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THE EFFECT OF WARM UP IN SHORT DISTANCE SWIMMING PERFORMANCE

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RUNNING HEAD: Warm-up effect in short distance swimming performance

ABSTRACT

Warming up before physical activity is usual and became assumed as essential in competition and training events. It is expected an optimization in performance but the literature is still ambiguous on this subject. The aim of this study was to assess the effect of the regular warm-up in 50 m swimming performance, in female swimmers. Seven national-level swimmers (mean ± SD; age 15.3 ± 1.1 years-old, height: 1.61 ± 8.1 m, body mass: 56.5 ± 7.0 kg) volunteered for this study. Each swimmer performed 50 m freestyle at the maximum velocity, after previous warm-up and without performing the same, with 24 h between conditions. Times were registered and capillary blood lactate concentration was assessed after the swimming trial at the 1st and 3rd min of recovery. Additionally, the Borg ratings of perceived exertion scale were used and biomechanical parameters such as stroke frequency, stroke length and stroke index were assessed. The 50 m swimming times were not different with and without warm-up (33.05 ± 2.34 s and 32.71 ± 2.07 s, respectively, p =.40). No differences were found in lactate values (8.63 ± 1.49 $\text{mmol}\cdot\text{l}^{-1}$ and 7.93 ± 1.92 $\text{mmol}\cdot\text{l}^{-1}$, respectively; p = .71), ratings of perceived exertion (15.86 ± 1.07 and 15.14 ± 1.22, respectively; p =.24), stroke frequency (0.81 ± 0.08 Hz and 0.81 ± 0.04 Hz, respectively; p = .79), stroke length (1.87 ± 0.14 m and 1.89 ± 0.12 m, respectively; p = .74) and stroke index (2.85 ± 0.31 $m^2\ c^1\ s^{-1}$ and 2.91 ± 0.34 $m^2\ c^1\ s^{-1}$, respectively; p = .40). These results suggested that regular warm-up used by the swimmers does not influence the 50 m freestyle performance, in female swimmers.

KEYWORDS: evaluation; female; freestyle; lactate; biomechanics.

INTRODUCTION

Warm-up is commonly known as a preparatory practice that aimed to improve the subsequent performance (Hedrick, 1992). It is intended to result in an improvement of muscle dynamics, reduce the risk of injury and prepare the athlete for the demands of the main activity

(Woods, Bishop & Jones, 2007). This positive effect on athletic performance seems to be a widespread belief of coaches and their athletes, though the scarcity of conclusive scientific evidence (Atkinson, Todd, Reilly & Waterhouse, 2005; Burnley, & Jones, 2002). When the muscle is exposed to physical activity, there is an increase in their temperature, proportionally to the work done (Saltin, Gage, & Stolwijk, 1968). The mechanisms related to the raise of core and muscle temperature appear to be of great importance for the proposed effects of warming-up before physical activity (Bishop, 2003a). Muscular performance is affected by decreasing the viscous resistance of the muscles and joints (Wright, 1973) and decreasing stiffness of the fibers during muscle contraction (Buchthal, Kaiser, Knappeis & 1944). Complementary, it is suggested to increase nerve conduction rate and speeding of metabolic reactions, such as the muscle glycogenolysis, glycolysis and high-energy phosphate degradation (Febbraio et al., 1996). Moreover, the hyperthermia resultant of the activity might contribute to increase the blood flow (Pearson et al., 2011) and the oxygen delivery to the muscles, via a rightward shift in the oxyhaemoglobin dissociation curve and the vasodilatation of muscle blood vessels (McCutheon et al., 1999). Warm-up exercises also allowed the athletes to begin subsequent tasks with an elevated baseline of oxygen consumption, saving more anaerobic capacity for later in the task (Febraio et al., 1996). Although all these effects proposing improvements in performance after the warm-up routines, the specialized literature is not clear in this matter. There were several studies demonstrating improvements in performance after warming-up (i.e., Atkinson et al., 2005; Burnley et al., 2002), and there were others reporting no changes or even detrimental changes in performance (i.e., Mitchell and Huston, 1993; Bishop, Bonetti, & Dawson, 2001).

Specifically in swimming, the few existing studies are unclear regarding to changes in performance. Moreover, some of them were restricted to physiological assessment, omitting the performance values and limiting the conclusions (Houmard et al., 1991; Robergs et al 1990). DeVries (1959) and Thompson (1958) suggested improvements in swimming velocity in distances until 91 m. These results were confirmed by Romney and Nethery (1993), who were able to verify significant improvements in 100 yards performance after 15 min of warm-up when compared with the absence of any activity prior to the trial. More recently, the maximal and mean values of propulsive force during 30 s of tethered swimming appeared enhanced after regular warm-up (Neiva, Morouço, Silva, Marques, & Marinho, 2011). If, on one hand these results reinforce the general idea that the warm-up is beneficial to the swimmer performance, there are several studies contributing to the controversy on this subject.

No effects in performance were suggested by Mitchell and Huston (1993), and Bobo (1999) in 100 m swimming trials. Regarding to short distance swimming, Neiva, Morouço, Pereira, and Marinho (2012) revealed that regular warm-up did not improve 50 m swimming performance. Blood lactate concentration ([La-]) and perceived exertion were also similar between no warm up and warm up conditions. These results are the opposite of those verified in the study of Balilionis et al. (2012). Better swimming times in 50 yards (0.2 s) after regular warm-up procedures were revealed. Therefore, the contradictory results emerges the need to more investigation to further determine the influence of warm-up procedures, their optimal structure and specificity related to each sport. Hence, the aim of the current study was to verify the effect of warm-up procedures in short distance swimming performance (50 m freestyle), in female swimmers.

This way, it is intended to better understand and better know the effects of warming up in swimming.

METHODS

Subjects

Seven female swimmers (mean ± SD; age: 15.3 ± 1.1 year-sold, height: 1.61 ± 8.1 m, body mass: 56.5 ± 7.0 kg, fat mass: 14.3 ± 3.3 kg) participated in this study. Body mass and fat mass were assessed through a bioelectric impedance analysis method (Tanita BC 420S MA, Japan). All of them participate in the National Championships and their training experience was of 5 years at least. Volunteer's parents and coaches were informed about research propose and signed an informed consent to participate. All the procedures were approved by the institutional review board.

Procedures

All testing procedures were performed in a 50 m indoor swimming pool at a water temperature of 27.5 °C. The experiments took place one week after the main competition (National Championships) of the season second macrocycle. Each swimmer performed 50 m freestyle at the maximum velocity, in two different days. The use or no use of warm up procedures before the maximal test was the variable that distinguished two implemented protocols, performed with 24 hours of difference between them. In the warm-up condition, swimmers performed their usual warm-up before a competitive swimming event (1000 m of total volume). In-water starts were used. Times were registered by 2 experienced coaches using stopwatches (Seiko, Japan) and the average of these times was considered for further analysis. Capillary blood samples were collected from the fingertip before and after each swimming maximal test (at the 1st and 3rd min of recovery) to assess the higher value of [La-] (Accutrend Lactate®Roche, Germany). The Borg (1998) ratings of perceived exertion (RPE) scale of 15 points (6 – 20) was used to quantify exercise level of exertion after each test.

For biomechanical assessment both stroke frequency (SF) and stroke length (SL) were measured. SF was obtained with a chrono-frequency meter (Golfinho Sports MC 815, Aveiro, Portugal) from three consecutive stroke cycles, in the middle of the trial test. Then, SF values were converted to International System Units (Hz). SL was estimated as being (Craig, Skehan, Pawelczyk, & Boomer, 1985):

$$SL = \frac{V}{SF} \tag{1}$$

Where SL is the stroke length, V is the average velocity of the swimmer during the 50 m, and SF is the stroke frequency (Hz). The SI, considered as one of the swimming stroke efficiency indexes, was adapted and computed as (Costill, Kovaleski, Porter, Fielding, & King, 1985):

$$SI = V \times SL \tag{2}$$

Where SI is the stroke index ($m^2 c^1 s^{-1}$), V is the swimmer velocity ($m s^{-1}$) and the SL is the stroke length ($m c^1$) of the swimmer.

Statistical analysis

Standard statistical methods were used for calculation of means and standard deviations. The sample normality was determined by Shapiro-Wilk test. Since the very low value of the N (<30) and the rejection of the null hypothesis (H0), non-parametric procedures were adopted. In order to compare the data obtained with and without warm-up, nonparametric Wilcoxon signed rank test was used. Differences were considered significant for $p \leq 0.05$.

RESULTS

Table 1 presents the mean ± SD values for the 50 m maximal swimming test variables assessed, namely the 50 m times and its partials of 25 m, blood lactate concentration, ratings of perceived exertion, stroke frequency, stroke length and stroke index. No significant differences were evident for the data obtained when comparing the warm-up condition with the no warm-up condition.

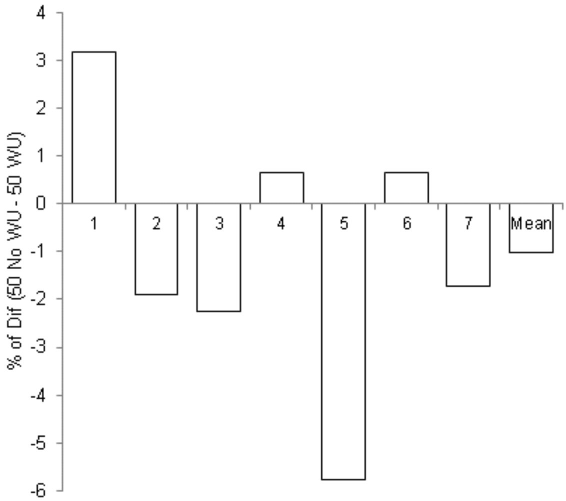
TABLE 1 Mean ± standard deviation (mean ± SD) values of 50 m swim time and each partial of 25 m (s), blood lactate concentration (mmol·l-1), RPE, stroke frequency (Hz), stroke length (m.c-1) and stroke index (m2 c-1 s-1) in the 50 m maximal test with no warm-up and with previous regular warm-up. *P – values are presented*.

	No WU **Mean ± SD**	**Regular WU** **Mean ± SD**	**Sig (*p*)**
1st 25 m time (s)	15.01 ± 0.90	15.24 ± 1.06	0.31
2nd 25 m time (s)	17.70 ± 1.18	17.80 ± 1.33	0.73
50 m time (s)	32.71 ± 2.07	33.05 ± 2.34	0.40
[La-] (mmol·l^{-1})	7.93 ± 1.92	8.63 ± 1.49	0.71
50 m RPE	15.14 ± 1.22	15.86 ± 1.07	0.24
Stroke Frequency (Hz)	0.81 ± 0.04	0.81 ± 0.08	0.79
Stroke Length (m c^{-1})	1.89 ± 0.12	1.87 ± 0.14	0.74
Stroke Index (m^2 c^{-1} s^{-1})	2.91 ± 0.34	2.85 ± 0.31	0.40

Note: WU = Warm-up. [La-] = Blood lactate concentration. RPE = ratings of perceived exertion

Figure 1 shows the percentage differences between the individual times performed without warming up and with previous warm-up. Positive values means better results in the 50 m freestyle after warm-up, whereas negative values means that the swimmers had registered superior 50 m performances without warming up. The results revealed that three of the participants had enhanced performances with warm-up, and the other four without any warm-up procedures.

Figure 1 Percentages of the individual differences between 50m times with no warm-up (No WU) and after regular warm-up (WU) (n=7).



DISCUSSION

The purpose of this study was to evaluate the effect of the warm-up in the 50 m swimming performance, in female national level swimmers. The option for the 50 m freestyle was because it is the shortest event in swimming competition and it is easier to apply and to obtain maximal performances of the swimmers. Main results suggested the 50 m freestyle is not influenced by the previous execution of regular warm-up procedures. There were no statistical differences between the two experimental conditions (with and without warm-up) in the several parameters assessed as the swimming time, [La-], RPE, SF, SL and SI.

Warm-up is used to maximize athlete's performance, increasing muscle and tendon mobility, stimulating blood flow and increase muscle temperature (Smith, 2004). Although the great importance placed in warm-up procedures, it is a fact that their effects or even their ideal structure or type are not well known. Specifically in swimming the limited existing literature is controversy (Fradkin, Zaryn, & Smoliga, 2010). De Vries (1959) and Thompson (1958) suggested improvements in the swimming velocity in short distances (until 91 m) with the previous warm-up. These results were confirmed by the research of Romney and Nethery (1993) that verified significant improvements in the 100 yards performances, after warming up for 15 min. The studies of Mitchell and Huston (1993) and Bobo (1999) reinforced the debate on this matter, as they observed no differences in performance when preceded by different warm-up procedures including no warm-up condition.

In the present research, no differences in the experimental test performed in the two evaluated conditions were observed (Table 1). The 50 m times in freestyle swimming remained equivalent with or without performing the regular warm-up (33.05 ± 2.34 s and 32.71 ± 2.07 s; *p* = .24). In the same way, 25 m partials were similar in the warm-up and in the no warm-up conditions (1st 25 m: 15.01 ± 0.90 s and 15.24 ± 1.06 s; p = .31; 2nd 25 m: 17.80 ± 1.33 s and 17.70 ± 1.18 s ; *p*= .73). Similar results were presented by Neiva et al. (2012) comparing the same test conditions in male swimmers. Although these results suggest that regular warm-up is not essential to 50 m performance, Balilionis et al. (2012) verified different results that could lead to opposite conclusions. These authors noticed that regular warm-up led to improvements (~ 0.2 seconds) in 50 yard times when comparing with no warm-up. Complementarily, Neiva et al. (2011) verified that the swimmers exert greater values of maximal and mean propulsive force (11% and 15%, respectively) during 30 seconds of tethered swimming, when previous regular warm up is completed. However, the same research did not show differences in [La-] and in RPE values after the maximal test when preceded by warm-up and with no warm-up common activities. Considering that the trial test performed approaches to 30 s at maximal intensity, the contribution of anaerobic metabolism is essential to fulfill the total energy expenditure (Gastin, 2001). Since [La-] had been commonly used to estimate the contribution of glycolytic metabolism to exercise (di Prampero & Ferretti, 1999), the values seem to highlight the preponderance of the anaerobic system to meet the energy requirements of the exercise. Mandegue et al. (2005) and Beedle and Mann (2007) proposed that warm-up could be used to maintain the acid-base balance at an appropriated level by stimulating the buffering capacity. This way, it could result in the reduction in the [La-] values. Several studies confirmed these suggestions by observing reductions in blood and muscular lactate concentrations when exercising after priming activities routines (i.e., Gray & Nimmo, 2001; Robergs, Pascoe, Costlill, & Fink, 1991). Diverging from these statements, the metabolites assessed in this study kept similar in the two situations. As it can be noticed in Table 1, the non-existence of differences in [La-] values after the 50 m in both conditions corroborated previous results abovementioned, which did not show modifications of the physiological parameters with and without warm-up (De Bruyn-Prevost and Lefebvre, 1980; Neiva et al., 2011; Neiva et al., 2012).

In agreement with previous studies, the level of perceived exertion demonstrated no differences between the two experiments implemented. The RPE values obtained are similar to those presented in previous studies (Neiva et al., 2011; Neiva et al 2012; Balilionis et al., 2012). This scale is used to quantify, monitor and assess an individual's exercise level of exertion (Borg, 1998). Robertson et al. (1986) suggested that an increase in the ratings of perceived exertion could be a consequence of the more usage of anaerobic capacity. The accumulation of ions of hydrogen in the active muscles and blood, follow-on the dissociation of lactic acid can cause a superior perception of effort. As [La-] values did not change in the 50 m performed with warm-up and without warm-up, it would be expected that the RPE values were maintained similar.

Regarding to the stroke cycle kinematics, the registered values showed no differences with and without previous warm-up procedures. SL and SF are independent variables that are related to swimming velocity (Pendergast et al., 2006). The female swimmers of this study did not perform differently the 50 m freestyle in the two test situations, and the swimming velocity was also similar. This could lead to no changes in stroke kinematics as well as in SI. SI is considered as an estimator for overall swimming efficiency (Costill et al., 1985). Thereby, it is assumed that at a given velocity, the swimmer with greater SL has the most efficient swimming. In this case, it can be suggested that warming up did not influence the swimmer efficiency.

Although there was found no statistical differences, it can be noted in Figure 1 that there were swimmers responding differently in each situation. They swim as individual subjects and their performance is also individual, not responding to the warm-up procedures in the same way. In Figure 1 it can be noted that more than 50 % of the female swimmers responded positively to the inexistence of warm-up. However, a great variability was found between swimmers, thus suggesting that coaches should focus their attention on the response of each swimmer, instead of applying the same warm up procedure for all the swimmers.

In conclusion, although the usual changes attributed to warm-up, its efficiency in swimmers performance is still not clear. It was observed that there were no differences in performance as well as no differences in the assessed parameters (physiological and biomechanical). These results allow us to suggest that regular warm-up does not seem to be determinant in short distance performances, in female swimmers. Bishop (2003b) pointed some possible explanations for the negative or unaltered results in performance, as the warm-up being of low intensity and not causing the necessary changes in the subjects; being to hard and causing fatigue; and not allowing to recovery sufficiently before exercise. Insufficient and unclear data published, enhances the necessity for further studies to better understand this issue.

PRACTICAL APPLICATIONS

The small sample of subjects does not allow strong statements and certainties, whereby it is needed to amplify the number of swimmers evaluated. Results of the present study indicated no significant influence of using regular warm-up in 50 m swimming, in females. However, as Balilionis et al. (2012) suggested, coaches should work individually with the swimmers, in order to maximize their training or competition performance. It could be noted different responses to the use or no use of warm-up before the maximal trial. This should be taken in consideration when preparing competition, and coaches should focus in each individual needs to achieve optimal performance.

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