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The relationship between anthropometrical and physiological parameters of young elite boys in crawl and backstroke swimming

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Abstract

Background: The aim of study was to investigate the correlation between anthropometrical and physiological characteristics of young elite boys and their performance in crawl and backstroke.

Methods: This study was a descriptive research. Subjects of the study consisted of 122 young elite boy swimmers (mean age 12-13 years; height 1.540±8.24m; weight 47.820±6.84kg), who participated in 2018 national championship 2018 in Shiraz and filled the consent forms.

Results: There was a significant negative relationship between foot length (r=-0.400, P=0.028), leg power (length jump) (r=-0.477, P=0.008), static balance (r=-0.380, P=0.038) and dynamic balance (inferior) (r=-0.367, P=0.046) with 100m crawl (n=30) time. Whereas, there was a significant positive relationship between leg action and reaction velocity (r=0.438, P=0.015) with 100m crawl time. Furthermore, a significant negative relationship was found between head circumference (r = -0.507, P=0.019) and 400m crawl (n=21) time. Moreover, leg power (length jump) (r=0.543,P=0.011) was positively correlated with 400m crawl time, while a negative correlation was revealed between trunk circumference at nipple height (r=0.381,P=0.038), trunk circumference at hip (r=-0.523,P=0.003), forearm length (r=-0.412,P=0.024), hand length (r=-0.400,P=0.029), and tight length (r=-0.461, P=0.010) with 100m backstroke (n=30) time. In addition, there was a significant negative relationship between seated height (r=-0.399, P=0.039), hand length (r=-0.400, P=0.039), and tibia length (r=-0.415, P=0.032) with 200m backstroke (n=27) time. Whereas, relationship between trunk circumference at hip (r=0.600, P=0.001), and leg power (high jump) (r=0.408, P=0.035) with 200m backstroke time was significantly positive.

Conclusion: anthropometrical and physiological characteristics were significantly correlated with the performance of young elite boys in crawl and backstroke. It´s recommended that coaches and swimmers pay attention to results of the study at the earliest stages of adolescence for getting more success in reaching the peak of athletic performance.

Key Words: Anthropometrics, Elite boy swimmers, Physical fitness parameters, Relationship, Talent identification.

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1- INTRODUCTION

In recent years, substantial attention has been given to the expertise, identification, and development of talented performers. But Most of the scientific community focus on adult/elite swimmers and a few to their younger counterparts (i.e. children) (1). Researchers are constantly trying to find and classify factors which determine the highest precision in the swimming performance (2, 3); because, masters of swimming competitions dedicate much time and effort to excel in masters' events, as happens in elite sports (1).

There are specific physical characteristics in many sports such as anthropometric and physical profile that indicate whether the player would be suitable to compete for the highest level of specific sports (4-7). There is no doubt that anthropometric, biomechanics, and physical fitness properties can be associated with and exercise performance of human sports (6-7). The competitions and trainings in swimming usually start before puberty (8); so, body structure can play an important part for determining the swimming performance level (9-14). The performance of the young athletes depends on training, as well as physical growth and development (8). Physiological maturity during puberty and maturation process lead to changes in anthropometrical and physiological parameters such as body height, body fat, upper extremity length, and skin-fold thickness in children and adolescents (15-17). Although, swimming performance is a multifactorial phenomenon (18), swimmers' physical characteristics have strongly determined the characteristics of successful elite swimmers (19-20).

Anthropometry is the most important factor for swimmers to achieve success and there is a strong correlation between age and height with swimming performance (20-21). Moreover, in competitive swimmers, physiological factors have been important for competitive performance (22-23). So, the appropriate selection of the athletes in each sport field, considering their body physical structure and physical capacities, prevents from wasting time and inappropriate investment. Thus, understanding the relationship between anthropometric parameters and race time is very important (24). Anthropometrical and physiological parameters are highly related to young swimmers' performance (5); but few studies have considered the correlation of anthropometric and physiological parameters with performance, and contradictory results have been reported in this regard _ positive, negative and no relationship with performance (5, 14, 20, 25, 26). Sammoud et al., in 2017, showed that fat-mass was the singularly most important whole-body characteristic in butterfly swimming speed performance (28). Salehi et al., in 2015, showed a direct correlation between sargent jump records and sitting height, LBM and fat calf in swimming. They found a 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 LBM to height (27). Morais et al., 2013 and Lätt et al., 2010 reported a positive correlation between hand and foot size with performance in swimming (6, 20). Whereas, Malina et al., 2004 and Zuniga et al., 2011 showed a non-significant relationship between anthropometrical parameters with swimming performance in both genders at early ages (14, 25).

To our knowledge, no study has investigated different variables (anthropometrical, body composition, and physiological parameters) as predictors of middle swimming distances in young swimmers. Therefore, the current study aimed at assessing the correlation of anthropometric and physiological parameters with performance of young swimmers in crawl and backstroke swimming for predicting success and talent identifying in this swimming.

2- METHODS

2-1. Study design and population

In this cross sectional, survey research study, 122 young elite boy swimmers participated (mean age 12-13 years; height 1.540±8.24 m; weight 47.820±6.84 kg). They had got top ranks in their provinces' competitions and entered national competitions entrance records. Prior to data collection, informed consent was obtained from all the participants.

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, Number of non-cooperation (fallen) (due to lack of cooperation on the measurement of two anthropometrical and physiological parameters), and Number of subjects in 50m crawl, 100m crawl, 200m crawl, 400m crawl, 50m backstroke, 100m backstroke and 200m backstroke of young elite boys in Iran national competitions.

Table-1: Number of swimmers, Number of non-cooperation (fallen), and Number of subjects of young elite boys in national competitions

Swimming	50m crawl	100m crawl	200m crawl	400m crawl	50m backstroke	100m backstroke	200 backstroke
Number of swimmers	46	42	38	31	36	36	34
Number of non-cooperation (fallen)	7	12	8	10	7	6	7
Number of subjects	39	30	30	21	29	30	27

(2, 29, 30, 31)

2-2. Measuring tools: validity and reliability

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 meter of Chinese rubber band, with a sensitivity of one millimeter. Height was measured, 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. BMI was measured by weight (kg)/height × height (m^2). To measure arm spam, the arms were open and parallel to the ground.

Anthropometrical parameters including 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 parameters include 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) were measured during the national competitions.

The distance between the tip of the third right and the tip of the third left finger was measured after a deep breath using a graded wall with meter. The head circumference was measured from the temporal region with meter. The chest circumference was measured 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 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,while the hand was bent at the elbow, and the forearm was 90°. The length of the hand was measured with 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 the 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 her knee bent 90°. Tibia length was measured from the patella to the ankle, while the subject was sitting on a chair with a 90-degree knee. 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), on 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 (13, 28).

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 leg fingers was measured in this position. Highest legs strength were measured while subject stood on the dynamometer and pull the handle towards herself (the Grip Dynamometr-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 took it with 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 her hand over her head. Then she performed the Sargent jump to the top, and the highest point she could reach, was measured. Leg power (high jump) was measured by long jump, while the subject jumped to the forward on the graded ground and paired legs. Then the last point of the foot hit the ground was measured (2, 29, 30, 31).

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 jumpers and throwers 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 and exclusion criteria

Subjects were athletes participating in the national swimming competitions, having first won to third positions in their provinces (2018), 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 relationships between anthropometrical and physiological parameters with swimming time were analyzed by Pearson correlation coefficient. A $p<0.05$ and 95% confidence intervals were considered for being statistically significant. SPSS for Windows, version 25.0 (SPSS Inc; Chicago,IL) was used for all analyses.

3- RESULTS

Shapiro-Wilk test showed the normal distribution all data at P <0.05. **Table 2** shows baseline characteristics of subjects including age, height, weight, BMI, history of swimming, 400m crawl swimming time.

Table-2: Baseline characteristics of subjects of young elite boys in national competitions.

Parameter, mean± SD	50m crawl (n=39)	100m crawl (n=30)	200m crawl (n=30)	400m crawl (n=21)	50m backstroke (n=29)	100m backstroke (n=30)	200 backstroke (n=27)
Age (year)	12.49±0.51	12.47±0.51	12.50±0.51	12.48±0.51	12.41±0.50	12.50±0.93	12.57±0.51
Weight (Kg)	48.17±7.94	48.62±8.28	49.24±8.74	48.82±6.87	46.71±11.69	46.99±2.18	46.62±2.18
Height (cm)	155.71±8.48	154.58±7.76	154.40±8.32	154.50±7.50	153.31±11.39	153.48±2.22	152.27±12.15
BMI (Kg/m^2)	19.77±2.23	20.27±2.69	20.53±2.59	20.40±2.13	19.62±2.75	19.68±0.49	19.68±2.79
History of running (year)	5.30±0.15	5.40±01.32	5.25±0.07	5.36±0.36	5.36±0.36	5.57±0.57	5.47±0.38
Time (Second)	33.06±2. 80	72.43±0.06	176.27±0.31	360.57±0.51	39.59±3.17	86.00±0.07	182.22±0.51

SD: Standard deviation.

Table 3 and 4 show mean of anthropometrical and physiological parameters and their relationship with 50m crawl (33.06±2.80 S), 100m crawl (72.43±0.06 S), 200m crawl (176.27±0.31 S), 400m crawl (360.57±0.51 S), 100m backstroke (39.59±3.17 S), 200m backstroke (86.00±0.07 S) and 200m Backstroke (182.22±0.51 S) of Iranian young elite boy swimmers.

Table 3 shows that there was a significant negative relationship between foot length (r = -0.400, P = 0.028) and 100m crawl swimming time. There was a significant negative relationship between head circumference (r = -0.507, P = 0.019) and 400m crawl swimming time. There was a significant negative relationship between trunk circumference at nipple height (r=-0.381, P=0.038), trunk circumference at hip (r=-0.523, P=0.003), forearm length (r=-0.412, P=0.024), hand length (r=-0.400, P=0.029), tight length (r=-0.461, P=0.010) and 100m backstroke swimming time. There was a significant negative relationship between seated height (r=-

0.399, P=0.039), hand length (r=-0.400, P=0.039), tibia length (r=-0.415, P=0.032) and 200m backstroke swimming time. Whereas, there was a significant positive relationship between trunk circumference at hip (r=0.600, P=0.001) and 200m backstroke swimming time. In contrast, there were no significant relationships between anthropometrical parameters and 50m crawl, 200m crawl, 50 m backstroke swimming time.

Table-3: The relationship between anthropometrical parameters with 50m crawl, 100m crawl, 200 crawl, 400 crawl, 50 backstroke, 100 backstroke and 200 backstroke swimming time of Iranian young elite boy swimmers

Parameter	50m crawl (n=39)	100m crawl (n=30)	200m crawl (n=30)	400m crawl (n=21)	50m backstroke (n=29)	100m backstroke (n=30)	200 backstroke (n=27)
Seated height (Cm)	78.75±5.42 r=0.0001 P=0.999	78.96±4.96 r=-0.120 P=0.529	79.33±4.28 r=0.023 P=0.903	79.40±4.28 r=0.129 P=0.577	77.53±5.85 r=-0.050 P=0.796	77.97±5.86 r=-0.342 P=0.064	77.39±5.80 * r=-0.399 P=0.039
Arm Span (Cm)	158.99±10.69 r=-0.060 P=0.715	159.65±9.02 r=-0.169 P=0.373	160.23±10.17 r=-0.090 P=0.635	161.90±9.26 r=0.132 P=0.569	158.69±12.13 r=-0.112 P=0.528	159.08±12.66 r=-0.307 P=0.099	158.11±12.69 r=-0.355 P=0.069
Head circumference (Cm)	52.91±5.52 r=-0.037 P=0.822	53.13±6.94 r=-0.236 P=0.210	54.11±1.72 r=-0.243 P=0.195	53.96±1.53 * r=-0.507 P=0.019	73.55±6.87 r=-0.056 P=0.774	53.62±6.82 r=-0.160 P=0.398	53.19±7.12 r=-0.097 P=0.632
Trunk Circumference at Nipple Height (Cm)	76.84±9.90 r=-0.073 P=0.685	75.81±11.62 r=-0.188 P=0.319	78.87±6.29 r=-0.101 P=0.596	77.29±10.07 r=-0.213 P=0.354	74.82±11.55 r=-0.174 P=0.366	74.83±11.57 * r=-0.381 P=0.038	72.91±13.59 r=-0.336 P=0.087
Trunk Circumference at Hip (Cm)	76.34± 8.24 r=0.027 P=0.869	73.52±12.74 r=-0.207 P=0.273	76.41±10.29 r=-0.075 P=0.695	76.76±9.70 r=-0.082 P=0.723	74.30±9.56 r=-0.286 P=0.133	74.67±8.81 ** r=-0.523 P=0.003	72.14±11.08 **r=0.600 P=0.001
Forearm Length (Cm)	25.89±5.87 r=0.068 P=0.679	25.10±5.01 r=-0.172 P=0.364	25.05±5.06 r=-0.064 P=0.736	46.68±1.39 r=0.122 P=0.598	24.29±3.89 r=-0.010 P=0.959	24.50±4.44 * r=-0.412 P=0.024	23.91±2.44 r=-0.117 P=0.378
Hand Length (Cm)	17.82±1.88 r=0.306 P=0.058	17.82±1.99 r=-0.174 P=0.357	17.83±2.00 r=0.056 P=0.769	18.21±2.08 r=0.186 P=0.420	18.20±2.84 r=-0.276 P=0.147	18.10±2.82 * r=-0.400 P=0.029	17.64±2.50 *r=-0.400 P=0.039
Thigh Length (Cm)	46.47±4.17 r=0.208 P=0.205	45.85±4.45 r=-0.039 P=0.836	45.82±5.37 r=0.090 P=0.638	40.89±4.56 r=0.230 P=0.316	44.43±6.17 r=-0.142 P=0.462	43.95±6.40 * r=-0.461 P=0.010	43.42±6.15 r=-0.228 P=0.252
Tibia Length (Cm)	37.81±6.69 r=-0.089 P=0.588	38.50±6.12 r=-0.129 P=0.496	38.99±6.29 r=-0.059 P=0.758	40.86±3.37 r=0.132 P=0.568	39.26±5.79 r=-0.075 P=0.698	39.23±5.65 r=0.120 P=0.529	39.11±5.77 * r=-0.415 P=0.032
Foot Length (Cm)	26.39±4.18 r=0.120 P=0.468	25.00±2.05 * r=-0.400 P=0.028	25.26±1.83 r=-0.130 P=0.493	25.13±1.91 r=-0.110 P=0.636	25.94±3.82 r=-0.065 P=0.738	25.67±3.73 r=-0.235 P=0.212	25.43±4.02 r=-0.268 P=0.176
Triceps Fat (mm)	8.69±2.93 r=0.044 P=0.790	9.10±3.11 r=0.106 P=0.577	9.53±3.98 r=0.112 P=0.554	10.17±5.21 r=0.147 P=0.525	8.71±2.92 r=-0.038 P=0.846	8.47±2.86 r=-0.174 P=0.358	8.93±4.11 r=-0.051 P=0.801
Subscapularis Fat (mm)	8.46±2.58 r=0.073 P=0.657	9.00±2.82 r=0.313 P=0.092	9.03±3.13 r=-0.030 P=0.874	9.21±4.29 r=0.228 P=0.319	8.66±3.18 r=-0.197 P=0.305	8.77±3.19 r=-0.155 P=0.413	8.32±3.28 r=-0.137 P=0.495
Supraspinatus Fat (mm)	8.08±2.84 r=-0.084 P=0.612	8.68±2.39 r=0.230 P=0.222	8.63±2.31 r=-0.145 P=0.445	8.88±3.59 r=0.205 P=0.372	8.90±3.51 r=-0.146 P=0.449	9.13±3.43 r=-0.048 P=0.800	09.15±4.23 r=-0.205 P=0.305
Performance	33.06±2.80	72.43±0.6	176.27±0.31	365.71±0.51	39.59±3.17	86.00±0.07	186.22±0.51

(time) (Second)							

* Pearson correlation coefficient is significant at P<0.05. ** Correlation is significant at P<0.01.

Table 4 shows that there was a significant negative relationship between leg power (length jump) (r=-0.477, P=0.008), static balance (r=-0.380, P=0.038), and dynamic balance (inferior) (r=-0.367, P=0.046) and 100m crawl swimming time. Whereas, there was a significant positive relationship between leg action and reaction velocity (r=0.438, P=0.015) and 100m crawl swimming time. There was a significant positive relationship between leg power (length jump) (r=0.543, P=0.011) and 400m crawl swimming time. Furthermore, there was a significant positive relationship between leg power (high jump) (r=0.408, P=0.035) and 200m backstroke swimming time. In contrast, there were no significant relationships between physiological parameters and 50m crawl, 200m crawl, 50m backstroke and 100m backstroke swimming time.

Table-4: The relationship between physiological parameters and 50m crawl, 100m crawl, 200 crawl, 400 crawl, 50 backstroke, 100 backstroke and 200 backstroke swimming time of Iranian young elite boy swimmers

Parameter		50m Crawl (n=39)	100m Crawl (n=30)	200m Crawl (n=30)	400m crawl (n=21)	50m Backstroke (n=29)	100m Backstroke (n=30)	200m Backstroke (n=27)
Trunk Flexibility (cm)		27.02±6.12 r=-0.068 P=0.681	26.95±2.37 r=-0.086 P=0.652	26.92±6.22 r=-0.053 P=0.781	25.00±5.96 r=-0.223 P=0.332	25.96±5.77 r=-0.329 P=0.081	26.88±6.08 r=-0.405 P=0.027	27.41±6.43 r=-0.012 P=0.952
Leg Strength (kg)	Right	24.58±5.49 r=-0.113 P=0.494	25.00±2.42 r=-0.271 P=0.147	24.65±5.10 r=-0.012 P=0.951	25.24±5.48 r=-0.039 P=0.868	23.59±5.00 r=-0.039 P=0.840	23.53±5.22 r=-0.120 P=0.527	23.56±2.29 r=-0.106 P=0.600
	Left	25.21±5.63 r=-0.128 P=0.438	25.60±2.26 r=-0.191 P=0.311	25.60±4.39 r=-0.024 P=0.901	25.90±4.91 r=0.303 P=0.181	23.71±5.23 r=-0.070 P=0.720	23.12±5.23 r=-0.440 P=0.015	23.87±2.24 r=-0.195 P=0.331
Leg Power (Cm)	High Jump	31.46±12.89 r=0.235 P=0.150	31.20±2.52 r=0.073 P=0.702	30.72±14.33 r=0.211 P=0.262	29.87±15.71 r=0.166 P=0.471	27.92±16.56 r=-0.099 P=0.611	28.92±15.33 r=0.389 P=0.034	30.29±2.47 * r=0.408 P=0.035
	Length Jump	161.12±14.10 r=-0.314 P=0.052	163.09±2.71 * r=-0.477 P=0.008	159.19±13.09 r=-0.323 P=0.081	154.93±15.09 * r=0.543 P=0.011	164.97±14.87 r=-0.070 P=0.717	163.20±14.31 r=-0.360 P=0.051	163.04±2.71 r=-0.177 P=0.378
Leg Action and Reaction Velocity (cm)		21.26±6.56 r= 0.206 P=0.208	20.79±1.25 * r=0.438 P=0.015	19.19±1.54 r=-0.210 P=0.265	19.14±5.17 r=0.064 P=0.783	20.67±6.15 r=-0.005 P=0.978	20.41±5.73 r=0.239 P=0.203	20.76±1.39 r=0.358 P=0.067
Static Balance (S)		42.00±12.95 r=-0.293 P=0.070	44.20±9.36 * r=-0.380 P=0.038	45.18±9.60 r=-0.093 P=0.625	46.74±8.25 r=-0.004 P=0.985	46.11±10.90 r=0.009 P=0.962	45.82±10.80 r=-0.131 P=0.489	44.65±4.96 r=-0.407 P=0.035
Dynamic Balance (cm)	Inferior	75.73±6.77 r=-0.311 P=0.054	77.40±1.45 * r=-0.367 P=0.046	76.75±6.51 r=-0.287 P=0.124	74.50±7.36 r=-0.350 P=0.120	77.88±6.47 r=-0.052 P=0.787	78.20±5.87 r=-0.241 P=0.200	78.59±1.33 r=-0.005 P=0.982
	Posterior	69.90±13.83 r=-0.291 P=0.072	71.72±4.76 r=-0.046 P=0.731	69.69±13.82 r=-0.155 P=0.414	70.18±8.67 r=0.141 P=0.543	70.55±16.15 r=-0.136 P=0.481	69.67±15.48 r=-0.292 P=0.117	69.06±6.04 r=-0.065 P=0.748
	Lateral	68.00±10.96 r=0.093 P=0.574	69.25±2.30 r=-0.262 P=0.162	68.17±11.01 r=0.056 P=0.769	69.93±12.10 r=-0.209 P=0.363	68.67±9.44 r=0.169 P=0.380	67.92±9.61 r=0.148 P=0.435	67.85±2.04 r=0.136 P=0.497

	Internal	53.50±10.10 r=-0.081 P=0.623	53.90±1.66 r=0.0001 P=0.998	52.10±13.78 r=0.035 P=0.853	49.14±9.68 r=-0.024 P=0.918	54.93±17.35 r=0.153 P=0.428	53.85±16.26 r=-0.057 P=0.765	54.70±1.68 r=0.065 P=0.748

* Pearson correlation coefficient is significant at P<0.05.

4- DISCUSSION

The aim of this study was to investigate the correlation between anthropometrical and physiological parameters of young boy elite swimmers and their swimming time, for talent identification and performance predicting. The results revealed that there was a significant negative relationship between foot length, leg power (length jump), static balance and dynamic balance (inferior) and 100m crawl swimming time. Whereas, there was a significant positive relationship between leg action, reaction velocity and 100m crawl swimming time. The longer foot length, the bigger foot stroke, is an important factor for producing the driving force (32, 33). Increasing foot strength and power (long jump) 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 (33-35). Increase of leg strength (jump jump) has a positive effect on the record of 100m swimming time in this study. The swimmers’ performance is affected by the athletes’ physical active strength (36). 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 (24), such as 50m and 100m crawl. A stronger kick makes a major contribution to the forward propulsion in swimming (37). Therefore, a greater ability to generate propulsive force seems to contribute effectively to a better displacement in water.

Increasing static balance and dynamic balance (inferior) led to improved coordination of hand and foot action and thus improved 100m crawl swimming time in the present study. Increasing foot action and reaction speed led to increase in 100m crawl swimming time; in other words, along with the increase of foot action and reaction speed, the record of 100m breaststroke swimming worsens. In crawl swimming, legs movements are performed alternately and sequentially. Whip 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. Leg whipping and continuous action leads to stabilization of linear position of body and provides the necessary balance for optimal swimming. The share of legs in body position, balance and timing in speed swimming varies. In the 100m crawl, any downward stroke is essential to facilitate body rotation. Increasing leg action and reaction speed leads to decrease legs strength. The weak kick due to the increase of leg action and the reaction speed in 100m crawl swimming, in the present study, probably prevents from optimal rotation of the body (32-35).

The results of the present study also revealed a significant negative relationship between head circumference and 400m crawl swimming time. Whereas, there was a significant positive relationship between leg power (length jump) and 400m crawl swimming time. That is, increasing head circumference has a positive effect on the record of 400m crawl swimming. Larger head circumference increases body balance and maintains linear position of body in 400 crawl swimming, which leads to a reduction in time and improves the 400m swimming record in the present study. Increasing leg strength (long jump) in 400m crawl led to an increase in 400m crawl swimming time; however the 400m crawl record worsened. The probable reason might to be related to an increase of strength and power of leg muscles without increasing strength of the other muscles of body. So, optimal balance in 400m crawl 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 hand and foot movements; reducing the coordination of hand and foot movements can be related to that increase in power (33, 35)

The results of the current study revealed a significant negative relationship between trunk circumference at nipple height, trunk circumference at hip, forearm length, hand length, tight length, and 100m backstroke swimming time. Along with increasing the trunk circumference at the level of the chest, shoulders and pelvis, the muscles of shoulder and pelvis become larger and greater, which will increase the strength of shoulder girdle and pelvis and increase the strength of the upper and lower limbs, thus increasing the effective pressure on water. So, 100m backstroke swimming time increases (32). The wider the shoulder and pelvis, the larger the muscles of the shoulder girdle and pelvis, and the more force thus produced. Consequently, when more force is applied, the swimming record improves (34-35). The arm and forearm length increase the torque arm, thereby the forward force also increases and the swimmer's record improves. Therefore, the longer length of the swimmer's forearm, the more tensile force in crawl and backstroke swimming in the stretching and pressure stage; and accordingly, the swimmer will progress and perform faster (32). Larger palm width increases the strength of the palm grip. Therefore, the larger width of palm, the more palm force that exerts on water during stretching phase, resulting in better moving swimmer (23). The longer the thigh and lower limb, the greater the impact of foot length in swimming. A larger foot blow increases moving force and so the swimmer’s body moves forward faster. Hence, the larger length of thigh creates a greater torque arm, and in step of leg movement, the swimmer will produce greater torque, which will increase the swimmer's progress (32). The optimal length of the limbs is determined mainly by the athlete's physical characteristics and makes larger force (31). This force is influenced by the strength and power 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 (31-35).

As revealed in the present study, there is a significant negative relationship between seated height, hand length, tibia length and 200m backstroke swimming time. Whereas, there was a significant positive relationship between trunks circumferences at hip, leg power (high jump) and 200m backstroke swimming time. The lengths of leg and lower limb can greatly enhance the foot length impact during swimming. A larger foot blow increases the moving force, thereupon, the swimmer moves forward faster. Larger leg creates a greater torque arm, so in each leg movement, the swimmer will produce a greater torque, which will increase the swimmer's progress (32). Larger width palm increases the strength of palm grip. Therefore, the wider the palm, the more palm force. It exerts grip force on water during the stretching phase, resulting in swimmer’s progress (23).

Based on our results, greater trunk circumference in the 200m backstroke swimming increased the friction between water and trunk, so the 200m breaststroke swimming time increased and the record worsened. Due to the fact that speed of athletes is determined by the length and frequency of the upper and lower limbs (31-35), it can be said that with increasing the length of the limbs in 100m backstroke and 200m backstroke swimming, the swimming speed is increased and the time decreased. So, since the movements and actions of the hands are in harmony with the movements and actions of the legs, this increase of the length, force and movements of hands has been transferred to the legs (33-36). It was found in the present study that along with increasing seated height, hand length, and tibia length among adolescent elite swimmers, there happens a Reduction in time and improvement in the record of swimming; this is probably due to the coordination of the action of the arms and legs during swimming and the transfer of hand movements to the legs, upon which the legs move faster. Whereas, the increase in trunk circumference at hip causes friction between the trunk and water, and 200m backstroke swimming time will be increased (18, 33, 37). Findings of our study were also Consistent with these results. Some other studies have also studies shown that there are resistant and hydrodynamic drag forces between trunk circumference and water surface (36); and to enable better performance, the swimmer should minimize the hydrodynamic drag (36). Furthermore, bending the foot, while kicking during swimming, after contact with the water increased (34-35) 200 m crawl swimming time in this study.

Also, it can be said that the increase of leg bending and the high jump record cause the increase of foot contact with the water; so swimming time is increased.

In 400m crawl and 200m backstroke, in contrast to 100m crawl, larger leg power increased 400m crawl and 200m backstroke swimming time. The increase in leg muscle strength increases the swimming time of 400m crawl and 200m backstroke. So, the time for this type of swimming gets worse, because of the increase of muscle strength and power, as well as the foot bends, while kicking during swimming, after contact with water in this study. Whereas, in 100m crawl swimming, increasing leg muscle strength led to a reduction in time and improved swimming record (33-41).

Our results showed that anthropometrical and physiological parameters were not significantly correlated with 50m crawl, 200m crawl and 50m backstroke swimming time. These results are consistent with Dokumaci et al., (2017) (39), Salehi et al., (2015) (27), and Knechtle et al., (2010) (22). Whereas, our results are inconsistent with Eichtenberger (2013) (40), Zuniga et al., (2011) (14) and Malina et al., (2004) (25). The probable cause of these differences is the age and gender of the subjects, the level of elation and the type of swimming.

4-1. Study limitation

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

5- CONCLUSION

Among anthropometrical parameters, foot length was negatively correlated with 100m crawl time, head circumference with 400m crawl time, and trunk circumference at nipple height, trunk circumference at hip; forearm length, hand length, and tight length with 100m backstroke time; and also, seated height, hand length, and tibia length with 200m backstroke time. However, there was a significant positive relationship between trunk circumferences at hip with 200m backstroke time. Among physiological parameters, there was a significant negative relationship between leg power (length jump), static balance and dynamic balance (inferior) with 100m crawl time; leg action and reaction velocity were correlated with 100m crawl time, and finally, leg power (length jump) was shown to have a positive correlation with 400m crawl time; and leg power (high jump) with 200m backstroke time. The findings of the present study can be generalized to Iranian 12-13 young elite boy swimmers. Therefore, it is recommended that coaches and swimmers pay attention to the characteristics of anthropometrical and physiological parameters of young elite swimmers in crawl and backstroke swimming at the earliest stages of adolescence, and their relationship with the swimming performance that is most inherited, for talent identification, saving time and money, and getting more success in reaching the peak of athletic performance. Also, this study will produce guidelines for trainers and coaches to develop training program for young swimmers engaged in competitive swimming.

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