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Relationship between Anthropometrical and Physiological Parameters with Jumping and Throwing Distance of Elite Girls

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Abstract

Background: The relationship between anthropometrical and physiological parameters with jumping and throwing distance is important. We aimed to investigate the relationship between anthropometrical and physiological parameters with jumping and throwing distance of young elite female jumpers and throwers for talent identification and performance predicting.

Materials and Methods: In this cross sectional study, subjects were selected from 122 elite girl runners, 14-16 years old, who participated in the 2019 national championship selection of the country in Ardabil, Iran. All anthropometrical and physiological parameters were measured with appropriate and reliable tools. Limbs' circumference, trunk flexibility and dynamic balance were measured using a China rubber band meter. Limbs' length was measured with China VERINER caliper. Subcutaneous fat and hands and legs strength were measured with Iran Pouya Caliper (Reliability 99.32% and validity 99.8 %), and the dynamometer (the Grip Dynamometr-Blue model (0-130 Kg), American model), respectively. Static balance was measured with timer (KhosRo1 / 100SECSW50). Pearson correlation coefficient was used to examine the relationships between variables.

Results: There was a significant negative relationship between hand action and reaction time (r=-0.545, P=0.009) with high jump distance (n=22). There was a significant negative relationship between palm width (r=-0.011, P=0.002) and hand action and reaction time (r=-0.458, P=0.028) with javelin throw distance (n=23). In contrast, there was no significant relationship between anthropometrical and physiological parameters with triple jump distance, weight throw, and discus throw.

Conclusion: Based on the results, there was a significant negative relationship between hand action and reaction time with high jump distance, between palm width and hand action and reaction time with javelin throw distance.

Key Words: Anthropometrical parameters, Physiological parameters, Young elite females.

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1- INTRODUCTION

Exercise performance in adolescents is affected by various parameters such as anthropometrical, physiological, biomechanical parameters and range of motion joints (1-6). There is no doubt that anthropometric and physical fitness properties can be associated with exercise performance (4, 7). These indicators should be considered to predict the performance of adolescent athletes (1, 8, 9). Identifying talent is the most important and most effective factor in successful competitive sports (10-12). An analysis of athletes' performance at major international competitions and the Olympics shows that an athlete's success is influenced by a combination of his or her athletic ability, body composition, morphological and physiological characteristics (13-17).

Therefore, these indices can be useful in identifying susceptible individuals, especially as body indices are influenced by genetic factors and have little effect on exercise and nutrition (16). Anthropometry is known as a non-invasive and inexpensive method that provides considerable information in a short time to a large number of subjects (13-14). Anthropometrical parameters are used as an important part of the screening process of talent identification in track and field (13-14). Track and field is a basic sport and its growth in each country leads to the development of other sports. In addition, there are over 47 separate medals in the Olympic championships, 24 men's and 23 women's (10-12). A number of studies considered the relationship between anthropometrical and physiological parameters with sport performance of young elite athletes and reported contradictory results. Natchtel et al. (2008) and Modess et al. (2013) showed that there is a significant relationship between height, body mass, fat and lean body mass index, arm circumference, thigh length, subcutaneous fat and limb circumference with sport performance (18,19). Singh et al. (2010), and Langer (2009) reported that athletes in the jump fields have an ectomorph-mesomorphic body type (20, 21). Linton (2008) reported that the physiological characteristics and range of motion joints affect triple jump performance (22). In addition, the biomechanical properties of discus and hammer throwers and height jumpers in the Singapore national team influence jump and throw performance (22). Graham-Smith (1999) showed that anthropometric and physiological characteristics and range of motion joints affect triple jump performance (23). Tungen and Wendrich (1994) showed that physiological characteristics influence the length of the jump and the relationship of the jump (24). In contrast, Foland et al. (2017) showed that there is no significant relationship between the characteristics of running and running performance (25).

Wei (2000) also showed there is not a relationship between static and dynamic hip extension and physiological characteristics with running performance on treadmills (26). The characteristics of physiological, physical-motor fitness and skill are very important in identifying talented athletes in endurance, speed running, jumping, and throwing. Girls and boys benefit from exercise and competition (27-28). They are able to improve their running and jumping performance from childhood to adolescence (27). Girls and boys usually exhibit the best running and jumping performance at 12 to 18 years old (27-28). Jumps and throws have high technical demand, but they grow with the improvement of strength and maturity. The ability for vertical jumping and horizontal jumping and throwing is similar in boys and girls before adolescence. The ability to jump and throw increases with age but reaches high in adulthood (29).

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 (4, 6). Athletes usually start serious training before the onset of puberty and achieve international competitive level at a relatively early age. It is necessary to study different parameters that might affect complex jumping and throwing performance, taking into account various anthropometrical and physiological aspects of jumping and throwing at this age (2, 6, 30). This enables consideration of specific parameters when predicting success and planning specific training programs in young athletes (30). In addition, athletes start heavy training at a relatively young age. Therefore, it is important to assess which parameters may be the best predictors of jumping and throwing distance performance. Further studies need to investigate which elements, acquired skills and techniques have the highest impact on the throwing and jumping distance (5).

Undoubtedly, disregarding some of the early determinants or prerequisites of talent will limit and weaken achievement of the best performance. To our knowledge, no studies have investigated the anthropometrical and physiological parameters for talent identification and predicting elite jumping and throwing distances in young girls. Therefore, the aim of present study was to determine the relationship between anthropometrical and physiological parameters with jumping and throwing distance of young female elite jumpers and throwers for talent identification and performance predicting.

2- MATERIALS AND METHODS

2-1. Study design and population

In this cross sectional, survey research study, 122 elite young girl jumpers and throwers (age: 14-16 years; height: 166.3±21 cm; weight: 51854±1630 g), who get top ranks in their provinces' competitions and entered national competitions entrance records, signed the consent form. Anthropometric and physiological parameters were measured in Ardabil Takhti gym for 5 days. Thirty girls competed in triple jump except two subjects, due to lack of cooperation on the measurement of two parameters and declines in the study. So, the anthropometrical and physiological parameters were measured from 28 subjects. Twenty-four girls competed in high jump except 2 subjects, due to lack of cooperation on the measurement of two parameters and declines in the study. So, the anthropometrical and physiological parameters were measured from 22 subjects. Twenty-six girls competed in weight throw except 3 subjects, due to lack of cooperation on the measurement of two parameters and declines in the study.

So, the anthropometrical and physiological parameters were measured from 23 subjects. 27 girls competed in discus throw except 2 subjects, due to lack of cooperation on the measurement of two parameters and declines in the study. So, the anthropometrical and physiological parameters were measured from 25 subjects. Twenty-seven girls competed in javelin throw except 4 subjects, due to lack of cooperation on the measurement of two parameters and declines in the study. So, the anthropometrical and physiological parameters were measured from 23 subjects (13, 28).

2-2. Measuring tool

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. To measure the circumference of the arm, the arms are open and parallel to the ground. The distance between the tip of the third right and the tip of the third left

finger is measured after a deep breath using a graded wall with meter. The head circumference is measured from the temporal region with meter. The chest circumference was measured with 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 meter horizontally in the serine muscle area while the subject was standing anatomically. The length of the humerus was measured while the hand was bent at the elbow and the forearm was 90°, from the greater tuberosity to olecranon process at posterior part with a Chinese VERINER caliper with an error of 0.02 mm. 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 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. Shoulder width, the distance between the two acromion processes at posterior, was measured with caliper while the subject was sitting. The circumference of humerus was measured in the largest section with meter while the subject was standing, her elbow bent and her forearms 90°. Forearm, wrist and palm circumference were measured at the greatest section with meter while subject was sitting, elbow bent and forearm 90°. Second and fourth fingers' lengths to the tip were measured with meter while subject was sitting, elbow bent and forearm 90°. Second to fourth finger ratio was measured. The circumference of the thigh was measured in the largest section while subject was sitting on a chair and the right leg bent with knee at 90°. Tibia circumference at the greatest section was measured while subject was standing and leg was straight. Ankle circumference at the greatest section was measured while subject was standing and the leg was straight. 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), 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. Performance (distance) was measured the greatest distance triple jump, high jump, weight throw, discus throw and javelin throw in competition (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. Highest hands strength were measured in standing position while subject presses the dynamometer [the Grip Dynamometr-Blue model (0-130 Kg) of the American model] with hand and maximum effort, in two steps. Hand action and reaction velocity was measured by hand Nelson test, while subject sat on the chair and bent the elbow 90°, then the examiner dropped the ruler and the subject took it and the value was measured at this point. 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 (13, 28).

2-3-Ethical consideration

All measurements were performed in duplicate. This study was approved by the Ethics Committee of the Medical University of Ardabil (IR.ARUMS.REC.1398.185), according to the Helsinki Declaration regarding human research. 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 track and field competitions who won first to third positions in their provinces and had 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 jumping and throwing distance were analyzed with Pearson correlation coefficient. A $p<0.05$ and 95% confidence intervals were considered to be statistically significant. SPSS for Windows, version 23.0 (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 throwing and jumping, throwing and jumping distance. **Tables 2 and 3** show mean of anthropometrical and physiological parameters and their relationship with triple jump (3.10±0.11 m), high jump (1.22±0/19 m), weight throw (07.18±0.10 m), discus throw (11.04±0.15 m), and javelin throw (1.82±0.68 m) of Iranian young elite female jumper and thrower. **Table.2** shows that there were no significant relationships between anthropometrical parameters with triple jump, high jump, weight throw, and disc throw distances. Whereas there was a significant negative relationship between palm width and javelin throw distance ($r = -0.011$, $P = 0.002$). **Table.3** shows that there were no significant relationships between physiological parameters with triple jump, weight throw, and disc throw distances. Whereas there was a significant negative relationship between hand action

and hand reaction time and high jump distance (r = -0.545, P = 0.009). In addition, there was a significant negative relationship between hand action and hand reaction time and javelin throw distance (r = -0.458, P = 0.028).

Table-1: Baseline characteristics of subjects and history of throwing and jumping and of young elite female jumpers and throwers in national competitions.

Parameter, mean± SD	Triple jump (n=28)	High jump (n=22)	Weight throw (n=23)	Discus throw (n=25)	Javelin throw (n=23)
Age (year)	15.17±0.17	15.34±0.16	15.24±0.19	15.16±0.11	15.40±0.13
Height (cm)	164.23±0.18	162.94±1.18	164.62±0.33	162.54±1.34	163.16±0.46
Weight (Kg)	53.43±1.13	51.70±1.21	52.39±1.45	53.35±1.60	52.45±1.14
BMI (Kg/m^2)	19.86±0.11	19.73±0.11	19.48±0.32	20.36±0.31	19.50±0.30
History of throwing and jumping (year)	5.09±1.17	5.23±1.07	5.17±1.12	5.18±1.22	5.23±1.04
Distance (m)	3.10±0.11	1.22±0.19	07.18±0.10	11.06±0.15	16.82±0.68

SD: Standard deviation.

Table-2: The relationship between anthropometrical parameters with triple jump, high jump, weight throw, discus throw and javelin throw of Iranian elite jumper and thrower young girls.

Parameter	Triple jump (n=28)	High jump (n=22)	Weight throw (n=23)	Discus throw (n=25)	Javelin throw (n=23)
Age (year)	15.43±0.18 r=-0.269 P=0.166	15.31±0.23 r=0.324 P=0.141	15.35±0.19 r=0.093 P=0.671	15.56±0.18 r=-0.086 P=0.682	15.48±0.25 r=-0.151 P=0.491
Weight (without shoes) (kg)	51.88±1.41 r=-0.110 P=0.578	51.00±1.62 r=0.078 P=0.732	51.74±1.89 r=0.103 P=0.640	53.52±1.23 r=0.191 P=0.361	52.25±1.56 r=0.102 P=0.643
Height (Cm)	163.00±0.98 r=-0.052 P=0.794	163.14±1.09 r=-0.036 P=0.874	162.22±1.54 r=0.371 P=0.082	163.96±1.93 r=-0.069 P=0.744	163.09±1.34 r=0.202 P=0.356
Arm Span (Cm)	157.03±2.50 r=-0.150 P=0.445	156.41±3.02 r=0.089 P=0.692	153.87±2.77 r=0.196 P=0.371	161.16±1.42 r=-0.046 P=0.827	158.74±1.57 r=-0.112 P=0.611
Head circumference (Cm)	56.64±1.29 r=-0.046 P=0.815	54.73±0.32 r=0.133 P=0.554	56.78±1.58 r=0.089 P=0.688	56.96±1.43 r=0.146 P=0.486	54.52±1.34 r=-0.038 P=0.864
Torso Circumference at Nipple Height (Cm)	79.64±1.02 r=-0.191 P=0.331	80.50±1.02 r=-0.097 P=0.668	80.48±1.43 r=-0.194 P=0.376	80.04±1.05 r=0.192 P=0.358	80.52±1.18 r=0.205 P=0.348
Torso Circumference at Hip (Cm)	68.68± 1.02 r=-0.048 P=0.806	67.18±1.10 r=0.240 P=0.281	69.521.35 r=-0.139 P=0.527	69.80±0.97 r=0.057 P=0.788	68.17±0.27 r=0.070 P=0.750
Humerus length (Cm)	33.40±0.47 r=0.260 P=0.182	33.91±0.38 r=-0.145 P=0.520	32.30±0.78 r=0.094 P=0.670	32.96±0.56 r=0.043 P=0.839	33.04±0.51 r=-0.142 P=0.518
Forearm Length (Cm)	23.77±0.51 r=-0.201 P=0.305	23.55±0.74 r=0. 278 P=0.211	22.33±0.48 r=0.011 P=0.960	24.06±0.64 r=0.310 P=0.132	22.78±0.57 r=-0.234 P=0.283
Hand length (Cm)	19.04±0.59 r=-0.090 P=0.649	18.09±0.17 r=0.176 P=0.432	19.70±0.93 r=0.110 P=0.617	19.56±0.71 r=-0.224 P=0.281	18.09±0.55 r=-0.011 P=0.961

Shoulder Width (Cm)	37.64±0.41 r=0.001 P=0.997	38.23±0.44 r=-0.004 P=0.987	36.65±0.47 r=-0.189 P=0.387	37.64±0.44 r=0.371 P=0.068	37.48±0.51 r=-0.367 P=0.085
Humerus circumference (Cm)	22.82±0.41 r=-0.003 P=0.989	22.68±0.45 r=0.175 P=0.435	23.00±0.57 r=0.032 P=0.593	23.28±0.37 r=0.130 P=0.536	23.30±0.52 r=0.009 P=0.969
Forearm circumference (Cm)	21.68±0.37 r=-0.204 P=0.299	21.64±0.38 r=0.164 P=0.466	21.61±0.46 r=0.118 P=0.593	22.00±0.37 r=0.048 P=0.819	22.09±0.43 r=0.029 P=0.897
Wrist circumference (Cm)	16.04±0.40 r=-0.083 P=0.998	15.64±0.25 r=-0.068 P=0.763	16.00±0.48 r=0.282 P=0.193	16.24±0.43 r=-0.071 P=0.736	15.70±0.23 r=-0.022 P=0.920
Palm Width (Cm)	16.38±0.17 r=0.178 P=0.676	16.43±0.14 r=-0.128 P=0.569	16.24±0.23 r=-0.004 P=0.984	16.30±0.19 r=0.328 P=0.110	16.37±0.20 †r=-0.011 P=0.002
Second finger length (Cm)	7.67±0.38 r=-0.001 P=0.993	7.32±0.13 r=0.185 P=0.411	7.66±0.47 r=-0.100 P=0.649	7.71±0.43 r=0.069 P=0.744	7.24±0.17 r=0.097 P=0.660
Fourth finger length (Cm)	7.77±0.36 r=0.043 P=0.828	7.48±0.11 r=0.315 P=0.153	7.63±0.45 r=-0.106 P=0.631	7.84±0.40 r=0.161 P=0.442	7.41±0.14 r=-0.239 P=0.273
Second to fourth finger ratio	0.98±0.01 r=-0.048 P=0.807	0.98±0.02 r=-0.065 P=0.775	1.00±0.01 r=0.047 P=0.831	0.98±0.02 r=-0.237 P=0.254	0.98±0.02 r=0.390 P=0.066
Thigh circumference (Cm)	44.82±0.81 r=-0.046 P=0.814	44.86±0.99 r=0.124 P=0.581	43.26±0.86 r=0.194 P=0.375	45.36±0.85 r=-0.338 P=0.098	44.91±0.87 r=-0.270 P=0.214
Tibia circumference (Cm)	33.55±0.56 r=-0.288 P=0.138	33.41±0.76 r=0.034 P=0.881	32.98±0.65 r=-0.014 P=0.950	34.14±0.50 r=0.300 P=0.146	33.96±0.59 r=0.023 P=0.917
Ankle circumference (Cm)	22.46±0.29 r=-0.230 P=0.239	22.32±0.33 r=-0.187 P=0.403	22.39±0.34 r=-0.004 P=0.986	22.68±0.28 r=-0.124 P=0.555	22.43±0.36 r=0.159 P=0.469
Thigh Length (Cm)	41.14±0.36 r=0.019 P=0.924	41.77±0.47 r=0.087 P=0.701	40.78±0.39 r=-0.095 P=0.666	41.24±0.039 r=0.149 P=0.478	41.65±0.50 r=-0.148 P=0.502
Tibia Length (Cm)	36.04±0.48 r=0.120 P=0.542	35.50±0.50 r=0.219 P=0.328	36.30±0.59 r=0.329 P=0.125	36.60±0.48 r=0.029 P=0.891	35.87±0.52 r=0.202 P=0.518
Foot Length (Cm)	24.00±0.24 r=0.174 P=0.377	24.50±0.28 r=-0.101 P=0.654	23.48±0.44 r=0.287 P=0.184	24.04±0.24 r=0.194 P=0.353	24.04±0.44 r=0.033 P=0.354
Triceps Fat (mm)	11.45±0.71 r=-0.076 P=0.701	10.69±0.68 r=0.225 P=0.315	12.27±0.91 r=0.071 P=0.748	11.84±0.76 r=-0.033 P=0.875	12.02±0.86 r=-0.235 P=0.279
Subscapularis Fat (mm)	7.96±0.43 r=-0.027 P=0.899	7.49±0.44 r=0.247 P=0.269	8.74±0.88 r=-0.212 P=0.331	8.17±0.46 r=-0.015 P=0.942	8.79±0.86 r=0.147 P=0.503
Supraspinatus Fat (mm)	10.29±0.94 r=-0.085 P=0.668	11.26±1.45 r=-0.022 P=0.923	12.42±1.62 r=0.024 P=0.912	10.28±1.04 r=-0.054 P=0.796	13.44±1.64 r=0.401 P=0.058
Performance (Distance) (m)	3.10±0.11	01.22±0.19	07.18±0.10	11.06±0.15	16.82±0.68

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

Table-3: The relationship between physiological parameters with triple jump, high jump, weight throw, discus throw and javelin throw of young Iranian female elite jumpers and throwers.

Parameter		Triple jump (n=28)	High jump (n=22)	Weight throw (n=23)	Discus throw (n=25)	Javelin throw (n=23)
Trunk Flexibility (cm)		40.61±2.10 r=-0.285 P=0.142	36.63±2.76 r=0.339 P=0.122	38.52±2.14 r=-0.056 P=0.799	42.20±2.12 r=-0.072 P=0.731	37.96±2.61 r=-0.273 P=0.207
Leg Strength (kg)	Right	68.89±2.54 r=-0.168 P=0.393	67.91±2.72 r=-0.051 P=0.823	70.00±2.85 r=0.087 P=0.693	71.36±2.53 r=0.102 P=0.626	70.17±2.79 r=0.143 P=0.516
	Left	68.11±2.53 r=-0.094 P=0.635	66.81±2.77 r=0.125 P=0.579	68.22±2.57 r=0.132 P=0.548	71.04±2.37 r=0.064 P=0.761	69.57±2.56 r=-0.036 P=0.870
Hand Strength (kg)	Right	62.23±2.68 r=-0.257 P=0.187	61.30±2.96 r=-0.137 P=0.544	63.93±2.91 r=0.085 P=0.699	64.76±2.73 r=-0.081 P=0.702	64.00±2.94 r=0.177 P=0.419
	Left	60.50±2.90 r=-0.200 P=0.307	58.50±3.22 r=0.101 P=0.656	61.30±2.85 r=0.181 P=0.409	63.84±2.81 r=-0.042 P=0.842	61.57±2.99 r=0.049 P=0.825
Hand Action and Reaction Velocity (cm)		19.70±1.36 r=0.245 P=0.209	17.22±1.56 **r=-0.545 P=0.009	18.89±1.52 r=-0.354 P=0.098	20.38±1.49 r=-0.081 P=0.699	17.35±1.60 *r=-0.458 P=0.028
Leg Action and Reaction Velocity (cm)		22.21±1.37 r=0.045 P=0.821	20.73±1.10 r=0.154 P=0.494	24.87±1.63 r=0.208 P=0.341	23.32±1.54 r=0.061 P=0.774	22.61±1.19 r=0.298 P=0.167
Static Balance (S)		95.39±7.00 r=-0.344 P=0.073	82.21±9.36 r=-0.153 P=0.497	91.39±7.00 r=0.142 P=0.518	76.88±5.35 r=-0.207 P=0.320	73.76±3.49 r=0.039 P=0.860
Dynamic Balance (cm)	Inferior	55.072.03 r=-0.075 P=0.704	52.18±1.30 r=-0.226 P=0.312	55.61±2.62 r=0.301 P=0.163	55.96±2.30 r=-0.068 P=0.746	51.87±1.31 r=-0.044 P=0.840
	Posterior	76.36±6.04 r=0.040 P=0.841	70.82±5.34 r=-0.007 P=0.974	79.30±7.26 r=0.270 P=0.213	72.84±5.32 r=-0.053 P=0.803	66.35±1.92 r=-0.163 P=0.458
	Lateral	60.29±2.00 r=-0.141 P=0.474	58.05±2.33 r=0.200 P=0.372	61.83±2.64 r=0.145 P=0.508	59.80±1.85 r=-0.148 P=0.481	59.17±2.34 r=-0.125 P=0.569
	Internal	55.96±1.72 r=-0.063 P=0.751	53.36±1.54 r=-0.045 P=0.842	55.70±1.80 r=-0.301 P=0.163	56.60±1.86 r=-0.077 P=0.716	52.00±1.44 r=-0.168 P=0.442
Leg Power (cm)	High Jump	69.79±4.47 r=0.051 P=0.795	76.77±3.44 r=-0.131 P=0.541	60.72±4.76 r=0.119 P=0.588	67.34±4.87 r=0.005 P=0.980	70.65±3.44 r=-0.378 P=0.076
	Length Jump	152.54±4.01 r=0.006 P=0.976	149.68±4.62 r=-0.127 P=0.574	155.39±4.31 r=-0.064 P=0.773	153.12±4.54 r=0.140 P=0.504	149.74±4.95 r=0.139 P=0.528

* Correlation is significant at P<0.05.

4- DISCUSSION

The aim of this study was to investigate the relationship between anthropometrical and physiological parameters with jumping and throwing distance of young female elite jumpers and throwers for talent identification and performance predicting. Our results showed that there was a significant negative relationship between palm width and javelin throw distance. This means that the lower the width of the palm, the longer the throw distance. The probable reason is that decreasing the width of the

palm in javelin throw in the present study in adolescent girls, frictional forces between the palm and the javelin at the moment of the throw and the release of the javelin have been reduced (23, 31). Also, there was a significant negative relationship between hand action and hand reaction velocity and distance of javelin throw. That is, by decreasing the speed of hand action and the reaction, the distance of javelin throw is increased. One-step of the hand in javelin throw technique is keeping javelin above the head. In this situation, the shoulders have no rotation, they are completely perpendicular to the throw path and the elbow is to the throw direction. After this step, while the javelin is held close to the body, it is pulled back in a direct path for keeping the elbow perfectly straight. With this action, the shoulder axis and generally the upper body are diverted to the javelin throw path (31).

When the muscles and tendons are stretched, elastic force is stored in the hand (23). Stored elastic and muscle forces in the throw hand (23) are transferred to javelin very fast and the javelin throw distance in the elite teenage girls is increased in the present study. This issue needs to be investigated. In addition, our results showed that there was a significant negative relationship between hand action and reaction velocity and high jump distance in elite jumper teenage girls. That is, by decreasing the hand action and reaction velocity, high jump distance increases and the jump record improves. High jumping track and field includes distant running, take off, crossing the barrier and landings (32). Increasing the reserve forces in the muscles and tendons at height jumps is necessary to increase the jump speed (32). The increase of speed and length steps in distant running phase will be transferred to the end of the long step, making this the longest step. Gradually lowering the center of gravity of the body before take-off phase leads the length of the last step being shortened. For this reason, during the last step, the foot will be in a longer support position. Hand movements at height jumps are natural and intermittent, which can be one-handed or two-handed depending on the technique (32). In the final step, the freestanding arm is held behind the trunk, while the side arm of the leap is pulled back. In this situation, both hands are behind the trunk (32-35). Holding the hands back is associated with reduced reaction time in the take-off phase. Due to the relationship between force and velocity, the lower the reaction of the hands, the greater the reserve force in the muscles and tendons in the hand and especially the legs, resulting in an increase in elastic force (23, 32, 35). Therefore, in order to justify the inverse relationship between hand action and reaction velocity with high jump distance in the present study, it can be said that with the decrease of hand action and reaction velocity, the elastic reserve force increased and eventually high jump distance was incremented in elite adolescent girls.

The findings of the present study showed that there was no significant relationship between any of the anthropometric characteristics and distance of triple jump, height jump, weight throw and discus throw. The findings also showed that there was no significant relationship between physiological characteristics and distance of triple jump, weight throw and discus throw distance. This finding is consistent with Foland et al. (25) and Sketch et al. (18), whereas our finding is inconsistent with Lintron (22), Wei et al. (26), Graham-Smith (23), and Tungen and Wendrich (24). The possible causes of these inconsistencies are the difference in jumping and throwing events, athletes' age and gender, and their elite and non-elite levels in different studies.

4-1. Study Limitations

Some limitation in the study were lack of desire of some athletes for measuring

anthropometrical and physiological parameters and lack of control of sleep the night before the test.

5- CONCLUSION

In conclusion, there was a significant negative relationship between hand action and reaction time with high jump distance and between palm width and hand action and reaction time with javelin throw distance. In contrast, there was no significant relationship between anthropometrical and physiological parameters with triple jump distance, weight throw and discus throw. Therefore, the results of this study are informal and useful for helping educators to design and teach training program. Therefore, we recommended that this study be considered by authorities, practitioners, educators and parents because of achieving optimum performance and better results without wasting time and energy and financial resources.

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7- CONFLICT OF INTEREST: None.

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