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The Investigation of Relationship between Anthropometrical and Physiological Parameters of Elite Young Boys in Breaststroke and Butterfly Swimming

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Abstract

Background: The relationship between anthropometrical and physiological parameters of elite young boys in breaststroke and butterfly swimming is essential. We aimed to investigate the relationship between anthropometrical and physiological characteristics with breaststroke and butterfly swimming time in elite swimmer boys.

Materials and Methods: This study was a descriptive research, comprised of 122 elite young boy swimmers (age 12-13 years; height 1.540±8.24 m; weight 47.820±6.84 kg), who participated in the national championship of the country's selection in 2018 in Shiraz, Iran, and who had signed the consent form Anthropometrical and physiological parameters were measured for 5 days. Pearson correlation coefficient was used to examine the relationships between variables.

Results: There were significant negative relationships between supraspinatus fat (r=-0.461, P=0.009), right leg strength (r=-0.376, P=0.037), and static balance (r=-0.629, P=0.0001) with 50 m breaststroke time, between leg power (jump length)(r=0.448, P=0.015), and static balance (r=-0.529, P=0.003) with 100 m breaststroke time, between head circumference (r=-0.472, P=0.023), and leg power (jump length)(r=-0.454, P=0.030) with 200 m breaststroke time, between subscapularis fat (r=-0.434, P=0.012), and trunk flexibility (r=-0.350, P=0.046) with 50 m butterfly time, between trunk flexibility (r=-0.445, P=0.029), and100 m butterfly time. Whereas, there were significant positive relationships between leg action and reaction velocity (r=0.411, P=0.013) with 50 m breaststroke time, between dynamic balance (Internal)(r=0.368, P=0.050), and 100 m breaststroke time, between leg power (jump length)(r=0.511, P=0.002), and 50 m butterfly time, between triceps fat (r=0.489, P=0.015), and subscapularis fat (r=0.561, P=0.004), and dynamic balance (lateral)(r=0.424, P=0.039) with 100 m butterfly time.

Conclusion: There was a significant relationship between anthropometrical and physiological characteristics with elite young boys in breaststroke and butterfly time.

Key Words: Anthropometrics, Talent identification, Physical Fitness Parameters, Students, Swimmers.

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1- INTRODUCTION

There are specific physical characteristics in many sports such as anthropometric and physical profile that indicate whether the player would be suitable to compete at the highest level in specific sports (1-3). Differences in the physical characteristics of young athletes might reflect the selection at a relatively young age for the body demands of a specific sport (2, 4). Athletes usually start serious training before the onset of puberty and achieve international competitive level at a relatively early age. Also, they start heavy training at a relatively young age (2, 4). Researchers are constantly trying to find and classify factors which determine the highest precision in the swimming performance (5-6). Masters swimming competitions dedicate much time and effort to excelling in masters events, as happens in elite sports (7).

Success in many sports may depend on the physical characteristics of young athletes (8). But, most of the scientific community focuses on adult/elite swimmers and only a few pay attention to their younger counterparts (i.e. children) (7). Although swimming performance is a multifactorial phenomenon (9), swimmers' physical characteristics have determined the characteristics of successful elite swimmers (10). Studies show that anthropometric, biomechanics, and physical fitness properties can be associated with exercise performance of human sports (2-3). The competition and swimming training usually start before puberty (11), because body structure can play an important part in determining the swimming performance level (12-14). The performance of the young athletes depends on training, physical growth and development (11). Physiological maturity during puberty and maturation process leads to change of anthropometrical and physiological parameters such as body height, body fat, upper extremity length, and skin-fold thickness in children and adolescents (15-17). Swimming performance is directly related to anthropometrical (1, 6), and physiological parameters (18-20). Some anthropometrical and physiological characteristics are highly related with young swimmers' performance (21). These indicators should be considered to predict the performance of adolescent athletes (4, 7). Therefore, identifying talent is the most important and most effective factor in successful competitive sports (2, 4). Anthropometrical and physiological factors are important for swimming competitive performance (22-23) to achieve success and there is a strong correlation between age and height with swimming performance (24). Therefore, the appropriate selection of athletes in sports considering their body physical structure and physical capacities can prevent wasting time and inappropriate investment. So, understanding the relationship between anthropometrical and physiological parameters and race time is very crucial (25).

As previously mentioned, anthropometric and physiological parameters are highly related with young swimmers' performance (1); but only a few studies considered the relationship between anthropometric and physiological parameters with performance and reported contradictory results, and no relationship with performance (20-22, 26-28). Dokumaci et al. (2017) reported that there is a strong correlation between anthropometry (height, upper limb length, and bi-iliac diameter), and 50m, 100m and 400m in young male swimmers (28). Sammoud et al. (2017) showed that fat-mass was the singular most important whole-body characteristic in butterfly swimming speed performance (29). Salehi et al. (2015) showed a direct correlation between Sargent jump records and sitting height, LBM and fat calf in swimming.

They showed significant negative relationships between swimmers record with arm length, forearm length, hand length, arm span length, foot length, the width of the palm, forearm circumference, hand grip strength, body fat percentage, the history of swimming, the ratio of forearm length to height and the lean body mass (LBM) to height (30). Morais et al. (2013), and Lätt et al. (2010) reported a positive correlations between hand and foot size with performance in swimming (2, 21). Knechtle et al. (2010) indicated that swimming race performance was inverse related with anthropometry in elite ultra-endurance swimmers (22).

Whereas, Eichtenberger (2013) showed that anthropometric characteristics have no relationship to race time with the exception of body mass index in men (31). Zuniga et al. (2011), and Malina et al. (2004) showed that non-significant relationship between anthropometrical and physiological parameters with swimming performance in both genders at early age (20, 26). To our knowledge, no studies have investigated different variables (anthropometrical, body composition, and physiological parameters) as predictors of short swimming distances in young swimmers. Therefore, the aim of the current study was to investigate the relationship between anthropometrical and physiological parameters with performance of young swimmers in breaststroke and butterfly swimming for predicting and identifying talent in this swimming.

2- MATERIALS AND METHODS

2-1. Study design and population

In this cross sectional, survey research study, 122 elite young boy swimmers (age range 12-13 years; height 1.540±8.24 m; weight 47.820±6.84 kg), who achieved top ranks in their provinces' competitions and participated in the national championship of the country's selection in 2018 in Shiraz, signed the consent form were selected. Anthropometrical and physiological parameters were measured for 5 days. Anthropometrical (seated height, head circumference, arm span, trunk circumference at nipple height, trunk circumference at hip, forearm length, hand length, thigh length, tibia length, foot length, triceps fat, subscapularis fat, supraspinatus fat), and physiological (trunk flexibility, right and left leg strength, right and left leg power, leg action and reaction velocity, static balance, dynamic balance [inferior, posterior, lateral, internal] parameters were measured in Shiraz Enghelab pool for 5 days. **Table.1** shows number of swimmers, non-cooperative (fallen) (due to lack of cooperation on the measurement of two anthropometrical and physiological parameters), and number of subjects in 50m breaststroke, 100m breaststroke, 200m breaststroke, 50m butterfly, and100m butterfly of young elite boys in Iran national competition.

Table-1: Number of swimmers participated in the national championship of the country's selection in 2018 in Shiraz, number of non-cooperative (fallen) swimmer boys, and number of young elite swimmer boys who participated in this study.

Swimming	50 m Breast stroke	100 m Breast stroke	200 m Breast stroke	50 m Butterfly	100 m Butterfly
Number of swimmers	40	37	31	43	34
Number of non-cooperative (fallen)	9	8	8	10	10
Number of subjects in this study	31	29	23	33	24

2-2. Measuring tools

2-2-1. Anthropometrical Parameters:

Anthropometrical (seated height, head circumference, arm span, trunk circumference at nipple height, trunk circumference at hip, forearm length, hand length, thigh length, tibia length, foot length, triceps fat, subscapularis fat, supraspinatus fat), and physiological (trunk flexibility, right and left leg strength, right and left leg power, leg action and reaction velocity, static balance, dynamic balance [inferior, posterior, lateral, internal]) parameters were measured by author. The weight without shoes was measured using the standard digital weighing scale (Omron HBF400). Shoeless height was measured after deep breathing using a graded wall with a one meter Chinese rubber band meter, with a sensitivity of one millimeter. Height was measured with a Stadiometer while the subject's head, shoulders, buttocks and ankles were connected to the wall. Seated height was measured in sitting position from head to hips; also body mass index (BMI) was measured by weight (kg)/height×height (m^2).

To measure arm spam, the arms are open and are parallel to the ground. The distance between the tip of the third right and the tip of the third left finger are measured after a deep breath using a graded wall with meter. The head circumference is measured from the temporal region with a meter. The chest circumference was measured with a meter at the height of the nipple while the subject was standing anatomically, and the arms were slightly away from the trunk, from the sternum in the fourth joint in the anterior part and a point marked on the same horizontal plate in the chest posterior. The hip circumference was measured with a meter horizontally in the serine muscle area while the subject was standing anatomically. The length of the forearm was measured with caliper in a standing position from olecranon to styloid process at the posterior, the hand was bent at the elbow, and the forearm was 90°. The length of the hand was measured with a meter while the subject was standing, the hand was bent at the elbow and the forearm was 90°, from the 3rd metatarsal to 3rd distal phalanx at anterior part. The length of the thigh was measured at the distance of the greater trochanter of the thigh to the head of the patella, while the subject was sitting on a chair with his knee bent 90°. Tibia length was measured from the patella to the ankle while the subject was sitting on a chair at 90 degree knee angle. All limbs' circumference were measured using a China rubber band meter, with a sensitivity of one millimeter.

All limbs' lengths were measured with China VERINER caliper with a sensitivity of 0/02 mm. Triceps fat thickness was measured by Iran Pouya Caliper, 99.32% and validity 99.8 % with sensitivity (0,5 mm), in the back of the arm between the shoulder and elbow joints, in a vertical direction. Subscapularis fat was measured by Iran Pouya Caliper from back to below the shoulder blade (subscapular) that is located below the shoulder blade at 45 degrees. Supraspinatus fat was measured by Iran Pouya caliper from the top of the iliac crest, the protrusion of the pelvic bone, slightly forward from the waist at the horizontal level (19, 29).

2-2-2. Physiological parameters including:

Trunk flexibility was measured with China meter, while subject stood up and spread his legs shoulder-width apart, then bent over and pulled his hands between his legs as far back as he could. The distance from the center of the feet to the tips of the foot fingers was measured in this position. Highest leg strengths were measured while subject stood on the dynamometer and pulled the handle towards himself (the Grip Dynamometer-Blue model (0-130 Kg) of the American model) with maximum effort, in two steps. Leg action and reaction velocity was measured by leg Nelson test while subject sat on the chair with straight knees, then the examiner dropped the ruler between two toes, the subject picked it up with his toes and the value was measured at this point. The time of Static Balance was measured by Flamingo Balance with timer (KhosRo1/ 100SECSW50). Dynamic Balance was measured by Star Excursion Balance Test in a graded earth in 4 directions (anterior, posterior, inner and outer) with meter. Leg power (high jump) was measured while subject stood by the graded wall and touched it with his hand over his head. Then he performed the Sargent jump to the top, and the highest point he could reach, was measured. Leg power (high jump) was measured by long jump, while the subject jumped forward on the graded ground and on paired legs. Then the last point of the foot hitting the ground was measured (5, 32, 33).

2-3-Ethical consideration

All measurements were performed in duplicate. The Ethics Committee of the Sport Sciences Research Institute of IRAN (IR.SSRI.REC.1397.353) has approved this protocol. All swimmers and their coaches were informed of the purposes and methods of the study and a written informed consent was obtained from the athletes, coaches and parents before participation in the study.

2-4. Inclusion criteria

Subjects were athletes participating in the national swim competitions who won first to third positions in their provinces and had been selected for national championships.

2-5. Data Analyses

The normality of distribution was assessed on all data using the Shapiro-Wilk test. Mean ± standard deviation (SD) values were used for all data. The relationship between anthropometrical and physiological parameters with swimming time were analyzed with Pearson correlation coefficient. A $p<0.05$ and 95% confidence intervals (CIs) were considered to be statistically significant. SPSS for Windows, version 25.0 (SPSS Inc., Chicago, IL) was used for all analyses.

3- RESULTS

Shapiro-Wilk test showed that all data have normal distribution at $P <0.05$. **Table.1** shows baseline characteristics of subjects including age, height, weight, BMI, history of swimming, and swimming time.

Table-1: Baseline characteristics of subjects of young elite boys in national competitions.

Parameter, mean± SD	50 m Breaststroke (n=31)	100 m Breaststroke (n=29)	200 m Breaststroke (n=23)	50 m Butterfly (n=33)	100 m Butterfly (n=24)
Age (year)	12.35±0.49	12.31±0.47	12.26±0.45	12.30±0.47	12.38±0.50
Weight (Kg)	45.66±8.15	46.09±9.08	46.96±7.14	46.61±8.61	46.06±9.06
Height (cm)	152.58±9.28	151.83±8.60	152.93±8.56	153.28±9.07	153.15±9.06
BMI (Kg/m^2)	19.51±2.42	19.83±2.47	19.60±2.43	19.70±2.34	19.49±2.49
History of swimming (year)	5.26±0.14	5.27±0.13	5.26±0.13	5.28±0.14	5.30±0.14
Time (Second)	43.23±5.30	98.31±10.68	203.16±16.67	37.52±4.56	86.32±9.90

SD: Standard deviation.

Tables 2 and 3 show mean of anthropometrical and physiological parameters and their relationship with 50 m breaststroke (43.23±5.30 S), 100 m breaststroke (98.31±10.68 S), 200 m breaststroke (203.16±16.67 S), 50 m butterfly (37.52±4.56 S) and 100 m butterfly (86.32±9.90 S) of Iranian young elite boy swimmers. **Table.2** shows that there was a significant negative relationship between supraspinatus fat (r = -0.461, P=0.009) with 50 m breaststroke swimming time. There was a significant negative relationship between head circumference (r = -0.472, P = 0.023), and 200m breaststroke swimming time. There was a significant negative relationship between subscapularis fat (r=-0.434, P=0.012), and 50m butterfly swimming time. Whereas there was a significant positive relationship between triceps fat (r=0.489, P=0.015), and subscapularis fat (r=0.561, P=0.004) with 100 m butterfly swimming time. In contrast, there were no significant relationships between anthropometrical parameters with 100 m breaststroke, swimming time.

Table-2: The relationship between anthropometrical parameters with 50 m breaststroke, 100 m breaststroke, 200 m breaststroke, 50 m butterfly and 100 m butterfly swimming time of Iranian young elite boy swimmers.

Parameters	50 m Breaststroke (n=31)	100 m Breaststroke (n=29)	200 m Breaststroke (n=23)	50 m Butterfly (n=33)	100 m Butterfly (n=24)
Seated height (Cm)	78.15±5.16 r=0.0001 P=0.998	78.42±4.40 r=0.167 P=0.386	78.14±5.06 r=-0.203 P=0.353	78.08±5.71 r=-0.116 P=0.521	77.78±4.99 r=0.013 P=0.954
Arm Span (Cm)	156.79±9.42 r=-0.329 P=0.071	156.17±9.62 r=-0.188 P=0.329	175.50±9.74 * r=-0.472 P=0.023	158.94±10.90 r=-0.082 P=0.652	158.63±9.30 r=0.154 P=0.472
Head circumference (Cm)	54.06±3.52 r=-0.106 P=0.569	54.29±3.43 r=-0.242 P=0.205	54.33±3.83 r=-0.070 P=0.751	54.37±2.55 r=0.136 P=0.450	52.80±6.89 r=-0.371 P=0.074
Trunk Circumference at Nipple Height (Cm)	74.09±9.29 r=-0.168 P=0.368	74.04±9.91 r=-0.108 P=0.576	74.08±9.86 r=-0.242 P=0.266	77.47±6.84 r=0.042 P=0.818	76.01±12.53 r=-0.206 P=0.335
Trunk Circumference at Hip (Cm)	72.06± 12.56 r=-0.023 P=0.902	72.62±13.44 r=0.055 P=0.778	72.21±13.58 r=-0.006 P=0.979	74.88±9.11 r=0.050 P=0.782	75.15±9.64 r=0.098 P=0.649
Forearm Length (Cm)	24.79±4.97 r=-0.117 P=0.530	24.59±4.73 r=-0.194 P=0.313	24.13±2.75 r=-0.402 P=0.057	24.78±4.83 r=-0.099 P=0.582	24.67±4.68 r=-0.114 P=0.595
Hand Length (Cm)	17.76±2.63 r=-0.322 P=0.077	17.88±3.18 r=-0.205 P=0.286	18.47±3.39 r=0.082 P=0.711	17.67±2.06 r=-0.233 P=0.192	18.23±2.78 r=-0.166 P=0.439
Thigh Length (Cm)	43.67±6.02 r=-0.338 P=0.063	43.48±6.37 r=-0.157 P=0.415	43.71±6.33 r=-0.131 P=0.550	45.30±5.09 r=-0.122 P=0.498	45.55±4.19 r=-0.196 P=0.358
Tibia Length (Cm)	38.03±5.90 r=-0.315 P=0.084	38.51±5.08 r=-0.253 P=0.185	40.08±4.30 r=-0.392 P=0.064	37.92±5.85 r=0.060 P=0.740	38.26±4.75 r=0.179 P=0.403
Foot Length (Cm)	25.32±4.02 r=-0.291 P=0.113	24.50±2.53 r=-0.182 P=0.344	24.97±2.53 r=-0.158 P=0.473	25.89±3.90 r=0.152 P=0.400	25.86±3.93 r=0.014 P=0.950

Triceps Fat (mm)	9.52±3.97 r=0.215 P=0.246	10.84±5.32 r=0.364 P=0.052	9.54±4.31 r=0.236 P=0.279	9.09±3.91 r=0.289 P=0.103	8.73±3.42 * r=0.489 P=0.015
Subscapularis Fat (mm)	9.03±3.58 r=0.338 P=0.063	9.64±4.22 r=0.186 P=0.333	8.96±3.71 r=0.271 P=0.211	8.80±3.48 * r=-0.434 P=0.012	8.77±3.61 ** r=0.561 P=0.004
Supraspinatus Fat (mm)	9.27±3.96 ** r=-0.461 P=0.009	9.71±4.05 r=0.307 P=0.105	8.98±3.72 r=0.167 P=0.446	8.70±3.61 r=0.322 P=0.068	8.40±3.71 r=0.377 P=0.069
Performance (time) (Second)	43.23±5.30	98.31±10.68	203.16±16.67	37.52±4.56	86.32±9.90

* Correlation is significant at P<0.05. ** Correlation is significant at P<0.01.

Table 3 shows that there was a significant negative relationship between right leg strength (r=-0.376, P=0.037), and static balance (r=-0.629, P=0.0001) with 50 m breaststroke swimming time. There was a significant negative relationship between leg power (jump length) (r=-0.448, P=0.015), and static balance (r=-0.529, P=0.003) with 100 m breaststroke swimming time. There was a significant negative relationship between leg power (jump length) (r=-0.454, P=0.030) and 200 m breaststroke swimming time. There was a significant negative relationship between trunk flexibility (r=-0.350, P=0.046), and 50 m butterfly swimming time. There was a significant negative relationship between trunk flexibility (r=-0.445, P=0.029), and 100m butterfly swimming time. Whereas there was a significant positive relationship between leg action and reaction velocity (r=0.411, P=0.013) with 50 m breaststroke swimming time. There was a significant positive relationship between dynamic balance (internal) (r=0.368, P=0.050), and 100m breaststroke swimming time. There was a significant positive relationship between leg power (jump length) (r=-0.511, P=0.002), and 50 m butterfly swimming time. There was a significant positive relationship between dynamic balance (Lateral) (r=0.424, P=0.039), and 100 m butterfly swimming time.

Table-3: The relationship between physiological parameters with 50m breaststroke, 100m breaststroke, 200m breaststroke, 50m butterfly and 100m butterfly swimming time of Iranian young elite boy swimmers.

Parameter		50 m Breaststroke (n=31)	100 m Breaststroke (n=29)	200 m Breaststroke (n=23)	50m Butterfly (n=33)	100 m Butterfly (n=24)
Trunk Flexibility (cm)		26.16±5.95 r=-0.255 P=0.166	26.56±6.54 r=-0.162 P=0.401	26.51±6.33 r=-0.344 P=0.108	25.88±6.69 * r=-0.350 P=0.046	24.92±6.46 * r=-0.445 P=0.029
Leg Strength (Kg)	Left	23.97±6.07 r=0.315 P=0.084	23.38±4.98 r=-0.174 P=0.365	25.13±6.68 r=-0.326 P=0.129	24.97±6.81 r=0.004 P=0.984	24.73±7.27 r=-0.350 P=0.094
	Right	24.37±5.20 * r=-0.376 P=0.037	22.88±5.12 r=-0.262 P=0.170	23.98±4.72 r=-0.103 P=0.639	25.76±5.78 r=0.159 P=0.377	25.25±5.46 r=-0.219 P=0.305
Leg Power (Cm)	High Jump	32.97±13.81 r=-0.139 P=0.455	33.47±12.40 r=0.235 P=0.219	31.91±13.47 r=0.003 P=0.988	32.62±15.96 ** r=0.511 P=0.002	29.10±13.59 r=0.294 P=0.163
	Length Jump	161.58±18.67 r=-0.299 P=0.102	155.84±16.97 * r=-0.448 P=0.015	159.89±18.87 *r=-0.454 P=0.030	158.90±14.65 r=-0.195 P=0.276	160.19±14.46 r=-0.271 P=0.199

Leg Action and Reaction Velocity (cm)		21.58±6.74 * r= 0.411 P=0.013	21.93±8.21 r=0.279 P=0.143	21.73±7.69 r=0.403 P=0.056	20.88±6.13 r=0.129 P=0.473	21.01±6.59 r=0.153 P=0.474
Static Balance (S)		42.86±11.87 ** r=-0.629 P=0.0001	41.45±12.82 ** r=-0.529 P=0.003	45.11±8.83 r=-0.406 P=0.054	43.09±11.19 r=-0.177 P=0.323	43.08±11.49 r=-0.071 P=0.741
Dynamic Balance (cm)	Inferior	76.85±8.26 r=-0.083 P=0.656	75.72±9.02 r=-0.079 P=0.682	75.48±9.27 r=-0.360 P=0.092	77.27±7.28 r=0.132 P=0.463	75.23±7.99 r=-0.247 P=0.246
	Posterior	74.13±12.94 r=-0.051 P=0.787	72.43±12.95 r=0.072 P=0.712	71.13±13.58 r=-0.307 P=0.154	70.15±14.55 r=-0.015 P=0.933	71.47±10.95 r=0.134 P=0.532
	Lateral	68.88±12.11 r=-0.129 P=0.489	65.47±11.31 r=-0.058 P=0.764	65.69±12.32 r=-0.140 P=0.525	68.23±10.81 r=0.257 P=0.149	68.81±11.63 * r=0.424 P=0.039
	Internal	57.45±18.31 r=-0.195 P=0.293	55.46±16.86 * r=0.368 P=0.050	54.17±17.12 r=-0.157 P=0.475	52.09±14.55 r=0.002 P=0.990	50.33±14.19 r=0.069 P=0.750

* Correlation is significant at P<0.05. ** Correlation is significant at P<0.01.

4- DISCUSSION

The aim of this study was to investigate the relationship between anthropometrical and physiological parameters with swimming time of young boy elite swimmers for talent identification and performance predicting. Our results showed that there was a significant negative relationship between supraspinatus fat, right leg strength and static balance with 50 m breaststroke swimming time. Whereas, there was a significant positive relationship between leg action and reaction velocity with 50m breaststroke swimming time. Increasing supernatant fat reduces the 50m breaststroke swimming record in the present study. The probable reason is that by increasing the percentage of supernatant fat, the buoyancy of the body increases, which helps maintain the balance of body in 50m breaststroke and improves swimming time. The existence of a significant negative relationship between right leg strength and record (time) of 50 m breaststroke swimming showed that, with increasing right leg strength, the swimming time decreases. So, with increasing strength of the limbs, which is a biomotor ability in adolescent elite swimmers, in the present study 50 m breaststroke swimming time decreased and the record improved (33-36). Increasing leg strength increases forward force in water. Thus, the body of swimmer moves forward with more force and power. Elite swimmers have more power to accelerate in the water (33-36). Increasing static balance led to improved coordination of leg action and created more pauses to perform powerful 50 m breaststroke swimming, thus improved 50m breaststroke swimming time in the present study. Increasing leg action and reaction speed led to increase in 50 m breaststroke swimming time, it means that the increase of leg action and reaction speed, the record of 50m breaststroke swimming worsens. In breaststroke swimming, leg movements are performed alternately and sequentially. Leg movements help to maintain the harmonious position of the body. Increasing leg action and reaction speed prevents strong and powerful performance of foot whip movements. Therefore, with increasing leg action and reaction speed, swimming speed decreased. On the other hand, leg kicking and continuous action leads to stabilization of body position and provides the necessary balance for optimal swimming. In the 50 m breaststroke, no side stroke is necessary to facilitate body balance. Increasing leg action and reaction speed leads to decrease the legs' strength. The weak kick due to increase of leg action and the reaction speed in 50m breaststroke swimming in the present study probably prevented optimal balance of the body (33-36). There was a significant negative relationship between leg power (jump length) and static balance with 100m breaststroke swimming time. Whereas, there was a significant positive relationship between dynamic balance (internal) and 100 m breaststroke swimming time. So, with increasing foot power (length jump), the swimming time decreases and as the leg power increases (jump length), the swimming time increases. The swimmers performance is affected by the athletes' physical active strength (37). As mentioned, increasing static balance means decreasing 100 m breaststroke swimming. Increasing static balance led to improved coordination of leg action and thus improved 100 m breaststroke swimming time in the present study. Increasing dynamic balance (Inferior) means increasing the inside movements (33) during 100m breaststroke swimming. In breaststroke swimming, the swimmer must avoid slowing down in the water due to excessive movement of the arms and legs to the sides (38). The coordination of hands and feet in breaststroke swimming affects the performance of swimming through the stability of the central muscles of the body, which is the main factor in transmitting force to the forward arm in the water (38). Increasing the coordination of the hands and legs improves the speed of swimming by increasing the stability of the central muscles of the body (38). Therefore, in order to increase the vertical speed and improve the 100 m breaststroke swimming record, the less the lateral movements, especially in the lower limbs, the better the swimming speed and record. So, it can be said that the more the dynamic balance (internal) of the foot in the present study, the greater the increase of the 100 m breaststroke swimming (38). There was a significant negative relationship between head circumference and leg power (jump length) with 200 m breaststroke swimming time. The existence of a significant negative correlation between head circumference and record (time) of 200 m breaststroke swimming means that 200 m breaststroke swimming time decreases as the head circumference increases and the swimming time decreases. Larger head circumference increases body balance and maintains body position in 200 m breaststroke swimming, which leads to a reduction in time and improves the 200 m breaststroke swimming record in the present study. Body movement, the head hitting the surface of the water and creating the driving force for progress in the water is important in 200 m breaststroke swimming.

Also, getting the head out of the water and strong breathing and creating a wave-shaped body movement is essential for progress in the water in 200 m breaststroke swimming (38). As mentioned above, the swimming time decreases and as the leg power increases (jump length), the 200 m breaststroke swimming time increases. It means the increase of leg strength (jump length) has a positive effect on the record of swimming. The swimmers performance is affected by the athletes' physical active strength (37). Swimming is a sport which involves all of these activities and depends on the power developed by both the upper and the lower limbs, especially in short and medium distance events (25), such as 100m and 200 m breaststroke swimming time. A stronger kick makes a major contribution to the forward propulsion in swimming (39). Therefore, a greater ability to generate propulsive force seems to contribute effectively to a better displacement in water. So, the probable reason of negative relationship is induced by a stronger contact kick with the increase in leg power (jump length). Our results showed that there was a significant negative relationship between subscapularis fat and trunk flexibility with 50 m butterfly swimming time. Whereas, there was a significant positive relationship between leg power (jump length) with 50 m butterfly swimming time. As mentioned, the probable reason is that by increasing the percentage of supernatant fat, the buoyancy of the body increases, which helps maintain the balance of body in 50m butterfly and improves swimming time. Lack of flexibility and range of motion of joints cause technical weakness, unsuccessful implementation of skills and prevent the achievement of maximum speed in swimming (38). Optimal flexibility and range of motion of joints make breaststroke swimming more efficient and delays fatigue (38). Also, the more flexibility and consequently the range of motion of joints, the better the grab and pull of water and the greater the ability to move in the water. Also, the method of warm-up affects the flexibility and range of motion of the joints (38).

So, exercise program to increase muscle strength and range of motion of the joints is effective in reducing fatigue and improving performance (38). Therefore, due to the negative relationship between trunk flexibility and (38) 50 m and 100 m butterfly swimming time in the present study, trainers are recommended to implement appropriate training programs to improve trunk flexibility and range of motion of joints. By increasing the trunk flexibility, the shoulder and trunk muscles will become softer and generate better coordination. Therefore, the more force applied, the more improvement occurs in the swimming record (36-37). More tensile force in butterfly swimming in the stretching and pressure stage results in the swimmer progressing and performing faster (40). The optimal trunk flexibility is determined mainly by the athlete's physical characteristics and produces a larger force (33). This force is influenced by the trunk flexibility of the athlete. Optimal speed depends on the swimming mechanics, the athlete's coordination technique, body size, body composition, and the relationship between motor and motor abilities (33-37). Therefore, with increasing trunk flexibility, the 50 m butterfly swimming time in adolescent elite swimmers in the present study decreased and the record improved. In contrast with 100 m and 200 m breaststroke swimming, the existence of a significant positive relationship between leg power (jump length) and 50 m butterfly swimming time showed that, with increasing leg power (jump length), the swimming time. It means the increase of leg strength (jump length) has a negative effect on the swimming record. Increasing leg power (jump length) in 50 m butterfly led to an increase in 50 m butterfly swimming time and its record worsened.

The probable reason is increase of strength and power of leg muscles without increasing strength of the other muscles of the body. So, optimal balance in 50 m butterfly swimming time in the present study is disturbed. This is probably due to the mismatch between increasing strength and power of the upper and lower limb muscles and thus the reduced coordination of hand and foot movements (34, 36) in the present study in 50 m butterfly swimming. There was a significant negative relationship between trunk flexibility with 100 m butterfly swimming time. Whereas there was a significant positive relationship between triceps fat and subscapularis fat, and dynamic balance (lateral) with 100 m butterfly swimming time. As mentioned, optimal flexibility and range of motion of the joints make breaststroke swimming more efficient and delays fatigue (38). The more the flexibility and consequently the range of motion of the joints, the better the grab and pull of the water and the greater the ability to move in the water (38). As fat increases in the triceps and subscapular, the strength of the hand muscles in the scapula and arm decrease. In butterfly swimming, hand strength is essential for elite swimmers to reduce butterfly swimming time. Therefore, with the increase of triceps and scapular fat in the present study, the strength of the muscles in the shoulder and arm in 100 m butterfly swimming decreased and the 100 m butterfly swimming time increased (38). As mentioned, to increase vertical speed and improve the butterfly swimming time, the less lateral movements, especially in the lower limbs, the better the swimming speed and record. Therefore, it can be said that the greater the increase of dynamic balance (internal) of foot, the more excessive the lateral movements and the slower the 100 m butterfly swim speed (Rafsanjan, swimming) in the present study. Our results are consistent with Dokumaci et al. (2017) (28), Sammoud et al. (2017) (36) Salehi et al. (2015) (30), and Knechtle et al. (2010) (22). However, our results are inconsistent with Eichtenberger (2013) (31), Zuniga et al. (2011) (20), and Malina et al. (2004) (26). The probable cause of these differences is the age and sex of the subjects, the level of elation and the type of swimming.

4-1. Limitations of the study

Some limitations in the study were lack of desire of some athletes for measuring anthropometrical and physiological parameters, lack of control of sleep the night before the test, and gender.

5- CONCLUSION

In conclusion, there was a significant relationship between anthropometrical and physiological parameters with breaststroke and butterfly swimming time. Therefore, it is recommended that coaches should pay attention to the characteristics of anthropometrical and physiological parameters of elite young swimmers in breaststroke and butterfly swimming at the earliest stages of adolescence, and their relationship with the swimming performance that is mostly inherited, for talent identification, time and money saving, and achieving greater success in reaching the peak of athletic performance. Also, this study produces guidelines for trainers and coaches to develop training program for young swimmers engaged in competitive swimming.

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7- CONFLICT OF INTEREST: None.

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