Future research is required to determine the effects of including isometric conditioning contractions to the rowing warm-up on a 2,000-m RETT, which is the typical race length.

Practical Applications

The current findings indicate that including a series of isometric conditioning contractions to the rowing warm-up elicits greater mean power outputs and mean stroke rates, which ultimately results in a faster 1,000-m RETT when compared with a rowing warm-up only. This investigation highlights the need for coaches to determine an individualized PAP protocol for each rower, and an adjustment of pacing strategies to maximize the most out of the isometric conditioning contractions employed in the rowing warm-up. The results from this investigation provide some potential for the inclusion of isometric conditioning contractions in a rowing specific body position, which may be more beneficial for short-term rowing performance of 1,000 m or less, and its use for eliciting greater power outputs during training.

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