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A CORRELATIVE STUDY BETWEEN AEROBIC, ANAEROBIC DRY LAND PERFORMANCES AND SWIMMING PERFORMANCE IN PROFESSIONAL INDIAN SWIMMERS

Jaspal Singh Sandhu, Simrat Kaur, Shweta Shenoy

Corresponding author:
Dr. Jaspal Singh Sandhu
Dean,
Faculty of Sports Medicine and Physiotherapy
Guru Nanak Dev University,
Amritsar-143005
jssandhudr@gmail.com
Telephone - 0183-2258802-09
Fax - 0183-2258820

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ABSTRACT
SANDHU, J. S.; KAUR, S.; SHENOY, S. A correlative study between aerobic, anaerobic dry land performances and swimming performance in professional Indian swimmers. Brazilian Journal of Biomotricity. v. 6, n. 3, p. 185-192, 2012. The purpose of this study was to establish the relationship between the aerobic, anaerobic dry land performances to the swimming performance in professional swimmers. 60 healthy National level swimmers aged 16 to 35 (mean=20.3±3.10) years were recruited for the study. Swimming performance was measured for the endurance and speed (i.e. 50x6 m & 25 x2 m) after a standard warm up and, the aerobic capacity was measured using VO₂ Max Treadmill Machine. 6 Repetitive Maximum (6 RM) was used as the baseline method for the measurement of strength. Upper limb and lower limb strength was evaluated by bench press (BP) and leg extension (LE) using the free weight barbell respectively. Results indicated that there was a strong association between the performance of professional swimmers and that of aerobic dry land performance, where the VO₂ max was found to be positively correlated to the swimming performance(r₅₀₀ =.343 and r₅₀ =.426). However the results also indicated that anaerobic dry land performance does not contribute significantly to swimming performance (r₉₀₀(LE)=0.149, r₅₀(BP)=0.018 and r₉₀₀(BP)=0.081, r₅₀(LE)=0.105). Therefore we conclude that with a higher aerobic dry land performance will arguably, display superior swimming performance.

Keywords: aerobic dry land performance, anaerobic dry land performance, swimming, VO₂ max.
INTRODUCTION

Sport swimming appertains to the group of mono-structural sports of the cyclical type (VOLCANSEK, 1996) and is characterized by predominantly simple movements, which differ in the form and manner of performance, and they are alternately repeated during certain swimming techniques (OKICIC et al., 2007). Studies have shown that, sports has its own distinctive skills, tactics and movement patterns, they all have similar physiological demands such as, high aerobic power, high lactate tolerance and increased anaerobic capacity (BANGSBO, 2000).

Exercises to improve maximal muscle strength and maximal aerobic endurance capacity are essential elements for enhancing competitive swimming performance (ASPENES et al., 2009). It has been acknowledged that many sports depend heavily upon muscular strength and aerobic enhancement especially at competition level (LEVERITT et al., 1993), with swimming being of no exception, reinforcing the need to ascertain the existence of an apparent correlation. As with competitive running and cycling, dynamic strength seems to be an important determinant of swimming performance too (TANAKA et al., 1993; TANAKA and SWENSEN, 1998) but, sport-specific assessment methods for muscle power output of the arms and legs for swimming are poorly developed compared with other sports (SWAIN E, 2000). Dry land, resisted/assisted sprint training methods on sprint performance were widely documented (STRASS ,1988; TANAKA et al., 1993; GIROLD et al., 2007) , also, combined intervention of strength and endurance training is common practice in elite swimming training, but the scientific evidence is scarce (ASPENES et al., 2009).

Endurance swimmers should be characterized by high aerobic capacity as the swimmer with high VO2max has a higher ability for endurance and performance (EL KADY, 2012). Maglischo (1993) showed that swimming training can be identified according to two terms: endurance training for developing aerobic work and speed training for developing anaerobic work. One of the most objective measures that can be used to assess aerobic or cardio-respiratory endurance is maximum oxygen consumption (RADOVANOVIC, 2009).

Furthermore, resistive exercise is used by athletes in non-endurance sports to promote strength, speed and power and by body builders to build muscle mass (LEVERITT et al., 1993). Few studies showed that combined strength and endurance training routine seems to inhibit strength and power development when compared with strength training alone (DUDLEY and DJAMIL, 1985; ABERNETHY and QUIGLEY, 1993). Also, Tanaka and Swensen (1998) noted that, traditional dry-land strength training or combined swim and strength training do not appear to enhance swimming performance in untrained individuals or competitive swimmers despite substantially increasing upper body strength.

Following a view supporting the existence of a relationship between aerobic and anaerobic performance and that of the performance in swimming, it is important to note that programs combining swimming with dry-land strength or within water resisted/assisted-sprint exercises evidently led to a similar gain in sprint performance that are more efficient than traditional swimming training methods alone (GIROLD et al., 2007). Thus, the aim of this study was to investigate that both aerobic and anaerobic dry land performances are highly supplementary to and correlate with the performance of swimming. Despite a range of views focusing on the different levels of correspondence and correlation, it seems apparent that a relationship exists, but a study is required to explore its extent.

METHODS

Subjects:

A sample of 60 elite male swimmers aged 16 to 35 years (mean=20.3±3.10) of national level participated in this study. The participants were provided with the written informed consent to participate in this research and the procedures were approved by the institutional ethical board, Faculty of Sports Medicine and Physiotherapy, Guru Nanak Dev University, Amritsar, Punjab, India and also tests were explained to the participating swimmers priorly.
Design:
Correlative study design was used to find the association between the anaerobic and aerobic dry land performance and swimming performance of the swimmers.

Methodology:
The tests were selected and programmed so as not to interfere with the training and competition schedule. A standard warm up routine of 15 – 20 min was performed by all the swimmers before the tests commenced. Each participant underwent the following tests.

Anaerobic dry land performance:
Each subject's six maximum repetitions (6-R M) were determined on the leg extension and bench press. Dynamic strength was assessed using a free-weight barbell machine. The maximal weight that could be lifted 6 times with correct form throughout the full range of motion was recorded. Following a 72 h rest period, the strength testing procedures were repeated to rule out any fatigue factor and heaviest 6-RM load lifted on each exercise, on either testing day, was interpreted as the 6-RM score (GARRIDO et al., 2010).

Aerobic dry land performance:
Each subject was asked to perform a maximal graded exercise testing using Bruce GXT protocol. This test consists of six, three minute stages in which participants exercise to the point volitional fatigue i.e. the point of exhaustion when the participant asks to terminate the test voluntarily. The test starts with subject walking at a speed of 1.7 mph at a 10% grade and imposes large increments in metabolic costs of exercise throughout the test with each 3 min stage. At every minute interval the inclination of the treadmill increases by 2% and the speed increases by 0.8 or 0.9 mph. The data was interpreted through computer software (Turbo-fit – vista VO2 lab system) where the results were declared upon completion of the test (WILMORE and COSTILL, 2005)

Swimming performance:
The swimming performance was evaluated with both 25x2 m and 50x6 m which were performed by all the swimmers, with a 15 min active recovery period between the two trials respectively. A standard warm-up routine was followed by tests beginning with the 25x2 m test. The tests were carried out with two days break. The protocol was carried out in a 25 m swimming pool. In case of the 25x 2 m test a dive start was performed whereas in case of 50x6 m push- starts was used and swimmers performed with maximal effort alone in each lane. A chronometer was used to evaluate the time to cover the swim distances. For each trial, mean value of both measurements were computed (PYNE, 2000).

Statistical Analysis:
To perceive the relationship of aerobic and anaerobic dry land performance to swimming performance (300m and 50m) of selected professional swimmers, coefficients of Pearson’s correlation were computed through SPSS version17 and results thereof has been given in table 1, 2 and 3.

RESULTS
Table 1 reveals that Vo2Max was significantly correlated with Swimming Performance (300 m) of selected professional swimmers as the obtained coefficients of correlation (r300(Vo2)=0.343) was statistically significant at .05 level. However, coefficients of r300(LE)=0.149 and r300(BP)=0.018 for leg power and arm strength respectively with swimming performance of the subjects were not found to be significant at .05 level, although, these variables had shown some degree of relationship with 300m swimming performance.

Table 1: Relationship of Vo2Max (ml/kg/min), Leg Power (kgs) and Arm Strength (kgs) to Swimming Performance (sec) (300 m) of Selected Professional Swimmers
Similarly, table 2 indicated that aerobic dry land performance measured as Vo2Max was significantly correlated with Swimming Performance (50m) of selected professional swimmers as the attained coefficients of r50(VO2)=-0.426 was statistically significant at r=0.05 levels. However, coefficients of correlation between leg power and 50 m swimming performance (r50(LE)= -0.081) and also between arm strength and 50 m swimming performance (r50(BP)=-0.105) of the subjects were not found to be significant at r= 0.05 level, although, these variables had exposed some degree of relationship with 50 m swimming performance.

Table 2: Relationship of Vo2Max (ml/kg/min), Leg Power (kgs) and Arm Strength (kgs) to Swimming Performance (s) (50m) of Selected Professional Swimmers

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Variables Correlated</th>
<th>Coefficients of Correlation (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vo2Max and Swimming Performance (50m)</td>
<td>-.426*</td>
</tr>
<tr>
<td>2</td>
<td>Leg Power and Swimming Performance (50m)</td>
<td>-.081</td>
</tr>
<tr>
<td>3</td>
<td>Arm Strength and Swimming Performance (50m)</td>
<td>-.105</td>
</tr>
</tbody>
</table>

(*) Significant at .05 level; r.05 (58) = 0.250

Correlation matrix in table 3 also indicated the significant correlation between leg power and VO2Max (r=.420) and with upper body strength(r=.525). However, upper body strength did not show significant correlation with VO2Max (r=.233).

Table 3: Correlation Matrix of aerobic and anaerobic dry land performances to swimming performance.

<table>
<thead>
<tr>
<th>Variable</th>
<th>SP300mts</th>
<th>SP50mts</th>
<th>LE6RM</th>
<th>BP6RM</th>
<th>VO2MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP300mts</td>
<td>1</td>
<td>.566*</td>
<td>-.149</td>
<td>.018</td>
<td>-.343*</td>
</tr>
<tr>
<td>SP50mts</td>
<td>1</td>
<td></td>
<td>-.081</td>
<td>-.105</td>
<td>-.426*</td>
</tr>
<tr>
<td>LE6RM</td>
<td>1</td>
<td></td>
<td>1</td>
<td>.525*</td>
<td>.420*</td>
</tr>
<tr>
<td>BP6RM</td>
<td>1</td>
<td></td>
<td>1</td>
<td>.233</td>
<td></td>
</tr>
<tr>
<td>VO2MAX</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) Significant at .05 level; r.05 (58) = 0.250
DISCUSSION

We hypothesized the existence of a correlation between aerobic and anaerobic dry land performances to the swimming performance of swimmers. The results reported in this study prove that aerobic dry land performance is essential and highly associated with the swimming performance, with anaerobic dry land performance not being an affective contributing aspect to swimming performance, thus partially supporting the hypothesis.

According Garrido et al. (2010) combined strength and aerobic swimming training allow dry land strength developments and enhancements of swimming performance. Positive effects of strength and endurance training have been stated in basketball (COSTILL et al., 1988) soccer athletes (HOFF et al., 2002), along with runners (TANAKA and SWENSEN, 1998; YAMAMOTO et al., 2008) and cyclists (TANAKA and SWENSEN, 1998). Inversely, Tanaka and Swensen (1998), Silva et al. (2007) and Abernethy and Quigley (1993) did not find any influence of dry land strength on performance and that dry land strength training or combined swim and strength training does not appear to enhance swimming performance in competitive swimmers. Similar results were observed in the present study, where the swimming performances of the swimmers were more inclined towards the VO2max and not both the factors simultaneously.

High level of aerobic capacity is indispensable for achieving success in many sports (COUTTS and ABT, 2008). Jorgic et al., 2010 discovered a correlation between VO2max and swimming performance which has been found to be similar in this study as well, only the aerobic component was found to be positively correlated with both swimming performance tests. Aerobic capacity (measured as maximal oxygen uptake, VO2 max), economy of motion (submaximal VO2) and fractional utilization of maximal capacity (%VO2max) reflect integrated responses of physiological adaptation such as increased number and size of mitochondria, increased ATP production, decreased amounts of lactic acid, lower glycogen depletion in the muscles during exercise, increased enzyme activity, and improved efficiency in utilising oxygen from the blood supply (TAYLOR et al, 1999). All of these adaptations allow the athlete to increase theirVO2 max (THOMPSON, 2000). Recent swimming research have also indicated that in single races, the alactacid and aerobic energy systems are dominant while a considerable amount of type II b fibers are developed through specific training and add to the oxidative energy pool for racing. Thus, the portion of the lactic acid system conversion that is oxidative adds to the ability of muscles to function with speed and endurance (RUSHALL, 2009) and enhancing their swimming performance. Thus, according to our findings aerobic performance like in other sports represents one of the most important components of physical fitness in swimming as well. The physiological capacities allow the player to repeat sprints often with quite short recovery periods over a prolonged duration (COUTTS and ABT, 2008), as proved in this study where the sprint swimming performance (50m) was significantly correlated to VO2 max.

Further, in this study we observed that, anaerobic dry land performance presented moderate but not significant associations with both swimming performance tests. Partially supporting our results, Watanabe and Takai (2005) analyzed the factors contributing to swimming performance, findings of this study showed that, muscle strength does not contribute strongly to the swimming performance. Anaerobic work capacity and factors/ indices are unrelated to swimming performances (PAPOTI et al., 2006; ROHRS et al., 1990; ZOELLER et al., 1998) and are difficult to determine in swimming (ALMEIDA et al., 1999). Swimming training employs aerobic function. Continual stimulations provoke some fast-twitch fibers to become oxidative type. Consequently, swimming training would stimulate the conversion of the fast-twitch fibers to oxidative metabolism. Thus, after sufficient training, an appreciable number of fast-twitch and all slow-twitch fibers function oxidatively. That could account for the absence of an association between anaerobic activity and swimming racing (RUSHALL, 2009).

Results showed that the aerobic component is significantly correlated to the swimming performance therefore, the strength component was less significant being reasonably associated to the swimming performance, also stated by Garrido et al. (2010), that simple dry land strength and power tests were moderately significant with sprint swimming performance.
Andreson (2004) stated that strength training has no effect on maximal aerobic capacity (VO\textsubscript{2max}). However, our study disproved the same, showing moderate correlation between limb strength and VO\textsubscript{2 max}, in agreement with Glaister et al. (2000) who proved that 1RM squat strength have significant relationships with power, speed and speed-endurance related variables. Typical strength training has minimal effects on VO\textsubscript{2 max} as it may be possible that stronger athletes are more efficient/economical in their movements leading to enhanced endurance capabilities as a result of performing less work for a given task (MILLET et al., 2002; HOFF et al., 1999).

Maximum oxygen consumption, as one of the most important elements of cardio-respiratory endurance, should be developed early in the swimming career, in accordance with the sensitive periods of its development (JORGIC et al., 2010). If this were so, it would be beneficial to develop a dry land based training programme that might enhance sprint performance (TANAKA and SWENSEN, 1998; GIROLD et al., 2007). Considering this and our results, we draw a conclusion that VO\textsubscript{2 max} forms the mainstay of swimming performance but, anaerobic performance is also imperative.

PRACTICAL APPLICATION

Studying this relationship in swimmers will assist upon forming apt exercise protocols, in order to increase the level of performance in accordance to the required demand of the sport. It should not be assumed that performance results from an isolated component. Thus, keeping the knowledge of various components of all round development and their role in sportive performance are fundamental factors in training swimmers towards the elite performance. Consequently, it should be concluded that an elite performance is not a result of either the skill or any physiological component, but is in fact a combination of them all, where each module supports the other.

REFERENCES


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