IMPACT OF DIFFERENT WARMUP PROCEDURES ON A 50-YARD SWIMMING SPRINT

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ABSTRACT

This study investigated to what degree three different warm-up routines affect 50-yard swim performance (45.7m). The 4 female and 9 male participants, NCAA Division I swimmers, performed on three different days, a general swimming warm-up (SWIM), a combination of plyometric exercises and swimming warm-up (COMBO), or a single 50yard Swim at 90% of the maximum effort (SHORT). Each treatment was followed by 50-Yard Freestyle swimming Sprint at maximal effort following a 5-minute rest period after the completion of each warm-up procedure. Self-reported heart rate was recorded after each maximal effort. The time of each trial was recorded using a standard Colorado Timing System. Although the 50y sprint performance was not significantly affected by the SWIM, the SHORT and the COMBO warm-up (23.79 sec ±2.32), (23.74 sec ±2.12), (23.63sec ± 2.21) respectively, 7 out of the 13 swimmers swam their fastest time with the SHORT warm-up and only three swam their fastest with the conventional warm-up (SWIM). Heart rates, on the other hand, were significantly (p<.05) higher following the SHORT warm up compared to the SWIM and the COMBO warm ups.

However, individual differences revealed that some athletes could benefit from a plyometric/swimming warm-up in order to improve overall swimming performance, especially when considering that a few hundredths of a second would make a significant difference in the outcome of a given race. It appears that the standard warm-up may not produce the best results for all swimmers. It is important to look at individual data when dealing with elite athletes.

Key words: Warm-up, Elite athletes’ performance, swimming warm-up

1. INTRODUCTION

Although different warm-up routines are often prescribed before physical activity, little research has been conducted to determine what effects these routines have on athletic performance and injuries (Church, Wiggins, Moodé & Crist 2001); (Thacker, Gilchrist, Stroup & Kimsey, 2004). In competitive swimming, researchers are concerned about more specialized warm-up for different events and even about post-warm up recovery prior to competition (Salo & Riewald, 2011); (Maglischo 2008) and between-sets interventions (Cometti, Deley, &Babault, 2011).

Competitive athletes engage in various kinds of physical activity prior to an event in an attempt to bring about alterations in their physiological status, which will optimize performance. Scientists suggest that warm-up may optimize performance by enhancing oxygen uptake and kinetics (MacDonald, Naylor, Tschakovskv & Hughson, 2001); (Hughson, 2009), increased temperature, enhance blood flow and metabolism (Hughson, Schijvens, Burrows, Devitt, Betik, &Hopman, 2003 ) and reaction time (Perrier, Pavol & Hoffman, 2011), improved lactate clearance, improved Oxygen distribution (Wittekind, Cooper, Elwell, Leung & Beneke, 2012); (Faisal, Dyson & Hughson, 2010); (DeLorey, Kovalchuk & Paterson, 2004 ), right-shifting the Oxygen-hemoglobin dissociation curve (Gerbino, Ward & Whipp, 1996).

Previous research has investigated the effect of high- and low- intensity warm-ups on physiological responses (Mitchell & Huston, 1993); (Houmard et al., 1991), lactate accumulation (Laia, Perez-Gomez, Nordsborg & Bangsbo, 2010), and high-intensity freestyle and tethered swimming performance. (Romney & Nethery,1993); (Mitchell & Huston, 1993); (Cervantes&Snyder, 2011).

Additionally, researchers have also investigated the effects of different warm-up and flexibility routines on vertical jump performance (Church et al., 2001); (Sotropoulos et al., 2007); (Villarreal, Gonzalez-Badillo & Izquierdo, 2007); (Vetter 2007), post warm-up recovery time prior to competition (Zochowski, Johnson & Sleivert, 2007), between-sets interventions (Cometti et al., 2011), and task-specific warm-up on anaerobic power (Hawley, Williams, Hamling & Walsh, 1989).

Furthermore, the more relevant study by Romney and Nethery (1993) analyzed the effects of swimming and dry land warm-up routines on 100-Yard freestyle performance and another study by Houmard el al. (1991) looked at the effect of general mild-intensity warm-up, intensity specific warm up, and no warm-up on swimmers’...
physiological and biomechanical responses and performance. Since the main interest of these researchers is in the area of competitive swimming, the idea evolved of looking at different warm-up procedures including plyometric exercises and its possible effects on swimming performance in 50-Yard freestyle sprint. The purpose of this study was to compare which of the three types of warm-up was best for producing optimal results in swimming performance, particularly in the 50-Yard freestyle crawl swimming performance.

2. METHODS

The subjects who voluntarily participated in this study were Division I varsity swimmers under the National Collegiate Athletic Association (NCAA) in the United States. The 9 males (84.58 ± 9.86Kg, 187.86 ± 8.19cm) and 4 females (65.55 ± 3.70 Kg, 170.0 ± 3.61cm) were members of the men’s and women’s swimming team with average years of experience in competitive swimming of (9.67 ± 4.15 years) and (11.75 ± 1.26yrs) for males and females respectively. This study was approved by the Institutional Review Board for the Protection of Human Subjects (IRB). Participants were informed of the purpose, procedures, risks, and benefits of the study before signing an IRB approved informed consent.

On three non-consecutive days in a counterbalanced manner, subjects performed one of three different types of warm-ups followed by a 50-yard Freestyle Sprint Swim (maximum effort) on a short course swimming pool (25 Yards). Warm-up routines' effects on the 50 yards time-trial performance were tested in a counterbalance manner. The three warm-ups consisted of:

a) A standard swimming warm-up with starts (SWIM); (described below),

b) A combination warm-up including swimming and plyometrics (COMBO); (described below), and

c) A single 50-yard warm-up sprint at 90% effort (SHORT).

The three types of warm-up are further described as follows:

**Standard Swimming Warm-up (SWIM):** Subjects completed a 400-yard swim choice on 6:00 min, 4 x 100 yard (50 drill/50 swim) on 1:40 min, 4 x 50 yard (25 kick/25 swim) on 1:00 min, 4 x 25 yard (Alternating 1 Fast from a dive, one easy choice) on 1:00 min. The 50-yard Sprint Swim (max effort) was done 5 minutes following the completion of the warm-up.

**Combination Warm-up (COMBO):** Subjects completed a mixed warm-up of: 1:00 min of Jump Ropes, 10 repetitions of maximal vertical jumps, 400 yard swim choice (any stroke) on 6:00 min interval, 10 maximal water vertical streamline pushes (push from the bottom of the 6ft deep water), 4 x 50 yard (25 kick/25 swim) on 1:00min interval, 5 maximal water vertical streamline pushes (push from the bottom on 6ft water). The 50-yard Sprint Swim (max effort) was done 5-minutes after the completion of the warm-up.

**Short Warm-up (SHORT)** – Subjects completed a 50-yard Swim at 90% of max effort, followed by the 50-yard Sprint at maximal effort. There was a 5-minute interval between the first and second swims. The 50-yard max effort Sprint Swim was done 5-minutes after the completion of each of the warm-ups. Testing was conducted on three non-consecutive days, with an interval of one day in between trials.

A subjective self-measured heart rate (HR) was reported and recorded after each maximal effort by having each subject counting his/her own heart rate for 10 seconds. Subjects were very experienced at this, since they measure their own HR daily in practice and, therefore, self-reported HR is a practical and reliable measure.

The time for each sprint trial was recorded using the computerized timing System 4000 Sports Timer (Colorado Time Systems, Inc., Colorado Springs, CO). The system consists of a “beep” automated start that triggers the clock, and a touchpad at the end of the lane that stops the clock. The results of the maximal efforts were recorded and then compared appropriately using the statistical package for social sciences (SPSS) software.

Statistical analysis for the data of this study consisted of a repeated measure analysis of variance ANOVA and some other basic descriptive statistics. An alpha level of (p< 0.05) was used to make inferences.

3. RESULTS

Test for homogeneity shows that Participants in this study were homogenous for age ((20.0 ± 1.41yrs) and (20.75 ± 1.5yrs) for males and females respectively and all other physical characteristics.

Participants’ Performance time of the 50 yards swimming – reported in seconds- and their post-performance self-reported heart rate after each warm up condition are reported in Table (1).

<table>
<thead>
<tr>
<th>Warm-Up</th>
<th>SHORT</th>
<th></th>
<th>SWIM</th>
<th></th>
<th>COMBO</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
<td>HR/10s</td>
<td>Time</td>
<td>HR/10s</td>
<td>Time</td>
<td>HR/10s</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.53 ± 1.04</td>
<td>27.5 ± 1.0</td>
<td>26.90 ± 1.20</td>
<td>26.75 ± 2.63</td>
<td>26.59 ± 1.10</td>
<td>26.25 ± 0.96</td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.50 ± 0.89</td>
<td>28.11 ± 0.93</td>
<td>22.42 ± 0.80</td>
<td>26.44 ± 1.51</td>
<td>22.33 ± 0.80</td>
<td>27.00 ± 1.22</td>
<td></td>
</tr>
</tbody>
</table>

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Actual performance times for each subject in the 50 yard swim trial and his post-performance heart rate (HR) are reported in Table (2). The performance time and HR was compared for all participants with their own trial using the standard warm-up (SWIM) as reference point. Percentage of variation in performance (increase or decrease in time or HR) was compared between each of the COMBO warm-up and the SHORT warm-up with the SWIM warm-up. Percent change might be small but for competitive swimmers each tenth of a second count.

Table 2. Differences in 50 yard swimming time and HR after each warm up trial

<table>
<thead>
<tr>
<th>ID</th>
<th>SWIM</th>
<th>SHORT</th>
<th>% Diff</th>
<th>COMBO</th>
<th>% Diff</th>
<th>SWIM HR</th>
<th>Bts/10s</th>
<th>SHORT HR</th>
<th>Bts/10s</th>
<th>% change</th>
<th>COMBO HR</th>
<th>Bts/10s</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26.51</td>
<td>26.43</td>
<td>0.30%</td>
<td>26.66</td>
<td>-0.6%</td>
<td>27</td>
<td>28</td>
<td>25</td>
<td>26</td>
<td>-13.0%</td>
<td>25</td>
<td>-8.7%</td>
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<tr>
<td>2</td>
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<td>25</td>
<td>26</td>
<td>-13.0%</td>
<td>25</td>
<td>-8.7%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>26.46</td>
<td>26.10</td>
<td>1.36%</td>
<td>26.35</td>
<td>0.4%</td>
<td>29</td>
<td>28</td>
<td>25</td>
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<tr>
<td>4</td>
<td>22.60</td>
<td>22.56</td>
<td>0.18%</td>
<td>22.74</td>
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<td>28</td>
<td>28</td>
<td>25</td>
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<td>28</td>
<td>29</td>
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<td>-3.6%</td>
<td>27</td>
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<tr>
<td>6</td>
<td>21.90</td>
<td>21.47</td>
<td>1.96%</td>
<td>21.66</td>
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<td>29</td>
<td>28</td>
<td>-7.7%</td>
<td>29</td>
<td>-11.5%</td>
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<tr>
<td>7</td>
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<td>2.34%</td>
<td>28.00</td>
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<td>28</td>
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<td>8</td>
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<td>27</td>
<td>28</td>
<td>25</td>
<td>26</td>
<td>-3.7%</td>
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<td>-3.7%</td>
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<tr>
<td>9</td>
<td>22.68</td>
<td>23.67</td>
<td>-4.37%</td>
<td>22.34</td>
<td>1.5%</td>
<td>24</td>
<td>29</td>
<td>22</td>
<td>28</td>
<td>-20.8%</td>
<td>28</td>
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<tr>
<td>10</td>
<td>22.48</td>
<td>22.28</td>
<td>0.99%</td>
<td>22.44</td>
<td>0.2%</td>
<td>28</td>
<td>28</td>
<td>25</td>
<td>26</td>
<td>0.0%</td>
<td>27</td>
<td>3.6%</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>22.34</td>
<td>22.81</td>
<td>-2.10%</td>
<td>22.57</td>
<td>-1.0%</td>
<td>25</td>
<td>29</td>
<td>24</td>
<td>28</td>
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<tr>
<td>12</td>
<td>23.88</td>
<td>23.40</td>
<td>2.01%</td>
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<td>13</td>
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<td>21.72</td>
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<td>27</td>
<td>28</td>
<td>27</td>
<td>28</td>
<td>-3.7%</td>
<td>27</td>
<td>0.0%</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1 shows participants’ 50 yards time trials repeated after three counterbalanced warm-up routines separated by 48hrs. Participants in this figure are shown in order of their best times (fastest to slowest). The difference in performance after the three warm-up routines were not significant (P> 0.05).

Figure 2 show post- performance self-reported Heart rate, analysis of variance shows significant differences (P<0.05) between the SHORT warm-up and the SWIM and between SHORT and COMBO warm up. Post hock statistics shows that heart rate after time trials for the 50 yard sprint was higher than the COMBO warm-up and more conventional SWIM warm-up.
The objective was to determine the best warm-up practices for competitive swimmers' 50-yard sprint performance (max effort). Such results could imply better overall performance in swimming events, especially when races and rankings are defined by hundredths of a second. In the present study, we found no overall statistically significant differences among the times achieved under SHORT (23.75, +/-2.12 sec), COMBO (23.64, +/-2.22 sec) and SWIM (23.80, +/-2.32 sec) warm-ups.

Although swimming performance was not significantly influenced by warm-up procedures (P>0.05), the data show some individual cases who improved under some conditions and performed poorer under others without any specific trend. Because swim competitions are often decided by differences of one 1000, or one hundredths of a second sometimes, it is important to take individual cases in consideration when designing athletes' warm-up.

Statistics used in this study (ANOVA followed by Bonferroni) show that there were statistically significant differences in post-performance heart rate (HR) after the maximal swim performance. The differences were between (SHORT) & (COMBO), (SHORT) & (SWIM), but not between (COMBO) & (SWIM). Swimmers heart rates following the SHORT warm-up condition were significantly higher than the COMBO warm-up (27.92, +/-0.95 bts/10 sec) (26.77, +/-1.17 bts/10 sec) respectively and higher than SWIM warm-up (26.54, +/-1.81 bts/10 sec) (P<0.05). This fact should not come as a surprise, since it can be resulted from greater amount of effort and oxygen debt that was used to produce a maximal effort without proper priming of oxygen kinetic and delivery system. Additionally, this increase in post-performance heart rate after the short warm-up can be explained as a necessity for recovering energy resources (ATP &Pcr ) and replenishing the higher Oxygen debt after the high energy demand in the 50 yard sprint since the metabolic system has not been functioning optimally after that kind of warm up ( Wilmore 0000). This finding would, in essence, support the current mainstream of belief in a standard warm-up pattern due to the lack of evidence in vertical jump performance after low or moderate intensity warm-up despite differences in electromyographic (EMG) activity prime movers.

Since the results of this, and other studies don't support specific warm-up pattern due to the lack of differences between means of performance achieved under different warm-up conditions, the practical application of this study would be for coaches to maintain the standard warm-up routines with further analysis of individual responses in performance ( as expressed in HR variable). Considering the reality of competitive swimming, individual differences, including percentage differences in performance (see table 2), however revealed a different scenario are very important data. When looking at the actual data (table 2), it is very important to notice that out of 13 subjects, 7 subjects performed faster times under the SHORT condition, 4 subjects performed faster times under the COMBO condition, and only 2 subjects performed faster times under the SWIM condition. Granted, these differences were not statistically different, but coaches work with a relatively small number of individuals not group means and the individual results makes the big story of successful carrier for both coaches and swimmers. Based on the data obtained in this study, it would appear that some type of SHORT warm-up routine might be appropriate for the 7 individuals who performed better under the SHORT condition, especially if these individuals are to compete in races of 50-Yards. By looking further into possible changes and adjustments, it is possible for coaches to better prepare these athletes to perform at their individual peak performance capacity.

We might expect that patterns would be apparent in these data. E.g. Perhaps sprinters would do better with a shorter warm-up and distance swimmers would need more. That was not the case in our study, there was no clear pattern. Perhaps with further studies some pattern may emerge. We believe the present study illustrates the necessity of examining individual as well as group mean differences in studies with application to elite athletes. If half of the group of athletes' benefits from a treatment and half experience a reduction in performance, the group mean may show nothing. However, any coach would recognize that the group benefiting could use the treatment, but never the group that did not benefit.

Clearly coaches would want to test their own athletes repeatedly to determine the best warm-up routine for each athlete and event. We believe these data illustrate that it is an error to assume the typical long warm-up is optimal.

4. DISCUSSION

Heart Rate After Different Warm-up Trials

![Graph showing Heart Rate After Different Warm-up Trials](image)

**Fig. 2. Post performance self-reported Heart rate in 10 seconds**

The purpose of this investigation was to compare the impact of three types of warm-up and/or plyometric routines on 50yard time trial. It was used to test the optimal technique. In fact, Romney and Nethery (1993) found that group means were not different among swimmers with three types of warm-up. Sotiropoulos et al. (2010) also found no differences in vertical jump performance despite differences in electromyographic (EMG) activity prime movers.


