

# THE EFFECTS OF DIFFERENT WARM-UP PROTOCOLS ON BENCH PRESS 1RM PERFORMANCE IN SPRINT KAYAKERS\*

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**Abstract:** In order to investigate the effects of different warm-up conditions on one repetition maximum (1RM) bench press performance, eleven highly trained male sprint kayakers completed 1RM bench press tests after 4 different general warm-up condition with a standardized bench press specific warm-up. The workloads of the warm-up protocols were individually designed according to the results of the incremental maximal kayak ergometer test that applied initially. The duration of the protocols were fixed as 15 min for each participant, but there were differences in the intensity of the warm-up. In data analysis, lactate, heart rate, rating of perceived exertion and bench press 1 RM results were dependent variables and differences in these variables were compared using a linear mixed model analysis. A probability level of 0.05 was established to determine statistical significance. As a conclusion, employing low intensity warm-up with five supramaximal sprints substantially improved 1RM bench press performance compared to other warm-up protocols. The suggested warm-up consisted of 15 minutes of low intensity (40% of  $VO_{2Max}$ ) kayak ergometer paddling with five supramaximal sprints that lasts 10 seconds at the intensity of 200 % of  $VO_{2Max}$ , in the last 5 minutes of the paddling.

**Keywords:** Continuous, intermittent, flatwater kayak, maximal strength

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## INTRODUCTION

Strength is one of the most important predictors of the performance in body-weight supported sports such as rowing and canoe-kayak (Akça and Müniroglu, 2008; Akça, 2014; McKean and Burkett, 2014). Sprint kayak is a sport that includes exceptional demands on the upper body and trunk musculature. Previous research (Bishop, 2000; Akça and Müniroglu, 2008; McKean and Burkett, 2014) suggest that sprint kayak paddlers possess high aerobic and anaerobic capacities and upper-body muscle strength. Upper body musculature and lean body mass of the kayakers who competed in the 2000 Sydney Olympics were found significantly higher compared with the data of the other olympic kayakers who competed from 1976 to 1996 (Ackland et al., 2003; Ridge et al., 2007).

Olympic events in canoe-kayak competitions have changed before 2012 London Olympic Games. According to the latest changes, 200-m was added and 500-m was removed from men's and 1000-m was removed from women's program. These changes in the Olympic Games program of kayaking events may have a potential to affect the training programs and preparations of elite sprint kayak athletes. Resistance training, assessment of strength measures and reprogramming according to the test results are an essential part of a long-term training plan of sprint kayak athletes (Akça and Müniroglu, 2008; McKean and Burkett, 2010). The one repetition maximum (1RM) test is the most common measure to assess the strength level of an athlete and the accuracy of the test is crucial to determine individual training loads precisely (Brown and Weir, 2001). The warm-up procedure (contains type of the exercise, stretching, specific activity) is amongst the factors which affect the precision of the 1RM strength tests (Brown and Weir, 2001; Bishop, 2003a; Bishop, 2003b; Woods et al.,

2007). Bench press is one of the most common exercises to develop upper body strength. Elite kayakers frequently use this exercise in their training programs. Previous studies demonstrated significant relationships between 1RM bench press results and sprint kayak performance (Akça and Müniroglu, 2008; McKean and Burkett, 2010; McKean and Burkett, 2014).

Various studies showed that employing general aerobic warm-up before activity specific warm-up improved strength performance more than specific warm-up alone. Therefore, it is generally recommended that the warm-up before maximum strength testing should contain both general aerobic and specific (task related, mimicking) exercises (Brown and Weir, 2001; Bishop, 2003b; Pescatello, 2014). The main aim of the general warm-up exercises is to increase body temperature, whereas the specific warm-up targets to increase neuromuscular activation (Brown and Weir, 2001; Bishop, 2003b; Gourgoulis et al., 2003; Pescatello, 2014). Recent studies demonstrated the beneficial effects of longer (15 minutes) duration general warm-ups over shorter duration (5-10 minutes) on 1RM strength performance (Stewart et al., 2003; Barroso et al., 2013). Besides, in a study which conducted on state level sprint kayakers, significantly better 500-m kayak ergometer performances were demonstrated after the warm-up that include short (10 seconds) supramaximal (200 % of  $VO_{2Max}$ ) intervals compared with continuous, constant load warm-up (Bishop et al., 2003). One of the aims of the present study is to investigate whether an addition of intermittent high force movements into a warm up improves 1RM strength performance.

To our knowledge, there is no study in the literature comparing the effects of general warm-up on bench press 1RM strength testing. The purpose of this study was to compare and demonstrate the effects of different constant load and intermittent general warm-up protocols on bench press 1RM performance in sprint kayakers.

## **MATERIAL AND METHODS**

### **Experimental Approach to the Problem**

To demonstrate the effectiveness of different warm-up protocols on bench press 1RM performance, subjects were tested in four different conditions. Initially, subjects performed a maximal incremental exercise test on kayak ergometer in order to determine the power for the warm-up protocols.

In a randomized crossover design, bench press 1RM performances were measured in four different times in a four visit to the laboratory. Different general warm-up protocols were used for each visit to the laboratory. After general warm-up, subjects were instructed to rest for three minutes and performed the specific warm-up protocol, which was standardized for all conditions (McKean and Burkett, 2014). Blood lactate level, heart rate (HR) and rating of perceived exertion (RPE) were measured before and immediately after each warm-up session. Subjects were asked to refrain from any food intake for three hours before the measurements and to avoid caffeine, alcohol and strenuous exercise for 48 hours before tests. Subjects were instructed to keep a diary of dietary intake on the day before tests and the same dietary intake was replicated on the following tests. Tests were conducted at least 48 hours apart and approximately at the same time of the day ( $\pm$  1hr) for each subject.

Strength test results would be expected to be greatest during the specific training period and can be reduced because of the altered training focus during the competitive period (García-

Pallarés et al., 2009). The tests were conducted at the end of the maximal strength phase of the yearly training plan.

### **Subjects**

Male sprint kayakers ( $n=11$ , age=  $20.07 \pm 1.89$  years, height=  $178.88 \pm 7.23$  cm, body mass=  $80.13 \pm 7.7$  kg,  $VO_{2Max}$ =  $56.4 \pm 6.6$  mL.kg<sup>-1</sup>) volunteered to participate in this study. All subjects were national medalists and eight of them had international racing experience in European and World Championships. They also had  $33.2 \pm 4.4$  months of strength training experience and performed bench press exercise during their regular training routine at least three times per week. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by clinical research ethics committee. All subjects signed an informed consent form.

### **Procedures**

#### *Maximal Incremental Exercise Test*

To determine the metabolic responses to loading, an incremental kayak ergometer test recommended by Australian Institute of Sport (AIS) was executed (Hahn and Bourdon, 2000). Body mass and body height of the subjects were measured upon arrival to the laboratory and entered into the testing ergometers' digital display. The test was conducted on a Dansprint Kayak Ergometer (Dansprint ApS, Hivodovre, Denmark) and the drag factor was setted to 40 as suggested by AIS (Bullock et al., 2012). The workloads for the submaximal stages were determined based on the recommendations of the testing protocols for kayak athletes. Initial workload was 100 watts and increased 25 watts per stage (Bullock et al., 2012). According to previous research, changes in body position related to height and length settings may change the test results (Heil et al., 1995; Price and Donne, 1997). Therefore, the height and length settings of the ergometer's footstretcher were recorded for each subject during the baseline measurement and the same settings were used for the subsequent tests. Ergometers were calibrated prior to tests to ensure that constant drag resistances were used in evaluations. The paddle shaft length was fixed at 166 cm (Bullock et al., 2012).

The test protocol was discontinuous with progressive four minutes increments, consisting of six submaximal stages and a final (7th) maximal stage. The stages were separated by one minute recovery intervals during which blood samples for lactate analyses were taken. The workloads for the submaximal stages were determined based on the recommendations of the testing protocols for elite kayak athletes (Bullock et al., 2012). The power output during these six submaximal stages were progressively incremented via an increase in the power output at the beginning of each stage. The final (7th) four minutes performed with maximal effort and verbal encouragement given for this stage.

Gas exchange during the test was measured breath by breath with a gas analysis system (Oxycon Mobile, Jaeger GmbH, Germany). Subjects wore a transmitter belt (Polar Electro OY, Finland) during tests, to record the HR via the sensor of gas analyzer. Blood lactate concentrations which were taken from earlobe were measured using an automated lactate analyzer (YSI Sport 1500, Yellow Springs, Ohio, USA). RPE was collected before and after each stage (Borg, 1982). Prior to tests the lactate analyzer was calibrated according to manufacturer's instructions. The gas analyzer system was also calibrated before each test using a calibration tube which contains a mixture of known concentrations of gases, according to the manufacturer's instructions.  $VO_{2Max}$  was determined by averaging the four highest consecutive oxygen consumption values recorded during the last stage of the test. Throughout

the test, visual feedback of total distance covered and power output was available for the subjects to maintain the predetermined output.

The collected data in the ergometer's memory were transferred into an Excel spreadsheet via the manufacturer-provided software. The data about the power output corrected for the known ergometer error (as determined by a calibration factor developed by the South Australian Institute of Sport for Dansprint ergometers) using the following equation:  
Men (Drag factor 40)= Dansprint power output x 1.262075 + 6.908012 (Bullock et al., 2012).

#### *Warm-Up Protocols*

The protocols were performed on the same kayak ergometer that used for the maximal incremental exercise test. Warm-up protocols were employed in a randomized manner in four different visit to the laboratory. The protocols were as follows:

1. Constant Low Intensity (CLI): 15 minutes at the power output that corresponds to 40 % of  $VO_{2Max}$ .
2. Constant Moderate Intensity (CMI): 15 minutes at the power output that corresponds to 65 % of  $VO_{2Max}$ .
3. Intermittent Low Intensity (ILI): 10 minutes at the power output that corresponds to 40 % of  $VO_{2Max}$  and five 10 seconds sprints equal to 200 % of the power output at  $VO_{2Max}$  during the last five minutes, each separated by 50 seconds of recovery at 55 % of  $VO_{2Max}$ .
4. Intermittent Moderate Intensity (IMI): 10 minutes at the power output that corresponds to 65 % of  $VO_{2Max}$  and five 10 seconds sprints equal to 200 % of the power output at  $VO_{2Max}$  during the last five minutes, each separated by 50 seconds of recovery at 55 % of  $VO_{2Max}$ .

Lactate, HR and RPE values were collected before and immediately after the completion of each warm-up protocol.

After the completion of the aforementioned protocols, subjects instructed to rest for three minutes (Barroso et al., 2013). After the rest, subjects performed the same specific bench press warm-up regardless of their general warm-up protocol. The specific bench press warm-up consisted, four sets of decreasing repetitions (4, 3, 2, 1) with increasing load (50 %, 70 %, 90 %, 95 %) with three minutes rest intervals before 1RM bench press was attempted. Several attempts were allowed for 1RM determination with four minutes rest intervals (McKean and Burkett, 2014). Because of the demonstrated negative effects of extensive stretching on strength performance (Rubini et al., 2007; Bacurau et al., 2009; Costa et al., 2014), only short duration, submaximal static stretching exercises were allowed under the supervision of a certified strength coach.

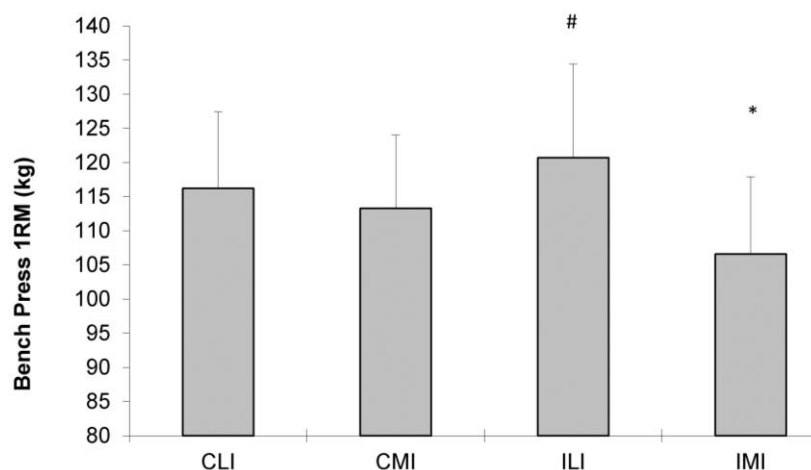
#### *1RM Bench Press Test*

The 1RM for the bench press was measured with an olympic free weight bar and weighted plates. During the test, subjects grasped the bar with thumbs over the bar and hands positioned at bi-acromial width (McKean and Burkett, 2014). The lower back stayed in contact with the bench and subjects were instructed to keep their feet in contact with the floor during the attempts (Abadie and Wentworth, 2000; Akca and Muniroglu, 2008). A repetition was counted if the tempo of the movement controlled correctly during eccentric phase and bar touched the chest before being pressed to full elbow extension (McKean and Burkett, 2014). To eliminate the rebound effect, duration of the eccentric phase of the movement were fixed as approximately four seconds for each subject (McKean and Burkett, 2010). Certified strength coach supervised test to provide correct movement technique and spotting.

## Statistical Analyses

Normality of the distribution was analyzed using Shapiro-Wilk test. Lactate, HR, RPE and bench press 1RM results were dependent variables and differences in these variables were compared using a linear mixed model analysis. Warm-up conditions were set as fixed factor while subjects as a random factor. Tukey post hoc test was employed whenever a significant difference was found. A probability level of 0.05 was established to determine statistical significance. All statistical analyses were conducted using SPSS version 20 (SPSS Inc., Chicago, IL).

## RESULTS



**Figure 1.** Bench Press 1 RM values for each warm-up protocol.

CLI = Constant low intensity; CMI= Constant moderate intensity; ILI = Intermittent low intensity; IMI = Intermittent moderate intensity.

# Significantly different ( $p < 0.05$ ) from other protocols.

\* Significantly different ( $p < 0.05$ ) from CLI, CMI and ILI.

As presented in Figure 1; the averages of bench press 1RM performances were  $116.2 \pm 11.2$  kg for CLI,  $113.3 \pm 10.7$  kg for CMI,  $120.7 \pm 13.1$  kg for ILI and  $106.6 \pm 11.3$  kg for IMI. Bench press 1 RM performance was better after ILI warm-up compared with other protocols ( $p < 0.01$ ). On the contrary, 1RM values were significantly lower when using IMI warm-up protocol than others. ( $p < 0.01$ ). No differences were detected between CMI and CLI warm-up protocols ( $p > 0.05$ ).

Table 1. Values of the measured variables after each warm-up protocol.

Warm-up Protocol	RPE	HR ( $b \cdot \text{min}^{-1}$ )
<b>Lactate (<math>\text{mmol} \cdot \text{L}^{-1}</math>)</b>		
CLI	$11.1 \pm 2.1^{\#}$	$115.8 \pm 10.1^{\#}$
$1.1 \pm 0.2^{\#}$		
CMI	$14.6 \pm 1.5^{\#}$	$150.2 \pm 17.7^{\#}$
$2.8 \pm 0.7^{\#}$		
ILI	$12.2 \pm 2.3^{\#}$	$124.3 \pm 12.2^{\#}$
IMI	$16.5 \pm 2.2^{\#}$	$164.6 \pm 16.5^{\#}$
$3.6 \pm 0.7^{\#}$		

\* HR = heart rate; RPE = Rating of perceived exertion; CLI = Constant low intensity; CMI= Constant moderate intensity; ILI = Intermittent low intensity; IMI = Intermittent moderate intensity.

# Significantly different ( $p < 0.05$ ) from other protocols.

† Significantly different ( $p < 0.05$ ) from CMI and IMI.

As presented in Table 1; differences in HR, RPE and Lactate parameters were statistically significant after IMI protocol compared with any other protocol ( $p < 0.01$ ). Lactate values were found significantly different between each protocol ( $p < 0.01$ ).

## **DISCUSSION AND CONCLUSION**

This is the first study to assess the effects of different warm-up protocols on 1RM bench press performance since no previous study was found in literature regarding this topic. 1RM bench press performance was significantly higher after ILI warm-up protocol and the 1RM performance was significantly lower after IMI warm-up protocol. The results of the present study indicated that HR and RPE measured after IMI were approximately 35 % higher than those after ILI (Table 1). The physiological stress associated with the load of IMI warm-up protocol seems to lead to muscle fatigue that may explain the decrease in 1RM bench press performance (Bishop, 2003b; Barroso et al., 2013).

Excessive depletion of high-energy phosphate concentration has been shown after exercise intensity above 60 % of  $VO_{2Max}$  (Karlsson et al., 1970). This mechanism may partially explain the performance decrements after moderate intensity (65% of  $VO_{2Max}$ ) IMI and CMI protocols in the present study. The ILI warm-up protocol that combines short intermittent sprint with low intensity exercise produced significantly better results than any other protocols. This result is similar with the studies that suggest employing warm-up with an intensity about 40-60 % of  $VO_{2Max}$  to efficiently increase muscle temperature. To maximize short-term performance, intensities about 40-60% of  $VO_{2Max}$  were suggested in order to limit the degradation of high-energy phosphates (Pyke, 1968; Sargeant and Dolan, 1985; Bogdanis et al., 1995; Bogdanis et al., 1998).

Increasing core and muscle temperatures beyond certain point effects physical performance negatively (Bishop, 2003a). Research show that muscle temperature is highly related to exercise intensity (Saltin et al., 1968; Starkie et al., 1999) and higher warm-up intensities cause greater increase in muscle temperature (Karlsson et al., 1970). At workloads greater than 60% of  $VO_{2Max}$ , inverse relationship between warm-up intensity and subsequent short-term performance has been reported (Karlsson et al., 1970; Sargeant and Dolan 1985).

Performance decrement after IMI warm-up may also be related to excessive core and muscle temperatures resulted from the intensity of the protocol; but further research, which includes core and muscle temperature measurements, is needed to precisely determine this phenomenon because of the lack of these measurements in the current study.

Elite athletes have more efficient thermoregulatory system compared with non-elites, therefore the duration of the warm-up must be longer for them to sufficiently increase core and muscle temperatures (Bishop, 2003b). Several studies demonstrated that a significant increase in muscle temperature have occurred only after 15-20 minutes of aerobic activity (Price and Campbell, 1997; Stewart et al., 2003). Duration of the warm-up conditions in the current study was selected according to the recommendations of previous research on the topic and the conditioning level of the subjects (Price and Campbell, 1997; Stewart et al., 2003; Bishop, 2003b).

Intensity of the warm-up is another important factor, which should be organized carefully. According to the results of the current study, when the duration of the general warm-up fixed as 15 minutes, exercise intensity should be low ( $\leq 40\%$  of  $VO_{2Max}$ ) in order to avoid performance decrease. Combining the 15 minutes long warm up with moderate intensity exercise (approximately  $65\%$  of  $VO_{2Max}$ ) may result in performance decrements because of the accumulated effect of the muscle fatigue and metabolic acidemia. Impaired strength, supramaximal and short-term performances after moderate or high intensity warm-up were reported in several studies (Bishop et al., 2001; Bishop, 2003b; Barroso et al., 2013).

In the current study, the ILI warm-up protocol produced significantly better results than any other protocols. Furthermore, for ILI protocol, physiological stress parameters (HR, RPE and Lactate) were the second lowest amongst the four protocols. Although CLI induced lower physiological stress than ILI, it can be speculated that because of the lack of the intermittent high intensity efforts in the CLI protocol, exercise impulse was insufficient to trigger appropriate muscle temperature and 1RM performance was lower compared with ILI. Positive effects of including intermittent sprints ( $200\%$  of  $VO_{2Max}$ , 10 seconds, for five times) into the warm-up have been observed in the present study and the same effect was also demonstrated in a study that compared two minutes kayak ergometer performance after continuous and intermittent warm-up (Bishop et al., 2003). It can be suggested that, the large voluntary contractions that occurred during intermittent sprint phase of the warm-up might have improved performance by increasing neuromuscular activation. High force, dynamic movements during the warm-up period might have a positive effect on explosive force production by enhancing neuromuscular function. This phenomenon is called as postactivation potentiation (PAP) and is believed to enhance power and strength performance by the changes in chemical, neuromuscular and mechanical structure of the muscle tissue (Robbins, 2005; Wilcox et al., 2006). Another possible mechanism is an increased muscle twitch potentiation after maximal voluntary contraction. Through employing supramaximal sprints, subjects may have been able to recruit additional motor units (McComas et al., 1983). Similarly, enhancements after maximal voluntary contractions in lower and upper body performance have been demonstrated in several studies (Gullich and Schmidtbleicher, 1996; Young et al., 1998).

The results that reported in the present study must be viewed with caution because only highly trained male sprint kayakers were studied. Whether the trend of the 1RM testing results is similar after the similar warm-up protocols in different athletic populations is a good perspective to future research. Investigating core body and muscle temperatures before and after warm-up and employing different number of sprints with varied intensities in order to fully optimize the warm-up protocol before 1RM bench press testing can be considered as another potential research area.

After the addition of the 200-m into the olympic program of sprint canoe-kayak competitions, increasing strength, optimizing strength training and the precision of the measurements related to strength become more important among sprint kayakers. Strength performance testing allows trainer to monitor the progression of the ongoing training plan. Therefore, it is vital to detect true 1 RM value which reflects the maximal possible strength of the athlete for that testing phase. According to the results of the present study, employing low intensity general warm-up with five supramaximal sprints substantially improved 1RM bench press performance compared to other warm-up protocols. The suggested warm-up consisted of 15 minutes of low intensity ( $40\%$  of  $VO_{2Max}$ ) upper body exercise and five supramaximal sprints

(which lasts 10 seconds at the intensity of 200 % of  $VO_{2Max}$ ,) at the last 5 minutes of the warm-up. Considering all results of the study, it can be suggested that these warm-up principles can also be applied before maximal strength training sessions of sprint kayakers. These suggestions are limited to 1RM upper body maximum strength tests and should not be applied to other strength tests such as muscular endurance or power.

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