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ORIGINAL SCIENTIFIC PAPER

Effects of Post-Activation Performance Enhancement in Kayak Sprint Competition within Same Day

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Abstract

The purpose of this study was to determine the post-activation performance enhancement in kayak sprint competitive simulation 2 times (S1 and S2) within the same day. This study was a crossover design, ten kayak sprint paddles national team performed different activations. All participants will be randomized crossover trials, get three interventions consisting of the Resistance program (2 x 4 x 80%1RM x Bench press and Bench row), Maximum sprint paddle (Ergometer all-out 2 x 10-sec x rest interval 2 min) and Control group (CON; Individual activity condition) followed 3-minute test (3MT). Maximum power, power average, stroke per minute, total distance, percentage of heart rate, and blood lactate concentration were recorded during the simulation competition. The main effect of the analysis showed that maximum power of the Resistance program was higher than the Control group in S1. The average power and total distance of the Resistance program in S2 were lower than in S1. Blood lactate concentration of the Resistance program and Maximum sprint paddle was higher than the Control group after the intervention, before the 3MT period, and remained rise until after 3MT, especially in S2. Also, blood lactate concentration before the intervention of the Resistance program in S2 was higher than in S1. The preconditioning by using the resistance or maximum sprint paddle improves maximum power only the first competition of the day. It seems that the resistance program leads to accumulated blood lactate concentration, and may decrease performance in the second competition of the day.

Keywords: *paddles sport, stimulate muscle, simulation competition, maximum voluntary contraction, Strategies warm-up*

Introduction

Preparing physically for performance in sports that use speed, power, and anaerobic energy is critical. The coordination of the upper body muscles is essential for athletic performance in Kayak sprints (Michael, Rooney, & Smith, 2008). A warm-up strategy is a way to help activate the muscles to be ready for a competitive day. Post-activation performance enhancement (PAPE) methods are preconditioning widely used (Prieske, Behrens, Chaabene, Granacher, & Maffiuletti, 2020). The physiological mechanism, the post-activation performance enhancement, had increased muscle temperature, dynamic fluid within the muscle fibre, and motivation from muscle activation (Blazevich & Babault, 2019; Boullosa, 2021). The intervention method had a maximum voluntary contraction (MVC) performance enhancement and effected a rise in the rate of force development (RFD) after activation for several minutes (7-15 min) (Blazevich & Babault, 2019; Prieske et al., 2020).

According to theories, short-term high-intensity exertion should follow a low-intensity warm-up (Blazevich & Babault, 2019; Boullosa, 2021). Even after an intermittent high-intensity warm-up, blood lactate concentration levels remain high in the body (Khamros, Peepathum, Senakham, Sriramatr, &

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Phongsri, 2023). Dynamic movements with maximum effort activate motor units (Tillin & Bishop, 2009), causing the neural drive to increase the rate of force development. Besides, dynamic resistance can improve movement ability for a short time (Young, Haff, Newton, Gabbett, & Sheppard, 2015) when slow rhythm movement stimulates and increases acceleration better than fast movement. However, the muscles should not be stimulated with heavy load resistance, which may lead to accumulated fatigue. The resistance load should be used with a sub-maximum load (Chen et al., 2023; Farup & Sørensen, 2010). The resistance method methodology should be applied to the specific muscle group of each type.

Pull and press exercises movement for the upper body muscle group are used for stimulation in sports where the upper musculature is primarily used, consistent with kayak sprint (Romagnoli et al., 2022). Stimulation of muscle upper body parts will effectively enhance kayaking performance (Khamros et al., 2023; McKean & Burkett, 2014). It is still being determined whether a preconditioning method can improve performance in athletes competing more than twice daily. Since competition occurs more than once daily, the recovery time is relatively short; such competition may impair the athlete's performance, although the recovery strategy has been reinforced. Athletes must have a proper strategy for competition preparation, such as implementing a pre-competition warm-up or incorporating a re-warm-up. It is recommended that specific guidelines regarding training methods for athletes be followed. The technique involves using the intensity load for a short duration of two minutes by method is adopting a Short Active Warm Up pattern, gradually increasing the intensity from moderate to near-maximal levels (Silva, Neiva, Marques, Izquierdo, & Marinho, 2018) or the resistance activities to activate the muscles have also been beneficial for athletes (Farup & Sørensen, 2010; Khamros et al., 2023; Young et al., 2015). However, it is important to be mindful of the consequences if too much stimulation affects anaerobic energy systems and muscle contraction, especially in kayak paddling, by Bishop, Bonetti, and Spencer (2003) have emphasised the need to balance muscle activation and over-stimulation when using these methods. The strategies for warm-up were essential for preparing before a competition again (Swinton, Symon, Maughan, Burgess, & Dolan, 2022).

When athletes compete many times in one day, there may be an accumulation of fatigue that affects and impairs physical performance. In addition to the recovery strategies used in many previous studies, implementing a strategic activation to prepare for the next competition is no less critical. There is little current evidence in the literature to suggest the effects of post-activation performance enhancement used more than once in competitions. Studies tend to focus only on the immediate impacts of various methods. For instance, a study conducted by Soh, Aziz, and Lee (2020) on a specific acute phase stimulation method for kayaks indicated no positive effects on athletes. However, in contrast, a study by Khamros et al. (2023) that used a PAPE theoretical load stimulation method yielded positive results on athlete performance. However, neither study specified post-activation performance when applied twice within the same day.

Applying the principles of sports science using the PAPE model to help stimulate increased performance in two competitions on the same day. This study aimed to determine whether post-activation performance enhancement, the methodology for preconditioning before the competition kayak sprints twice daily, can enhance performance. The outcome of this study may help explain the application of PAPE to increase the performance levels of athletes in competition.

Method

Participant

The participants were ten male kayakers who had attended international kayak sprint competitions for more than three years (Age 26.20±3.70 years, Height 178±4.48 cm, Weight 73.10±5.51 kg) and had no injuries to joints or muscles within one year, as shown in Table 1. The participants will be randomized crossover trials, all get experimental treatments in three interventions by a Latin square design experimental plan and have 48 hours to washout. The study included three interventions groups: a resistance programme (RSP), a maximum sprint paddle (MSP), and a control group (self-activation). The resistance programme used heavy load (2 x 4 x 80%1RM) in the bench press following the bench row exercise. The maximum sprint paddle involves kayakers paddling maximum effort on the ergometer (2x10 second rest intervals for 2 minutes). The control group usually warmed up by themselves. It continued to the 3-minute test to assess the intervention difference per performance of the simulated kayak sprint competitive two times within one day (The first simulated: S1 and the second simulated: S2). Before attending the experiment, the participant did not take dietary supplements for seven days, avoided drinks containing caffeine and alcohol, and performed physical activities at a moderate or vigorous level for at least 48 hours.

Ethics

Following the Declaration of Helsinki, this study was approved for ethics in human committee research by The Strategic Wisdom and Research Institute, Srinakharinwirot University, number SWUEC-G210/2565E. Each participant voluntarily provided written informed consent before participating.

Experiment in laboratory

The experiment occurred in the Sports Science Laboratory from 6 to 9 a.m. every morning. Participants partook in five sessions, with a control temperature range of 22-25 °C.

The first session was a body composition assessment, in-

Table 1. Descriptive physical characteristics of participant

Physical Characteristics	Mean±SD
Age (years)	26.20±3.70
Weight (kg)	73.10±5.51
Height (cm)	178±4.48
VO2Max (ml/kg/min)	53.45±6.10
1 RM (Bench Press)	111.46±11.09
(kg) (Bench Row)	109.33±8.10

cluding weight, height, and resting heart rate. The next test followed them. The one repetition maximum test (1RM) was used following Haff and Triplett's (2016) protocol for bench press and bench row exercises. In the second session, the participants went to the laboratory for the maximal oxygen consumption test (VO2max test). The VO2max test used an increment step test applied to the protocol from Santos (2012) by using a portable gas analyser (PNOE, ENDO Medical, Palo Alto, CA, USA). The participants wore a portable gas analyser on a kayak ergometer (Kayak Ergometer, WEBA Sport und med. Artikel GmbH, Liesneckgasse, Wien, Austria) starting at 100 watts and increasing to 30 watts every 2 minutes until the end of the test. At the end of the test, researchers determined criteria 2 from 4 specifications, such as the VO2 plateau <150 ml/min, the respiratory exchange ratio (RER) is not less than 1.15, and maximum heart rate and exhaustion cannot continue testing. The sample was to become familiar with the protocol (Intervention programme and equipment for testing) by trying all the processes. After both experiments in the laboratory, the subject rested 48 hours before the next test.

In the third to fifth sessions in the laboratory, the sample was randomised to one of the intervention programmes in each experiment to simulate a kayak sprint two times within one day. The sample measured blood lactate concentration before warm-up (BFW) in capillary samples from the earlobe and then started a general warm-up at 50–60% MHR combined with dynamic and static stretching for 10 minutes. After the general warm-up, the sample rested for 5 minutes following the preconditioning. Blood lactate was immediately measured after an intervention (AIV), then rested for 7–10 minutes to fully stimulate the physiological mechanisms. Then, the blood lactate concentration was checked before assessing the 3-minute paddling test (BF3). The 3-minute paddling test assessed physical performance after the physiological mechanism of intervention. After the 3-minute paddling test, the sample was tested for blood lactate concentration after resting for 6 minutes (AF3). After the first simulation, the sample will have 2 hours of rest and continue to the second simulation using the same protocol as the first simulation. All protocol processes were completed, and the sample had a 72-hour rest period and got to the crossover trial of another intervention.

Intervention

The resistance programme (RSP) uses bench press and bench row exercises to determine repetition and load for intervention at 2 sets x 4 repetitions at 80% of 1RM and 2-minute rest interval between exercises by using an alternating exercise protocol suggested by Khamros et al. (2023) adapt from Boullosa (2021). The maximum sprint paddle (MSP) was the maximum paddling effort on the kayak ergometer 2 set x 10 seconds and rest interval 2 minutes (Harat et al., 2020). Finally, the control group will exercise 10 minutes to precondition themselves for this intervention.

The 3-minute paddle test

The maximum effort is paddling on an ergometer for three minutes. This method is designed for critical power testing, and anaerobic work capacity is the main object of the test (Bergstrom et al., 2012). The protocol for the 3-minute test started without setting intensity in the first 1-2 minutes, then the sample paddled at maximum effort within 3 minutes. During the test, the sample was not monitored on the ergometer to avoid strategies of the paddle. The researcher controlled the testing, monitored, and asked for cooperation with the sample. During the test, the maximum power (MxP), average power (AvP), stroke per minute (SPM), total distance (TD) and Percentage decrement of maximum power and average power were recorded by using Weba Science software. The heart rate (PHR) percentage was recorded and controlled throughout the paddle (Polar H10, Kempele, Finland). Blood lactate concentration ([La-]b) (Lactate Plus Meter, Nova Biomedical, MA, USA) was measured in capillary samples obtained from the earlobe.

Statistical Analysis

The statistical analysis is represented as mean ± SD by using SPSS version 26 (IBM, Chicago, Illinois, United States of America) Normality of distribution data used for the Shapiro-Wilk test. Maximum power, average power, stroke per minute, and total distance and percentage of heart rate variables used One-way MANOVA. Blood lactate was measured using two-way repeated-measures MANOVA analysis each period to compare the interaction between intervention x periods. The Bonferroni test determined which measures differed significantly. All determined level of significance was set at $p \leq 0.05$. Further, the percentage of power decrement was compared between the first simulation (S1) and the second simulation (S2) for a comping percentage of power decreased (maximum power and average power) by the formula [(S1-S2) / S1) x 100].

Results

The main result of two-way repeated-measures MANOVA was that the interaction (Time x Trial) was p=0.013, the affected trial had a significant p=0.047, and time had a considerable p=0.002, respectively. The RSP and MSP had maximum pow-

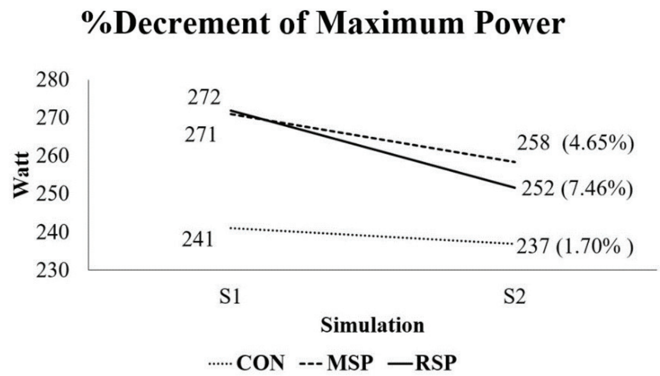

FIGURE 1 Percentage decrement of Maximum Power, Con - Control group, MSP - Maximum sprint paddle RSP - Resistance program

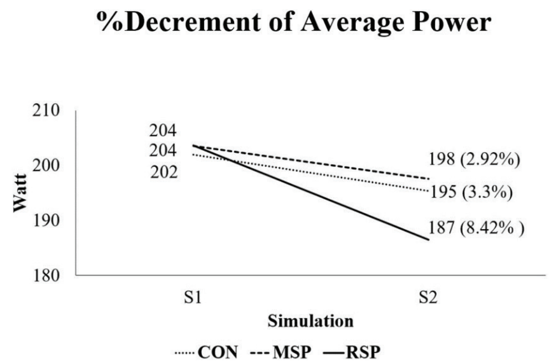

FIGURE 2 Percentage decrement of Average Power, Con - Control group, MSP - Maximum sprint paddle RSP - Resistance program

er higher than CON in S1 p=0.017 (RSP: 272.00±26.84, MSP: 271.00±27.26, and CON: 241.00±16.02), shown in Table 2. The average power in MSP and RSP found that S2 less than S1 all had significant p≤0.05, same as total distance that S2 lower than S1 all had significant p≤0.05 for all data as shown in Tables 2. The percentage of power decrement in RSP was higher than MSP and CON (7.46% for MxP and AvP 8.42%). Conversely, MSP can maintain the average power of paddles in S2, like S1 (AvP=2.92%) all shown in figures 1 and 2.

The percentage of heart rate was not significant for all periods. The blood lactate analysis in S1 revealed a substantial difference in AIV. RSP and MSP showed a considerable difference compared to CON (RSP vs CON p=0.024 and MSP vs CON p=0.001). Additionally, AF3 period in

Table 2 The analysis compared the variable between intervention in each simulation competitive (A) and compared between simulation within group (B)

Intervention			MxP	AvP	SPM	TD	PHR	MANOVA (p)		
			Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD			
A	Simulation 1	CON	241.00± 16.02	202.00± 13.71	101.78± 4.55	633.33± 20.02	89.33± 2.60	.016*	0.002*	0.013*
		MSP	271.00± 27.26	203.56± 13.01	105.00± 3.28	642.20± 12.04	92.00± 2.12			
		RSP	272.00± 26.84	203.67± 13.09	102.00± 2.36	635.22± 10.44	89.89± 2.85			
		p	.017*	.957	.131	.371	.083			
	Simulation 2	CON	236.88± 32.84	195.33± 15.00	104.55± 3.67	626.66± 15.81	90.44± 2.78	0.517		
		MSP	258.40± 32.21	197.60± 29.75	104.90± 3.17	635.00± 30.64	92.50± 3.37			
		RSP	251.70± 21.43	186.50± 14.81	103.50± 3.92	623.00± 21.10	91.30± 3.52			
		p	0.280	0.480	0.669	0.517	0.398			
B	CON	S1	241.00± 16.02	202.00± 13.71	101.78± 4.54	633.33± 20.02	89.33± 2.60	0.388	0.047*	
		S2	236.88± 32.84	195.33± 15.00	104.55± 3.67	626.66± 15.81	90.44± 2.78			
		p	0.753	0.202	0.110	0.262	0.070			
	MSP	S1	271.00± 27.26	203.56± 13.01	105.00± 3.28	642.22± 12.04	92.00± 2.12	0.626		
		S2	258.40± 32.21	197.6± 29.75	104.90± 3.17	635.00± 30.64	92.50± 3.37			
		p	0.069	0.041*	0.803	0.044*	1.00			
	RSP	S1	272.00± 26.84	203.67± 13.09	102.00± 2.36	635.22± 10.44	89.89± 2.85	0.114		
		S2	251.70± 21.43	186.50± 14.81	103.05± 3.92	623.00± 21.10	91.30± 3.52			
		p	0.036*	0.001*	0.754	0.012*	0.073			

Note MxP - Maximum power, AvP - Power average, SPM: Stroke per minute, TD - Total distance, PHR - percentage of heart rate; * p≤0.05

MSP, and RSP were significantly higher than CON with p≤0.05. In BF3, MSP had a different significance from RSP and CON (p=0.015), and RSP higher than CON had a significant p=0.013. Blood lactate in S2 and MSP difference CON in AIV and BF3 was significant (p=0.021 and p=0.006, respectively). In the AF3 period, MSP and RSP differed significantly (MSP vs CON p=0.026 and RSP vs CON p=0.001). Compared within the group, RSP in S2 higher than S1 had significant p=0.009 (RSP: S1=1.13±0.18 and S2=1.45±0.29).

Discussion

From this study, the resistance method tended to reduce performance in the second simulation but not decrease physical performance in other preconditions. By the results that occur after the first simulation, The Maximum voluntary contraction (MVC) after preconditioning using the resistance or maximum paddling effort plays a vital role in improving peak power performance for kayak sprint athletes (Borba et al., 2017; Brink et al., 2021; Chen et al., 2023; Krzysztofik et al., 2021). The maximum effort in a short time for activation produces a level of neural drive, which occurs after the mobilization of the muscle motor units during short, high-velocity contractions. The mechanism is the release of rate-coding potential, where rate-coding plays a significant role in muscle power and speed, leading to muscle contraction that results in maximum voluntary contraction (MVC) (Heckman & Enoka, 2012). As the motor unit recruitment increases, the rate coding becomes more efficient. It affects the activation of more muscle fibres, thus making the contraction of the muscles with maximum force more effective (Heckman & Enoka, 2012). The working process is constantly changing during movement. Over a while, the coding rate of neuronal discharge continues to decrease (Enoka & Duchateau, 2017). This results in an increase in the rate of force development (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2002; Tillin & Bishop, 2009).

Resistance exercises to activate muscles will cause muscle stiffness after exertion against external resistance (Dankel & Razzano, 2020). Downregulation of rate coding results from motor neuron and muscle remodeling (Taylor, Amann, Duchateau, Meeusen, & Rice, 2016). This causes the effect of activation that has previously mobilized the motor units to work. There is a decrease in performance. The mechanism will cause an increase in force. An increase in the intramuscular fluid has been associated with increased muscle stiffness and changes in muscle temperature caused by fluid circulation within the muscle. Although the initial stimulation produced positive results for the athletes performance the effects of resistance activation cause muscles to remain under tension (TUT) and continue into a state of ischemia, leading to more fatigue compared to other preconditions (Scott, 2006). the average power performance decreased, and the fatigue was cumulative from the first simulation, causing a change in kinematics and decreasing velocity during the second simulation's race.

Preconditions affected physical performance, so in the second simulation, the resistance method decreased the percentage of maximum power and the average percentage of paddling power to more than the maximum paddling exertion or self-warmup. Additional research has indicated that the disparities in performance observed between the initial and subsequent simulations of the resistance condition could be influenced by various other factors such as body balance, alertness, rest intervals, duration of warm-up sessions, and environmental conditions during the day's competition (Behrens et al., 2023; Jeffrey, Kristin, Nick, Harrison, & Tim, 2020). These factors affected the physical ability to perform high-intensity activities. However, the duration of the competition may not affect the competitive performance of athletes who are well-trained and continuously training (Kusumoto, Ta, Brown, & Mulcahey, 2021).

After preconditioning blood lactate increase, it is caused by high levels of energy expenditure from the resistance condition increasing lactate content (Lawson, Vann, Schoenfeld, & Haun, 2022; Lintmeijer, Hofmijster, Schulte Fischedick, Zijlstra, & Van Soest, 2018) and the maximum padding condition (Sang-Yong, Duk-Mook, & Jin-Seok, 2018) muscles remain in time under tension (TUT) and used anaerobic energy for metabolism. It causes a sudden spike in blood lactate (Gentil, Oliveira, & Bottaro, 2006; Lopes et al., 2018; Scott, 2006). Blood lactate remains in the muscles before subsequent breakdown (Sang-Yong et al., 2018). During rest between competitions, the athletes will have active and passive rest parallel to recover and prepare for their next competition.

During the second simulation, the blood lactate concentration was higher than the first, especially when using the resistance condition method. This high blood lactate concentration can lead to fatigue after a high-intensity competition, combined with accumulated resistance load and decreased muscle function for several hours. Therefore, blood lactate concentration can serve as an indication of the occurrence of this condition (Manojlović & Erčulj, 2019). However, blood lactate determinations of fatigue may not accurately assess the extent of fatigue. A high blood lactate may be related to the highest muscle oxidative capacity during resting competition. The oxidative ability of the energy system can contribute to the better breakdown of blood lactate and has been associated with delayed fatigue during high-intensity exercise. This was evident from the fact that the maximum paddling condition was like blood lactate concentration, but no physical performance was decreased.

Applying PAPE can increase maximum power in the first competition. The resistance model should not be used in subsequent competitions within the same day as it will reduce the athlete's performance. In contrast, paddling at maximum speed seemed more effective in maintaining performance than the resistance method in the second competition of the day. The accumulation of blood lactate from both preconditions could not explain the fatigue and performance degradation caused by the activation load. Coach or trainers should adopt the best methods to enhance their athletes' competitive performance. This study is an initial study of the application of the PAPE method to sports where two events are played within one day, showing that although it has a positive effect on the first event of the day, it may reduce it. Athlete's performance in the second competition of the day. As for applying the methods in this study to other sports, there may not be much consistency. In the next study, studies should be conducted in other sports. There are different competition periods.

Conclusion

This study describes an approach for implementing a preconditioning method for two daily bouts. The introduction of a maximum-speed paddle style of stimulation is likely to improve some aspects of the athlete's performance and is appropriate only for first-time competition. However, when used twice within the same day, stimulating methods may increase their effects on other physiological functions. Coach or trainers should adopt the best methods to enhance their athletes' competitive performance.

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Conflicts of interest.

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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