ORIGINAL ARTICLE

Influence of Physical and Anthropometric Properties on Sprint Swimming Performance

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ABSTRACT

Aim: The purpose of the present study was to investigate the effects of physical and anthropometric properties on sprint swimming performance.

Methods: Fifteen healthy and moderately active male swimmers [(mean±SD) age: 21.06±2.52 years; stature: 176.73±0.72cm; body mass: 75.35±13.71 kg; body fat %: 12.57±7.04; training age; 7.4±2.29 years; training session/week: 4.0±1.06] were participated as volunteer in this study. To determine the physical performance of the athletes; anaerobic power (countermovement jump), auditory reaction time, sit and reach test, and back extension strength was applied. To evaluate anthropometric measurements; stature, body mass, midstylion-dactylion, handbreadths, arm length, arm span, biacromial breadths, sitting stature, foot length, foot breadths, leg length, and shank length measurements were conducted. 50m and 100m freestyle swimming tests were applied to determine swimming performance.

Results: Statistically significant correlations were found between 50m freestyle swimming performance and stature (r=-0.606; p=0.01), arm length (r=-0.606; p=0.01), arm span (r=-0.562; p=0.02), leg length (r=-0.619; p=0.01) and shank length (r=-0.631; p=0.01). Likewise, there was a statistically significant correlation between 100m front crawl swimming performance and arm length (r=-0.521; p=0.04).

Conclusions: Anthropometric variables are important for 50 and 100 m freestyle swimming performance. Especially stature, arm length, arm span, leg length, and shank length. The respondents should consider anthropometric characteristics that are important for swimming performance.

Keywords: Swimming, anthropometric variable, anaerobic power, reaction time

INTRODUCTION

Swimming is an Olympic sport that is very popular around the world, it consists of freestyle, butterfly, breaststroke, and backstroke swimming styles (Banerjee, 2019). Swimming performance is affecting by numerous factors such as anthropometry, reaction time, endurance, speed, and muscle strength of swimmers. In previous studies, physical characteristics, anthropometric properties and some performance parameters of swimmers were examined. If you look at them briefly; Zampagni, (2008) reported that anthropometric and strength variables are good predictors for swimming performance. Propulsive power generated by swimmers affects the swimming performance (Sharp, 1982; Schneider and Meyer, 2005). The more propulsion force produced results in better displacement in water (Moura dos Santos, 2012). he propulsive power is affected by the swimming technique, biomechanical standards, and physical conditions of swimmers. The physical condition of swimmers depends on body composition and muscle strength (Schneider and Meyer 2005). Girold et al. (2006) found that a training-related strength increase improves swimming performance. Papoti et al., (2007) reported a correlation between force generated by swimmers and swimming performance. Anthropometry is another factor that affects swimming performance and helps predict swimming performance. Anthropometry is concerned with the measurement of the human body including body diameters, body circumferences (Banerjee, 2019). Anthropometric characteristics such as body height, arm span, and lean body mass highly determine the swimming technique (Latt, 2010). Moura et al., (2014) reported that anthropometric parameters correlated with propulsive force. Zampagni et al., (2008) found that body height, arm length, forearm length is negatively correlated with swimming times. Siders et al., (1993) reported a positive correlation between swimming times and body fat and a negative correlation between swimming times and body height for female swimmers. Geladas, (2005) investigated the correlation between anthropometry and 100 m swimming performance in young swimmers and height, upper extremity length, hand length, and foot length have been shown to correlate with swimming performance in male swimmers. Besides height, upper extremity length, and hand length were found to correlate with swimming performance in female swimmers. Grimston and Hay, (1986) reported that some anthropometric parameters correlated with stroke length and stroke frequencies, which are, affect the swimming speed. Besides they have suggested long-limbed individuals have an advantage for competitive swimming, so anthropometric measurements might be useful for the selection of talented athletes. As mentioned above strength and anthropometry affect the propulsive force. Therefore, swimmers perform better swimming performance with increasing propulsive force. Considering the above study results in the literature, swimming performance is affected by both anthropometry and physical performance.

Therefore, the purpose of this study was to examine the anthropometric properties and physical performance that affect 50-meter and 100-meter swimming performance.

MATERIAL & METHODS

Participants: Fifteen healthy and moderately active male swimmers [(mean±SD) age: 21.06±2.52 years; stature: 176.73±0.72cm; body mass: 75.35±13.71 kg; body fat %: 12.57±7.04; training age; 7.4±2.29 years; training session/week: 4.0±1.06] were participated as volunteer in this study. Each subject was informed about the procedures of the study (purpose, methods, contributions, and tests) in the first session. After that, we completed a medical history form and signed an informed consent each participant. This study was approved by the Clinical Research Ethics Committee of Abant Izzet Baysal University (Date: 20/12/2018, no: 245).

Experimental design: Procedures tests and assessments were conducted on three different sessions during the study period. On a first visit, anthropometrical and body composition parameters were assessed. On a second day, physical performance tests were conducted. On the third day, 50-m and 100-m freestyle swimming tests were applied in the 25-m swimming pool. Two weeks before the applications, participants were familiarized with all test protocols to avoid learning effects during the main test period. At this stage, each athlete had repeated the anaerobic power (countermovement jump), auditory reaction time, sit and reach, and back extension strength test. After that anthropometric measurements baseline values were taken; stature, midstylion-dactylion, handbreadths, length of the arm, arm span, biacromial breadth, sitting height, length of the foot, foot breadths, length of leg, and shank length. All anthropometric measurements were performed by the same person. The Schematic representation of the investigation is shown in Fig 1.

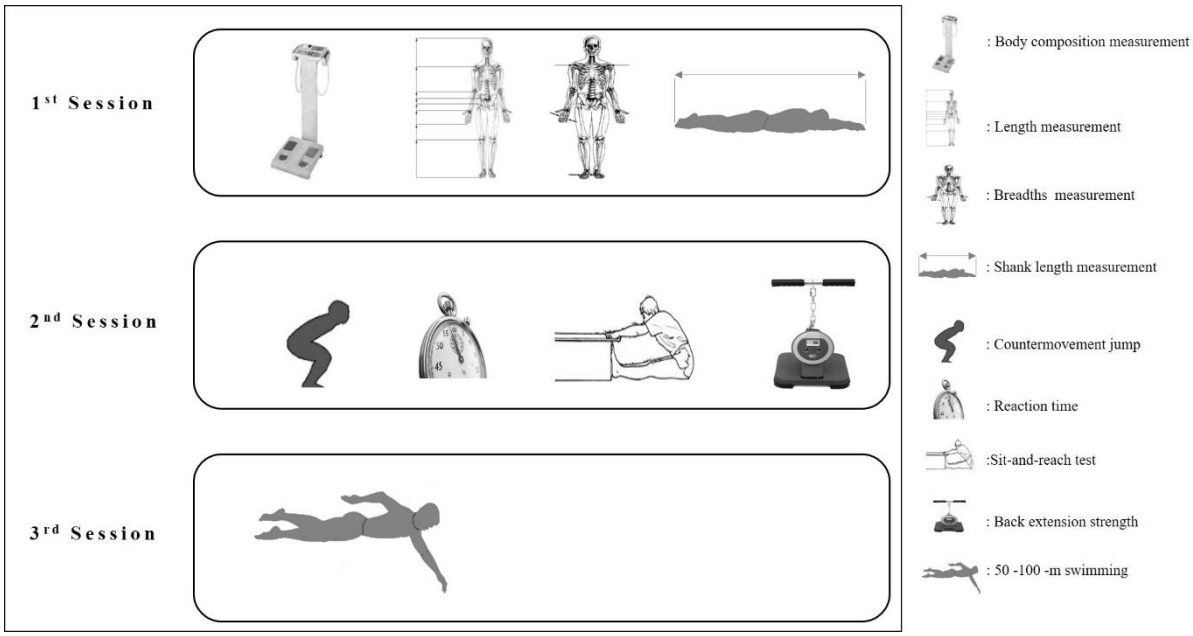

Fig 1. Schematic representation of the investigation

Anthropometric and Body Composition Measurements: For the stature, measurement to the nearest 0.1 cm via Stadiometer (Seca 700, Germany) was used. Body mass (±:0.1kg) and body fat percentage were assessed by using a bioelectrical impedance analyzer (BIA) (TanitaBC-418 MA; Tanita Corp., Japan). BIA measurements were performed in accordance with the manufacturer's procedures.

Midstylion-dactylion lenght: This measurement represents the length of the hand. For the measurement, a small sliding caliper was used. In the procedure of measurement, the subject assumes a relaxed standing position with the left arm hanging by the side. The right elbow is partially flexed, the forearm supinated, and the fingers extended. After that, the measurement was performed from the marked Midstylion line to the Dactylion (Marfell et al., 2012).

Length of Arm: The subject stood with the arms hanging loosely by the side of the body, fingers outstretched. The distance from the middle fingertip to the lateral part of the acromion process point was measured with a tape measure and recorded in cm (Marfell et al., 2012).

Arm Span: When the subject was standing with arms wide open parallel to the floor and hand was leaning against the wall, the distance between the middle fingertips was measured with a tape measure and recorded in cm (Norton et al., 2004).

Sitting Height: Sitting height is a measure of the upper segment of the body including the trunk, neck, and head heights(Mekjavic & Rempel, 1990). The subject was seated on a measuring box and instructed to take and hold a deep breath and while keeping the head in the Frankfort plane. After that measurement was performed between the sitting base and the top of the head (Marfell et al., 2012).

Length of Foot: The subject stands on the smooth floor relaxed standing position with the feet comfortably apart and weight evenly distributed. Between Akropodion to the Pternion distance was measured (Marfell et al., 2012).

Length of Leg: Leg length was measured in cm by measuring the distance between trochanterion and ground while the participants were in anatomical position (Marfell et al., 2012).

Length of Shank: When the subject was streamlining position, between fingertips and toes, was measured.

Handbreadths: Handbreadths measurement was performed between the distal ends of the 2nd and 5th metacarpals where the participant placed his hand on the table with his fingers facing the adjacent palm (Akın, Tekdemir, Gültekin, Erol & Bektaş, 2013).

Biacromial Breadths: The measurement was taken as the distance between the lateral borders of the acromion processes. The participant was standing position with the arms by the sides. The distance between the most lateral points on the acromion processes was measured with a large sliding caliper (Marfell et al., 2012).

Foot Breadths: The widest part of the foot was measured when the subject was standing.

Countermovement Jump (Bosco): To determined anaerobic power, the CMJ test was used. The test was conducted via Bosco Mat (Newtest 1000, Oulu, Finland). In this test, the athlete stood on the mat with weight evenly distributed over both feet. Hands were placed on the hips. The athlete squats down until the knees were bent at 90 degrees, the upper body kept straight. The athlete jumped vertically as high as possible and landed back on the mat with both feet hitting the ground at the same time. The best score of three attempts was recorded. 1-minute resting was given between trials. The time in the air was recorded. Power calculated with the formula shown below (Sayers et al., 1999)

Peak Power (Watts) = [60.7 x Jump height (cm)] + [45.3 x Body mass (kg)]-2055

Reaction Time: For the assessment of auditory reaction time Newtest 1000 reaction timer was used. The subject showed the response to the stimulus as soon as possible. The subjects were tested three times successively and best score was used.

Sit-and-Reach test: The subjects sat with their feet approximately hip-wide against the testing box. They kept their knees extended and slowly reached forward as far as they could by sliding their hands along the measuring board (López-Miñarro and Alacid, 2009). The last point they reached was recorded.

Back Extension Strength Performance: Measurement was conducted with Takei brand TKK 5402 model (Back-D, Takei Scientific Instruments Co. Ltd., Tokyo, Japan) back-leg strength dynamometer. The subject stood on the platform with the knees fully extended and the trunk flexed about 30° forward. The hand bar was positioned across the thighs, and thereafter the participants pulled it straight upward using the back muscle. Three trials were allowed with a 1-minute rest between the trials and the best score of three trials was recorded in kg force.

50-100m Swimming performance: The subjects underwent a 50-100-m swimming performance trial in 25 m swimming pool, under race conditions. All participants were included in the test after standard warm-up protocol (10-min jogging on land, 10-min on low speed swimming and short sprinting after that stretching exercise). 50m and 100m freestyle swimming was performed in the presence of referees. During the measurements, all athletes were given motivational feedback to demonstrate maximum effort. The swimming performance test was conducted via Casio brand hand chronometer. When the distance of 50-100 meter was completed, the degree obtained was recorded as 1/100 sec.

Statistical Analysis: The normality of distribution was assessed on all data using the Kolmogorov-Smirnov test. After that Means (M), standard deviations (SD), were calculated for all variables. The correlations between anthropometric variables, physical performance tests and 50-100m swimming performance were evaluated using the Pearson Correlation analysis. All analyses were evaluated with SPSS 20.0 version. Statistical significance was set at $p < 0.05$.

RESULTS

Mean (M± SD) 50-m performance time was 32.22 ± 2.51 sec, 100-m was 82.37 ± 10.28 sec. Descriptive statistics for anthropometrical, performance variables and their relationship with 50 and 100-m Freestyle swimming performance time variable are presented in Table 1.

Table 1. Anthropometrical, physiological parameters and their correlate with 50m-100m freestyle swimming performance of subjects (n =15).

Anthropometric variables	**M±SD**	**Correlation with 50-m (Swimming time)**	**Correlation with 100-m (Swimming time)**
Stature (cm)	176.7±0.72	**-.606***	-.489
Body mass (kg)	75.3±13.71	-.229	-.011
Body fat percentage (%)	12.5±7.04	.075	.252
Midstylion-dactylion (cm)	19.3±1.51	-.513	-.260
Hand breadths (cm)	8.66±0.48	-.371	-.298
Length of arm (cm)	78.0±4.61	**-.606***	**-.521***
Arm span (cm)	178.1±10.32	**-.562***	-433
Length of foot (cm)	26.1±2.02	.129	.246
Foot breadths (cm)	10.2±0.47	-.425	-.290
Length of leg (cm)	94.5±5.18	**-.619***	-.384
Sitting height (cm)	93.7±3.43	-.400	-.275
Biacromial breadths (cm)	40.8±2.63	-.272	-.397
Length of shank (cm)	237.7±12.34	**-.631***	-.458
Performance variables			
Audial reaction time (sec)	0.13±0.01	-.0.13	-.050
Anaerobic power (Watt)	3778,7±648,60	-.321	-.031
Sit-and-reach test (cm)	26,3±7,10	-.274	-.270
Back extension strength (kg)	154,6±22,23	-.230	-.010

* Statistically significant correlation ($p \leq 0.05$)

Table 1. Correlation analysis showed that 50-m freestyle swimming performance was significantly correlated stature (r=-.606; p=0.01), arm length (r=-0.606; p=0.01), arm span (r=-0.562; p=0.02), leg length (r=-0.619; p=0.01) and shank length (r=-0.631; p=0.01). Likewise, there is a statistically significant relationship between 100m freestyle swimming performance and arm length (r= -0.521; p=0.04).

DISCUSSION

This study investigated the contribution of different anthropometrical and performance parameters to sprint swimming performance in moderately active male swimmers. The main finding of this study was 50 m front crawl swimming performance was significantly related to stature, arm length, arm span, leg length, and shank length. Likewise, there was a statistically significant correlation between 100m front crawl swimming performance and arm length Table 1.

Previous studies have shown a correlation between swimming performance and anthropometric parameters (Latt, 2010; Demirkan, 2019; Geladas et al., 2005; Rozi, 2018; Jürimäe, 2007). In our study, 50-m swimming performance correlated with stature, length of the arm, arm span, length of leg, and length of the shank. Besides 100-m swimming performance was only correlated with the length of the arm. The correlation between stature and sprint swimming performance has been reported in the literature (Geladas, 2005; Rozi, 2018; Latt, 2010; Vitor, 2010; Zampagni, 2008). Besides, Cochrane et al., (2015) reported a correlation between stature and forearm flexion peak torque at 180°.s-1, forearm extension peak torque at 180°.s-1 estimated propulsion force. Moura et al., (2014) found a positive correlation between stature and propulsive force. The association of stature with swimming performance is attributed to taller swimmers that could be glide better through the water (Toussaint, 1994).

The correlation between length of the arm, arm span, and sprint swimming performance has been reported in the previous studies (Rozi, 2018; Latt, 2010; Moura, 2014; Zampagni, 2008). Akşit et al., (2017) reported the arm span related to critical swimming velocity and estimated propulsive force. Geladas et al., (2005) found a correlation between the length of the upper extremity and 100-m freestyle swimming performance. Moura et al., (2014) reported that propulsive force was positively affected by arm span. According to the results of our study, length of arm and arm span was related to swimming performance. This is probably due to the fact that the large upper extremity positively affects the propulsive force (Geladas, 2005; Latt, 2010). Therefore, swimming performance is positively affected by the lengths of the upper extremity.

Few studies have investigated the relationship between lengths of the lower extremity and swimming performance (Bond, 2015; Geladas, 2005; Vitor, 2010; Akşit, 2017). Bond et al., (2015) found a negative correlation between 100-m freestyle swimming time and upper leg length, foot length. Geladas et al., (2005) reported the relationship between 100-m freestyle swimming performance and foot length for boys, whereas 100-m freestyle swimming performance was not related to foot length for girls. Vitor et al., (2010) concluded that 100-m front crawl performance was not associated with foot length. Similarly, the correlation between foot length and swimming performance was not found in our study. Although there was no relationship with the length of leg, length of the shank, and 100-m swimming performance, length of leg and length of the shank was found related to 50-m swimming performance in our study.

Effects of strength and power of upper and lower extremity have been investigated in previous studies (Geladas, 2005; Demirkan, 2019; Vitor, 2010; Keiner, 2015; Zampagni, 2008; Cochrane, 2015). No significant correlation was found between short-distance swimming performance and athletic performance parameters in the present study. The relationship between jump performance and swimming performance was reported by the researchers (Geladas, 2005; Demirkan, 2019; Keiner, 2015). Demirkan et al., (2019) concluded Vitor et al., (2010) reported a correlation between anaerobic power and 100-m front crawl swimming performance. Apart from the strength and power of the lower extremity, the correlation between the strength of the upper extremity and swimming performance has been reported previously (Geladas, 2005; Zampagni, 2008; Cochrane, 2015). Our study reported that there was no correlation between flexibility and sprint swimming performance. Geladas et al., (2005) reported ankle and shoulder flexibility was not related to swimming performance for boys. However, they showed a correlation between shoulder flexibility and swimming performance for girls. Demirkan et al., (2019) concluded that flexibility was related to breaststroke and freestyle swimming performance.

CONCLUSIONS

To summarize the above results indicate that anthropometric property (stature, arm length, arm span, leg length, and shank length) are very important for front crawl sprint swimming performance especially 50 m. The practical advantage of this study is that anthropometric tests could be used to identify talented swimmers by assessing the anthropometric characteristics that influence swimming performance. It may be recommended to pay attention to these features when creating a team or choosing athletes for short-distance swimming.

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Conflict of interest: There is no conflicts of interest.

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