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ORIGINAL RESEARCH

The effect of anaerobic power on short distance swimming performance in prepubertal male swimmers

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Abstract

This relational model study aimed to assess the anaerobic power and short distance swimming performance in prepubertal male swimmers. A total of 20 male swimmers, age mean = 11.40±1.39 yrs, participated in this study. All participants trained on approximately two hours per session, five times per week. A mat was used to collect data on vertical jump. Swimming performance was evaluated for 50 meters in swimming pool using a stopwatch. The arm Wingate was used to assess the anaerobic arm power of the participants. It was observed that the peak power obtained from the vertical jump explained the swimming performance by 21.7%. On the other hand, when the effect of the anaerobic peak power obtained from the arm Wingate on the swimming performance of the swimming children was examined, it was seen that the peak power of the arm explained the swimming performance by 26.8%. In conclusion, it is seen that the anaerobic power obtained from the arms and legs affects the short-distance swimming performance by approximately 50%. It can be said that the power produced from the arm is more important by 5%. For 50 meters swimming performance, it is recommended that trainers include exercises to increase arm strength.

Keywords: Anaerobic, free style, prepubertal, swimming.

Introduction

The researches emphasizing the development of aerobic power were done by Scandinavian researchers led by Astrand in the early 1960s. However, further studies in the late 1960s comparing trained swimmers of different ability levels showed that $V0_{2max}$ was a rather poor predictor of elite swimming performance because all swimmers had similar aerobic abilities. Later, a swimmer's ability to "delay" the appearance of lactic acid, which builds up in the muscles and is measured in the blood stream during high-intensity exertion, was pointed out. This concept was based on the assumption that a significant contribution from the swimmer's anaerobic energy system is required and there is an intensity level called the "anaerobic threshold" that cannot meet their overall energy demands during short intense activity (Rodríguez & Mader, 2011). Many of these studies were pioneered by German sports scientists such as Kindermann et al. (1979) and Mader et al. (1978). They believed that this anaerobic threshold occurred at a constant lactate level of 4 mmol/l blood (Mader et al., 1978). This type of training is focused on maximizing an athlete's ability to develop their aerobic energy system by taxing the athlete at or just below the level where the anaerobic lactate system begins to become more prominent and lactic acid begins to build up in the bloodstream. Anaerobic power and capacity are important sport-specific fitness components related to overall sports performance and injury prevention (Plowman et al., 2013). Although anaerobic performance is important for all kinds of sportive

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activities, its importance increases even more in some sports branches where anaerobic performance is predominantly used (Yüksek et al., 2017). Swimming is represented in 16 different Olympic branches ranging from 50 m to 1500 m. Those between 50-100 m are considered as short distance (sprint), those between 200 m are considered as medium distance and those between 400-1500 m are considered as long distance branches (Aspenes & Karlsen, 2012; Özgünen, 2011). Anaerobic processes are thought to be more dominant in swimming branches below 200 m (Marinho et al., 2011; Bozdoğan, 2005). Anaerobic power comes to the fore even more in short-distance swimming branches (50 m, 100 m), as sudden and high-intensity power generation is needed (Yapıcı & Cengiz, 2015; Mahmut, 2022; Zamparo et al., 2011). Many studies have found a relationship between anaerobic power and swimming performance (Sharp & Troup, 1982; Hawley & Williams, 1991; Hawley et al., 1992; Mercier et al., 1993). Therefore, the aim of this study was examine to effect of anaerobic power on short distance swimming performance in prepubertal male swimmers.

Methods

Participants

This relational model study aimed to assess the anaerobic power and short distance swimming performance in prepubertal male swimmers. Participants were students who regularly practiced swimming 5 times a week. A total of 20 male swimmers (age mean=11.40±1.39 yrs; height mean=145.60±11.41 cm; body weight mean=42.09±10.97 kg) participated in this study. Prior to commencing the study, the coaches, swimmers, and parents or legal guardians of each swimmer were fully informed about the aims of the research, its potential risks and benefits. Also, Written informed assent (children)/consent (legal representatives) were obtained before the start of the study. This study was approved by the Ethics Committee on Human Research of the institution of affiliation of the authors (approval: 2020-09). In addition, an informed consent form was obtained from the participants. All the procedures adhered to the guidelines of the Declaration of Helsinki.

Design and Procedures

All participants included in this study trained on mean two hours per session, five times per week. A mat was used to collect data on vertical jump. Swimming performance was evaluated for 50 meters in an Olympic swimming pool using a stopwatch. The arm Wingate was used to assess the anaerobic arm power of the participants. In order to control the effect of fatigue on the results of the study, no vigorous and intense activity was made by the coaches for the children 24 hours before the test. The methodology employed during the tests is summarized in the following paragraphs.

Measures

Vertical jumping for peak power

A demonstration of how to jump was provided to each child and then each child was allowed to practice the jump until they met the jump criteria, which mostly took two jumps. The jump was a countermovement jump with the use of arms. The jump began from a standing position, with plantigrade foot and the leg vertically aligned (i.e. knee angle approximately 180º). On instruction, the countermovement was performed and the knees flexed to approximately 90º before rapid extension and take-off. Landing (initial contact with the jump mat) was with toes initially and the knee angle extended at approximately 180º. If these criteria were not met, the jump was performed again. A Jump training system SMARTJUMP Mat (Smart jump, Fusion Equipment, Brisbane, AUS) was used to measure flight time, which in turn was used to calculate jump height. Children wore sports footwear for jumping. Each child was allowed two jumps using the correct technique and the best jump height was recorded and incorporated into the power prediction equation. The prediction equation (equation 1) of Sayers et al. (1999) was used to predict peak leg power (Ppeak): P_{peak} (W) = 60.7 X jumping height (cm) + 45.3 X body mass (kg) - 2055

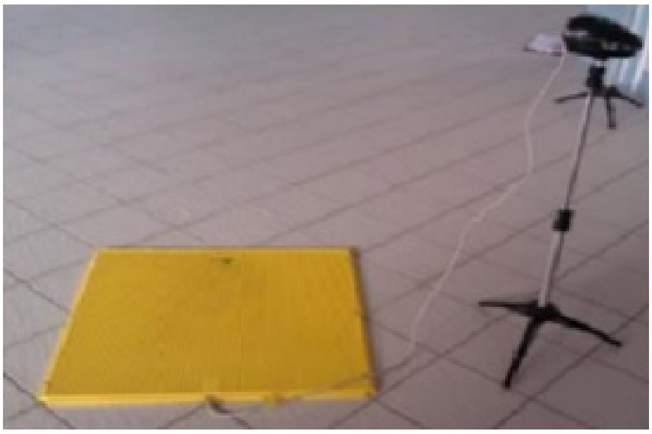

Figure 1. Smart Jump System.

Wingate anaerobic arm test for upper body anaerobic capacity

For the Wingate test for 30 sec with a resistance set at 6% of their body weight (Dotan & Bar-Or, 1983), a

Monarch 894E (made in Sweden) arm cycle ergometer that is modified for computer connection and compatible software were used. All swimmers were tested with a WAnAT at the same time of day (between 17:00 and 19:00) to avoid the effects of circadian rhythms (Souissi et al., 2004). Each player sat on an adjusted chair that allowed the shoulder to be at the same level with the center of the pedal axis and the elbow joint to be slightly flexed at the end point of the pedal cycle. The trunk was secured with belts over the thighs, waist, and chest. Before the test, there was a 5-min warm-up arm cranking with a resistance corresponding to 20% of the weight used as a load in the WAnAT at 60 rpm. After two 3-sec maximal efforts followed by 3 min of rest and stretching, the actual test was conducted. Revolutions were recorded every second with an optoelectronic reader. Strong verbal motivation was given during the test to all subjects. The produced power was corrected for the influence of inertia (Bassett, 1989; Kounalakis et al., 2009).

Short distance freestyle swimming performance

Swimming performance was conducted in a 50-m indoor swimming pool. All starts were voluntarily initiated by the swimmers. Three independent observers recorded performance times using stop watches. This was visually supervised by a qualified swimming coach. The mean of the three recorded values was used for further statistical analyses. The start signal for the observer was the moment as the swimmer's feet left the block. In addition, the consistency of swimming degrees was ensured by recording the camera during swimming. During the test, the temperature of the water was 26º C and the air temperature of the indoor pool was 27-28 ºC.

Data Analysis

SPSS IBM 22 statistical program was used to organize and calculate the obtained data. Data are summarized with mean and standard deviations. The normality test of the data was tested by dividing the skewness and kurtosis coefficients by their standard errors and using One Sample Kolmogorov-Smirnov tests, and it was determined that the data showed normal distribution. The homogeneity of the variances was tested with the Levene test and it was seen that the variances were equal. The effect of the independent variables on the dependent variable was tested with the Linear Regression test. This research was carried out at 0.05 error level.

Results

It was observed that the peak power obtained from the vertical jump explained the swimming performance by 21.7%. In addition, 1 unit change in peak power obtained from vertical jump affects swimming performance by 0.006. Swimming performance improves as the peak power for the vertical jumps of swimmers increases (Figure 2a). On the other hand, when the effect of the anaerobic peak power obtained from the arm Wingate on the swimming performance of the swimming children was examined, it was seen that the peak power of the arm explained the swimming performance by 26.8%. One unit change in the peak power of the arm affects the swimming performance by 0.044. At the same time, children's swimming performance improves as the peak arm strength increases (Figure 2b).

Table 1
Data summary for prepubertal male swimmers.

Variables	n	Mean	SD
Age (years)	20	11.40	1.39
Height (cm)	20	145.60	11.41
Body weight (kg)	20	42.09	10.97

Table 2
Mean and standard deviations of vertical jump, anaerobic arm power, and swimming performance of prepubertal male swimmers.

Variables	Mean	SD
Vertical jump height (cm)	26.44	6.21
Vertical jump peak power (watt)	1440.75	545.81
Wingate anaerobic arm peak power (Watt)	166.37	79.87
50 meter freestyle swimming performance (s)	44.78	6.72

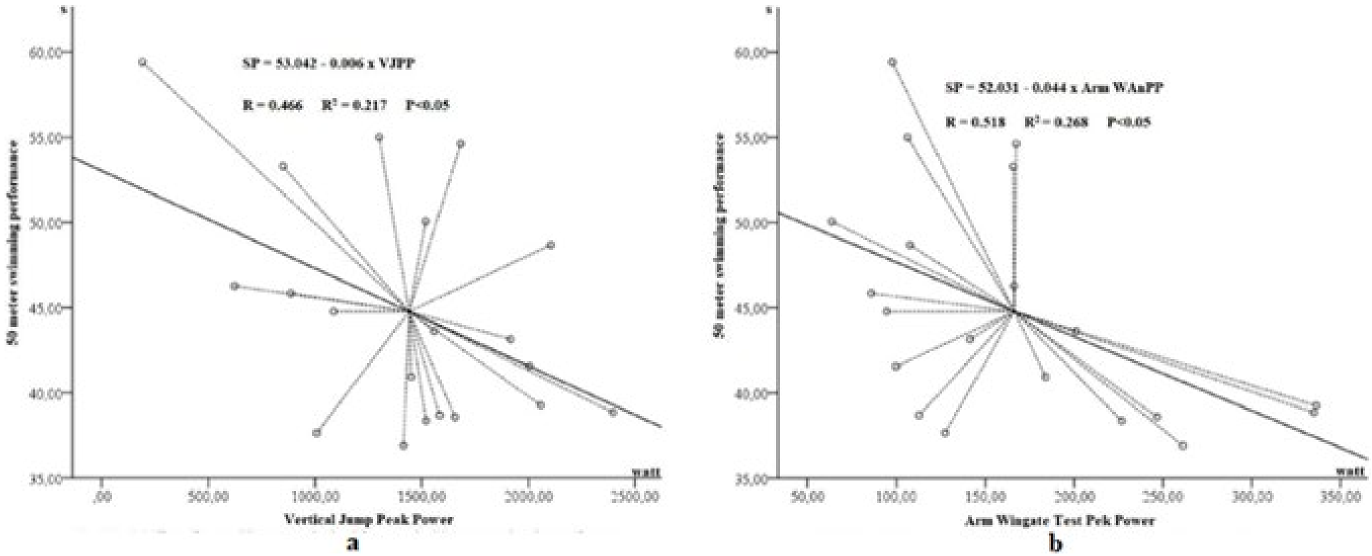

Figure 2. a) Effect of anaerobic power obtained from vertical jump on swimming performance. b) Effect of arm Wingate anaerobic power on swimming performance.

Discussion

In this study examining the effect of anaerobic power on swimming performance in swimming children, the peak power obtained from the vertical jump explained the swimming performance by 21.7% while the peak power of the arm explained the swimming performance by 26.8%. Like, it was found that the anaerobic mean power obtained from the arm Wingate explained the swimming performance by 27.3%. It has been determined that the anaerobic peak power per kilogram obtained from Arm Wingate explains the swimming performance by 20.2%, while the mean anaerobic power per kilogram explains the swimming performance by 22.8%.

Inbar & Bar-Or (1977) found a high correlation between mean power in the Wingate arm test and performance during 25 m freestyle swimming. Rohrs et al. (1991) found in their study that there was a high correlation between 25 and 50 yard swimming speeds and peak power while they found a higher correlation with mean power at 100 yards. In other studies, low correlations were found between upper body anaerobic test parameters and swimming performance (Guilherme et al., 2000; Ellis, 2010). When successful performances at 100 and 200 m distances were examined, it was stated that it was associated with mean power only in boys, and anaerobic mean power was positively correlated with the age of the athletes. It has been stated that the development of technical skills in older swimmers is important for more efficient use of anaerobic power in swimming. Partial correlation coefficients between 50 m freestyle swimming achievements and age-controlled mean power were calculated in the studies. Correlation coefficients: $r=-0.698$ ($p<0.006$) for girls and $r=-0.747$ ($p<0.001$) for boys. This shows some influence of swimming experience on swimming achievements of both genders. As the race distance increases, the correlation between anaerobic test results and swimming success decreases. This tendency is expressed in studies (Guilherme et al., 2000; Rohrs et al., 1991). Reilly & Bayley (1988) showed strong correlations between the results of the Cybex II dynamometer test, both maximum power and the amount of torque produced and swimming performance. Data collected via the Wingate protocol showed that maximal power and swimming performance were highly correlated. In a study found, the Wingate arm test and the 50, 100, 200, and 400-m crawl stroke swim tests, a high correlation was found between mean power and swimming speed obtained by performing the Wingate arm test during 50, 100, 200 and 400m swimming ($r=50.83$; $r=50.78$; $r=50.60$; $r=50.63$) (Hawley et al., 1992). While some studies have shown that relative anaerobic capacity is associated with short-distance swimming in young swimmers (Duche et al., 1993), they have stated that relative peak power is not a strong predictor of swimming performance since with the peak power test occurring within the first 5-6 seconds, the phosphagen energy system is dominant, while the glycolytic pathway is more dominant in anaerobic capacity (David et al., 2002). Guilherme et al. (2000) found the peak power, the mean power, and the fatigue index, which were obtained during the Wingate arm crank test, were not significantly correlated with the maximum swim velocities during the crawl freestyle tests of 14 (r=0.40; r=0.64; r=0.11), 25 (r=0.28; r=0.39; r=20.17), 50 (r=0.03; r=0.09; r=20.31), and 400 (r=20.52; r=20.37; r=20.65) m, respectively. Rohrs et al. (1990) found the peak power 56.9 W/kg and 5.4 W/kg, and the mean power 55.48 W/kg and 5.05 W/kg, respectively. Hollander et al. (1988) reported that the inclusion of the legs in swimming contributed only 4% to swimming speed during free swimming, with no significant difference in mean power output between the arms alone and between the whole strokes. Both studies showed that the longer the distance the swimmer swam, the less important the legs become, to the point where they can have an adverse effect other than a stabilizing effect. During a Wingate anaerobic test, a strong correlation was demonstrated between the muscle fiber percentage association ratio in the Vastus Lateralis and the peak power, mean power, and amount of fatigue in trained subjects (Froese & Houston, 1987; Bar-Or et al., 1980; Inbar et al., 1981; Jacobs et al., 1983). In a study by Doton & Bar-Or (1983), the differences in force production that occurred during test protocols are likely the result of differences in cross-sectional area of muscles in the upper body, but can also be explained in terms of fiber type morphology. Maud & Shultz (1989) reported that gender differences in mean power output during anaerobic power and capacity tests disappeared when expressed in relative terms (Watts per kilogram lean body mass). There are similar differences among athletes involved in different types of training. When swimming performance was evaluated by power, a Swim Bench test or Wingate arm test was used (Hawley & Williams, 1991; Sharp & Troup, 1982). Costill et al. (1985) and Sharp & Troup (1982) suggested that the correlation between swimming performance and the power measured by these tests is low when the subjects' performance is nearly equal and at a high level. Bampouras & Marrin (2009), in their study, compared the Wingate anaerobic test and the 14x25 m swimming test used to determine anaerobic power and capacity in underwater polo, and the 30 s jump tests performed under the shoulders of the athletes under water. They stated that there was no statistically significant relationship between the tests. Sharp & Troup (1982) and Mercier et al. (1993) found positive correlations with anaerobic power and swimming performance (r=0.9 and r=0.8, respectively). However, different test methods were used in both studies and Wingate tests were not performed. Sharp & Troup (1982) examined power using the Biokinetic Swim Bench to assess anaerobic power in swimmers. He found a high r = 0.9 correlation between mean power and a 25-yard swim. The high correlation rates may be due to similar muscles and muscle fibers used when using a Swim bench as in the pool. Yapıcı & Cengiz (2015) found a statistically significant relationship between 50 m free swimming performance and lower extremity Wingate anaerobic power and capacity test. In addition, there was no statistically significant relationship between Wingate fatigue index and 50 m swimming performance, relative anaerobic peak power, anaerobic capacity and anaerobic peak power; a statistically significant relationship was found between the relative anaerobic capacity, the relative minimum anaerobic power and the minimum anaerobic power. Işıldak (2018) examined the relationship between total leg volume and anaerobic power. It has been determined that there is a positive relationship between leg volume and anaerobic power. Işıldak et al. (2020) found that when the relationship between sprint swimming and leg volume was examined, there were significant relationships in the grades of the athletes. Several studies have found differences between men and women for absolute peak and average force production during a pool-based anaerobic assessment. It has been stated that force production in water is related to swimming performance (Zera et al., 2021; Dos Santos et al., 2013; Loturco et al., 2016; Morouço et al., 2014; Morouço et al., 2015). Other studies (Swaine & Winter, 1999) also tested swimmers using a Swim bench to assess aerobic parameters in different positions. Among swimmers, exercise intensity was found to be higher when using the Swim bench than with an adapter bicycle ergometer (Swaine & Winter, 1999).

Conclusion

In prepubertal male swimmers, it is seen that the anaerobic power obtained from the arms and legs affects the short-distance swimming performance by approximately 50%. It can be said that the other 50% is due to body, technical and psychological factors. It is thought that arm strength is more effective than leg strength in fifty meters freestyle swimming performance. It can be said that the power produced from the arm is more important by 5%. For short distance swimming performance, it is recommended that trainers include exercises to increase arm strength.

Authors' Contribution

Study Design: MB, AŞ; Data Collection: MB, AŞ; Statistical Analysis: MB, AŞ; Manuscript Preparation: MB, AŞ; Funds Collection: MB, AŞ.

Ethical Approval
The study was approved by the Dumlupınar University of Sports Science Faculty Ethical Committee (2020/09) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of interest
The authors hereby declare that there was no conflict of interest in conducting this research.

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