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The Anthropometrical and Physiological Parameters of Young Elite Boys and their Performance in Snatch and in Clean and Jerk

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Abstract

Background: Due to the importance of Anthropometrical and Physiological Parameters in Weightlifting performance, this study aimed to investigate the performance of Snatch and Clean and Jerk in young elite boys in relation to anthropometric and physiological parameters, for talent identification and performance predicting, in Ardabil, 2019.

Methods: The subjects of this descriptive study were 30 elite male weightlifters aged 13-15, participating in the country's selection competition in 2019 in Ardabil. The anthropometric and physiological parameters were measured. The relationships between the variables were measured by Pearson correlation coefficient.

Results: In anthropometric parameters, Clean and Jerk performance of young elite male weightlifter positively correlated with weight, height, BMI, sitting height, arm span, head, chest, waist, and hips circumference, humerus, forearm, and palm length, shoulder, and lumbar width, humerus, elbow, forearm, wrist, and palm circumference, fingers length, tight, tibia, and foot length, tight, knee, tibia, and ankle circumference, tight, ankle, and foot width, and Snatch performance. In contrast, biceps fat was negatively correlated with Snatch and Clean and Jerk performance. In physiological parameters, Snatch and Clean and Jerk performance was positively associated with right and left hand strength, leg strength, and leg power (high jump) ($P<0.05$).

Conclusion: The results of this study can help coaches in selecting talented teenage weightlifters with spending less time and money; so that they can gain more success in reaching the peak of athletic performance.

Key Words: Biomechanical parameters, Male athletes, Clean and Jerk, Snatch, Talent identification, Weightlifting Time and Performance, Young elite weightlifters.

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1- INTRODUCTION

Identifying talent is the most important and most effective factor in successful competitive sports (1-3). One of the main areas in the development of championship sports is talent identification in line with how to train talented athletes (4-6). 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 (7-11). Appropriate selection and guidance of athletes through talent identification saves time, money and energy for the coach and athlete (10-11). Identifying talents and individual differences in different people has always been a questionable topic among sports coaches and researchers (12-16). Examining the studies shows that the process of finding talents in Iran is not acceptable in comparison to many famous countries in the field of championship sports (5-6). Many recent studies in the field have focused on the performance of athletes at different ages, including during adolescence in relation to their anthropometric, physiological characteristics and range of joint motions (12, 17-19). Anthropometry is known as a non-invasive and inexpensive method that provides considerable information in a short time to a large number of subjects (7-8). Anthropometric parameters are used as an important part of the screening process of talent identification in weightlifting (19-21). Also, physical indices are influenced by genetic factors and are slightly affected by exercise and nutrition (10, 20-22).

Weightlifting, with its wide and growing international popularity, is one of the most important Olympic sports (22-25) and includes lifting heavy weights in the snatch and the clean and jerk movements (23-26). Various indicators such as muscle strength and power, flexibility, sensory awareness and proper weightlifting techniques are necessary for successful weight lifting, which is related to the physiological characteristics and special range of joint motions (27-28). Weightlifting is a sport in which the athlete lifts a barbell with the heaviest possible weight. Weightlifting competitions are held in the snatch and the clean and jerk competitions, and in each section, the weightlifter can perform three moves. Success in weightlifting does not depend only on physical strength. The throwing abilities of the body (explosive power) and the appropriate range of joint motions for quick execution of the movement play a role in the success of weightlifters (20, 28-29). Also, proper anthropometric and physiological parameters are necessary to lift heavy weights and be successful in weightlifting (20). Today, weightlifting competitions are performed in eight weights for men and seven weights for women (29-31).

Some researchers have shown that physical characteristics, body composition and range of joint motions are significantly related to weight lifting performance, while other researchers have found no significant relationship between weight performance and the physical characteristics, body composition and range of joint motion (19-24, 26-31). Chernogorov et al. revealed that the performance growth of professional weightlifters is significantly associated with their anthropometric and physiological characteristics (8). Vidal Perez et al. found a positive correlation between leg length, and maximum speed in the snatch, functional index in the snatch, and the clean and jerk movements of female weightlifters. There was a positive significant relationship between the length of the tibia and the average speed of the barbell in male weightlifters. There was a positive relationship between Muscle mass percentage and functional index in both techniques. Also, there was a negative relationship between the relative length of the upper limb and functional index (32). Chaabane et al. found a significant relationship between anthropometric characteristics, body composition, physical fitness and performance in Olympic weightlifters (10). Musser et al. reported a relationship between having long trunks and thighs in international professional female weightlifters and their ability to lift a heavier load in the snatch movement (27). Khaled demonstrated that anthropometric measurements and physical patterns, body composition, and physical ability help in the selection of talented adolescent weightlifters (15). Siahkouhian and Hedayatneja showed that the snatch and the clean and jerk records of weightlifting are significantly correlated with anthropometric variables, body composition, and flexibility (16). Fry et al. observed that elite youth Olympic weightlifters had higher levels (moderate to large effect sizes) of lean mass, lower percent body fat, and shorter arms, tibia, and trunk in comparison to non-elite youth weightlifters (33). Carlock et al. showed that weightlifting performance is significantly associated with physical characteristics and vertical jump strength (31). Lockie et al. showed that there was no relationship between men's leg and arm length and barbell speed in strength-based sports such as weightlifting, while there was a significant positive relationship between the upper and lower limbs of women and their average barbell speed (34).

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 (3-5). Athletes usually start serious training before the onset of puberty and achieve international competitive level at a relatively early age. Also, athletes start heavy training at a relatively young age. Therefore, it is important to assess which parameters may be the best predictors of the snatch and the clean and jerk performance in young weightlifters. Previous studies have recommended that further research should investigate which acquired skills and techniques have the highest impact on the snatch and the clean and jerk performance (25, 30). Undoubtedly, disregarding some of the early determinants or prerequisites of talent will limit and weaken achievement of the best performance. To our knowledge, no study has investigated the anthropometric and physiological parameters for talent identification and predicting performance of weightlifter elite young boys. Therefore, the present study aimed at determining how anthropometric and physiological parameters are correlated with the performance of the snatch and the clean and jerk in young elite boys for talent identification and performance predicting.

2- MATERIALS AND METHODS

2-1. Study design and population

In this cross sectional survey, 30 elite young boys weightlifters (age: 14.33±0.48 years; height: 167.90±11.68 cm; weight: 8400±2148 g), who had got top ranks in their province competitions and entered national competitions entrance records, signed the consent form. Anthropometric and physiological parameters were measured in Ardabil Takhti gym for 5 days (5, 6).

2-2. Measuring tools: validity and reliability

Among Anthropometric parameters, weight without shoes was measured using the standard digital scale of the model (Omron HBF400). Height without shoes was measured after a deep breath using a graduated wall with a China rubber band meter, with a sensitivity of one mm. BMI was obtained by dividing the weight (kg) by the square of the height (m2). Sitting height was obtained from the top of the head to the bottom of the spine in the sitting position. For measuring arm span, the hands were open and parallel with the ground, and the distance between the tip of the third right to the tip of the third left finger was measured after a deep breath using a graduated wall. Head circumference is measured from the temporal region. Chest circumference was measured while the subject was standing anatomically, and the arms were slightly distant, from the Sternum in the fourth sternal joint in the anterior part and a point passed at the same horizontal plane in the posterior part and the chest circumference. Waist circumference was measured at the navel level while the subject was standing anatomically. Hip circumference was measured while the subject was standing anatomically, and the vastest part of the sternal hump was on a horizontal surface. Humerus length was measured based on the distance between greater tuberosity to olecranon process from posterior part with VERNIER caliper, China made with a sensitivity of 0.02 mm, while the subject was in standing position, and the hands were elbow-bending and forearm was 90°, in the neutral state. Forearm length was measured based on the distance between olecranon to the radius of the radial spine from the posterior part while the subject was in standing position, and the hands were elbow-bending and forearm was 90°, in the neutral state. Palm length was measured based on the distance between the 3rd metatarsal to 3rd distal phalanx from the anterior section while the subject was in standing position, and the hands were elbow-bending and forearm 90°, in the neutral state. Shoulder width was measured based on the distance between two acromions from posterior part while the subject was in sitting position, and the hands were straight, in the neutral state. Lumbar width was measured based on the distance between two sacroiliaca of the pelvis from the posterior part while the subject was in sitting position, and the hands were straight, in the neutral state. Humerus circumference was measured while the subject was in standing position, the hands were elbow-bending and the forearm 90°, in the neutral state. Forearm, wrist and palm circumference were measured while the subject was in sitting position, the hands were elbow-bending and forearm 90°, in the neutral state, and the forearm, wrist and palm circumference at the greatest part. Fingers' lengths were measured while the subject was in sitting position, the hands were elbow-bending and forearm 90 °, in the neutral state. Second to fourth finger ratio was measured. Thigh length was measured while the subject sat on a chair; the test foot was bent from the knee and put on the other leg, and then the distance between the Tibias head on the inner side of the knee joint to the center of the ankle foot was measured. Tibia length was measured while the subject was in sitting position, and the legs were hanging, patella to ankle, in the neutral state. Foot length was measured while the subject sat down on the chair, with the center of the back of the heel to the tip of the second finger from inside of the foot (Line spacing between heel and distal phalanges of second finger). Thigh circumference and width was measured while the subject stood at anatomical position, and the right leg was bending from the knee on a chair, while the angle between the thighs and legs was 90 degrees; then, the distance between top of Patella bone to the middle of the femur bone at the anterior level with the transversal was measured. Knee and Tibia circumference and width at the greatest section were measured while the subject was in standing position, and the legs were straight, in the neutral state. Ankle circumference and width at the greatest section were measured while the subject was in standing position, and the legs were straight, in the neutral state. All limbs circumferences were measured using a China rubber band meter, with a sensitivity of one millimeter. All limbs lengths were measured with China VERNIER calipers with a sensitivity of 0/02 mm.

Biceps fat was measured by Iran Pouya Caliper, with the reliability of 99.32%, validity of 99.8 %, and sensitivity of 0.5 mm, from the front of the upper arm; this is located halfway between the shoulder and elbow joints. The fold is taken in a vertical direction directly on the center of the front of the arm. Triceps fat was also measured by Iran Pouya Caliper, with the mentioned reliability and validity indices, from the back of the upper arm; this is located halfway between the shoulder and elbow joints. The fold is taken in a vertical direction directly on the center of the back of the arm. Subscapularis fat was also measured by Iran Pouya Caliper from back, below the shoulder blade (subscapular) that is located below the shoulder blade; the skinfold was taken at 45 degrees. Abdominal fat was measured by Iran Pouya Caliper from front, at the navel level. The skinfold is taken approximately horizontally. Supraspinatus fat was measured from above the iliac crest, the protrusion of the hip bone, a little towards the front from the side of the waist. The skinfold was, again, taken approximately horizontally. Weightlifting Time (Second) was measured by recording the time during the movement. Weightlifting Performance (kg) was the maximum weight lifted by the subject in competition (5-7, 24).

Physiological parameters were also measured. Trunk flexibility was measured by China meter, while the subject stayed in the back, where she was graded according to the metric system with heels on a zero scale. Then opening the legs as wide as the shoulder, he tried to touch the farthest point behind him with fingers; the distance to the fingertips was the individual's record. Right and left hand strength were measured while the subject stood with hands hanging around the body. Then, he presses the dynamometer [the Grip Dynamometer-Blue model (0-130 Kg) of the American model] with right and left hands and with the maximum effort, in two steps, respectively. The highest right and left hand power were measured. Leg strength was measured while the subject stood and her hands were hanging around the body. Then, he presses the dynamometer with legs and with maximum effort, in two steps, respectively; the highest power of was measured for both legs. Hand action and reaction velocity were measured while the subject sat on the chair and bent the elbow for 90 degrees; then using Nelson test, the examiner abandoned the 50-centimeter ruler and the subject took it; the time amount was recorded at this point. Leg action and reaction velocity were measured while the subject sat on the chair with straight knees. Then, using the Nelson test, the examiner abandoned the 50-centimeter ruler and the subject took it with his toes; and the time amount was recorded. The time of Static Balance was measured with Flamingo Balance with a timer (KhosRo1/ 100 SEC SW50). Dynamic Balance, was measured by the use of Star Excursion Balance Test, in a graded earth in 4 directions (anterior, posterior, inner and outer) in cm; leg power (high jump) was measured while the subject stood in front of a measured wall with twisted legs with one hand up and performed a jump to the top; and the highest point he reached was recorded. Leg power (high jump) was measured while the subject performed on a flat, graduated ground with paired legs forward, and the last point of the collision with the ground was recorded (5-7, 24).

2-3. Inclusion and exclusion criteria

The inclusion criteria encompassed all male athletes participating in the province weightlifting competitions, won first to third positions in their provinces, and were selected for national championships.

2-4. Data Analyses

The normality of data distribution was assessed using the Shapiro-Wilk test. Mean ± standard deviation (SD) values were used for all data. The relationship between anthropometric and physiological parameters with weightlifting time and performance 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 the analyses.

3- RESULTS

Shapiro-Wilk test showed that all data were normally distributed at P <0.05. **Table.1** shows the baseline characteristics of subjects including age, height, weight, BMI, history of weightlifting, weightlifting time and performance.

Table-1: The participants' Demographic characteristics and history of weightlifting (n=30)

Age	Height	Weight	BMI	History of Weightlifting	Snatch Performance	Clean and Jerk Performance
year	Cm	Kg	Kg/m^2	year	Kg	Kg
14.33±0.48	167.90±11.39	84.00±21.48	29.40±4.97	4.45±0.44	88.13±43.91	108.93±51.71

Mean ± Standard deviation.

Tables 2 and **3** show the means of anthropometrical and physiological parameters and their relationships with Snatch performance (88.13±43.91Kg), and Clean and Jerk performance (108.93±51.70Kg) of young elite male weightlifters.

Table -2: The relationship between young elite boy weightlifters' anthropometrical parameters and their performance in Snatch (Kg) and Clean and Jerk (Kg)

Parameter	Mean ± SD	Snatch performance	Clean and Jerk Performance
Age (Year)	14.33±0.48	r=-0.107, P=0.574	r=-0.113, P=0.552
Weight (without shoes) (kg)	84.00±21.48	† r=0.859, P=0.0001	† r=0.881, P=0.0001
Height (Cm)	167.90±11.39	† r=0.800, P=0.0001	† r=0.806, P=0.0001
BMI (Kg/m2)	29.40±4.97	† r=0.672, P=0.0001	† r=0.696, P=0.0001
History of Weightlifting (Year)	4.45±0.44	r=-0.315, P=0.090	r=-0.302, P=0.0001
Sitting Height (Cm)	88.23±7.36	† r=0.796, P=0.0001	† r=0.818, P=0.0001
Arm Span (Cm)	166.67±10.40	† r=0.817, P=0.0001	† r=0.822, P=0.0001
Head circumference (Cm)	56.77±1.99	† r=0.557, P=0.001	† r=0.596, P=0.001
Chest Circumference (Cm)	100.53±12.33	† r=0.557, P=0.001	† r=0.596, P=0.001
Waist Circumference (Cm)	92.50±12.59	† r=0.576, P=0.001	† r=0.604, P=0.0001
Hips Circumference (Cm)	102.47±10.27	† r=0.834, P=0.0001	† r=0.842, P=0.0001
Humerus length (Cm)	26.00±3.28	† r=0.684, P=0.0001	† r=0.687, P=0.0001
Forearm Length (Cm)	23.37±2.81	† r=0.702, P=0.0001	† r=0.708, P=0.0001
Palm length (Cm)	18.63±1.54	† r=0.593, P=0.001	† r=0.604, P=0.0001
Shoulder Width (Cm)	50.83±5.59	† r=0.763, P=0.0001	† r=0.781, P=0.0001

Lumbar Width (Cm)	49.17±5.52	† r=0.773, P=0.0001	† r=0.792, P=0.0001
Humerus Circumference (Cm)	32.77±4.55	† r=0.837, P=0.0001	† r=0.853, P=0.0001
Elbow Circumference (Cm)	27.77±2.73	† r=0.850, P=0.0001	† r=0.867, P=0.0001
Forearm Circumference (Cm)	28.47±3.50	† r=0.879, P=0.0001	† r=0.895, P=0.0001
Wrist Circumference (Cm)	17.90±1.45	† r=0.757, P=0.0001	† r=0.786, P=0.0001
Palm Width (Cm)	9.70±0.99	† r=0.769, P=0.0001	† r=0.786, P=0.0001
First Finger Length (Cm)	6.33±0.71	† r=0.594, P=0.001	† r=0.585, P=0.001
Second Finger Length (Cm)	6.97±0.61	† r=0.594, P=0.001	* r=-0.604, P=0.0001
Third Finger Length (Cm)	7.77±0.68	† r=0.475, P=0.008	† r=0.477, P=0.008
Fourth Finger Length (Cm)	7.17±0.65	† r=0.674, P=0.0001	† r=0.653, P=0.0001
Fifth finger Length (Cm)	6.33±0.61	† r=0.503, P=0.005	† r=0.513, P=0.004
Second to Fourth Finger Ratio	0.98±0.09	r=-0.064, P=0.736	r=-0.062, P=0.744
Thigh Length (Cm)	41.40±4.61	† r=0.787, P=0.0001	† r=0.778, P=0.0001
Tibia Length (Cm)	18.60±2.59	† r=0.831, P=0.0001	† r=0.825, P=0.0001
Foot Length (Cm)	26.23±1.30	† r=0.686, P=0.0001	† r=0.681, P=0.0001
Thigh Circumference (Cm)	63.13±8.66	† r=0.860, P=0.0001	† r=0.869, P=0.0001
Knee Circumference (Cm)	40.17±3.35	† r=0.788, P=0.0001	† r=0.800, P=0.0001
Tibia Circumference (Cm)	40.03±4.30	† r=0.799, P=0.0001	† r=0.818, P=0.0001
Ankle Circumference (Cm)	24.77±1.77	† r=0.471, P=0.009	† r=0.487, P=0.006
Thigh Width (Cm)	16.13±2.65	† r=0.804, P=0.0001	† r=0.807, P=0.0001
Knee Width (Cm)	11.60±1.30	† r=0.598, P=0.0001	† r=0.613, P=0.0001
Tibia Width (Cm)	11.40±1.67	† r=0.866, P=0.0001	† r=0.875, P=0.0001
Ankle Width (Cm)	6.10±0.61	† r=0.511, P=0.004	† r=0.532, P=0.003
Foot Width (Cm)	7.67±0.76	† r=0.592, P=0.001	† r=0.604, P=0.0001
Biceps Fat (mm)	11.03±3.55	* r=-0.461, P=0.010	* r=-0.545, P=0.012
Triceps Fat (mm)	14.57±3.62	r=-0.276, P=0.140	r=-0.280, P=0.134
Subscapularis Fat (mm)	17.57±5.40	r=0.072, P=0.704	r=0.095, P=0.616
Abdominal Fat (mm)	15.13±5.51	r=-0.152, P=0.422	r=-0.138, P=0.466
Supraspinatus Fat (mm)	16.40±4.98	r=-0.043, P=0.822	r=-0.023, P=0.903
Snatch Performance (Kg)	88.13±43.91	1	* r=0.996, P=0.0001
Clean and Jerk Performance (Kg)	108.93±51.71	* r=0.996, P=0.0001	1

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

Table 3 shows that physiological parameters were significantly correlated with Snatch performance (Kg), and Clean and Jerk performance (Kg) of young elite male weightlifters.

The snatch performance of young elite male weightlifters was positively correlated with right hand strength (r=0.598, P=0.0001), left hand strength (r=0.536, P=0.002), leg strength (r=0.509, P=0.004), and leg power (high jump) (r=0.390, P=0.033). Furthermore, the Clean and Jerk performance of young elite male weightlifters was positively correlated with right hand strength (r=0.587, P=0.001), left hand strength (r=0.523, P=0.003), leg strength (r=0.499, P=0.005), and leg power (high jump) (r=0.385, P=0.035). Whereas, the Snatch and Clean and Jerk performances of young elite male weightlifters was not significantly correlated with trunk flexibility, hand action and reaction velocity, leg action and reaction velocity, static balance, dynamic balance (anterior, posterior, internal, and external), and leg power (length jump).

Table-3: The young elite male weightlifters' physiological parameters and their Snatch performance (Kg), and Clean and Jerk performance (Kg)

Parameter		Mean ± SD	Snatch performance	Clean and Jerk Performance
Trunk Flexibility (Cm)		51.97±15.30	r=0.201, P=0.288	r=0.178, P=0.347
Hand Strength (Kg)	Right	42.66±17.21	† r=0.598, P=0.0001	† r=0.587, P=0.001
	Left	40.17±15.76	† r=0.536, P=0.002	† r=0.523, P=0.003
Leg Strength (Kg)		163.28±77.25	† r=0.509, P=0.004	† r=0.499, P=0.005
Hand Action and Reaction Velocity (Cm)		31.40±8.31	r=-0.257, P=0.170	r=-0.238, P=0.205
Leg Action and Reaction Velocity (Cm)		33.37±7.17	r=-0.153, P=0.419	r=-0.140, P=0.462
Static Balance (S)		97.47±26.06	r=0.225, P=0.232	r=0.228, P=0.225
Dynamic Balance (Cm)	Anterior	30.17±1.00	r=0.283, P=0.129	r=0.273, P=0.144
	Posterior	25.33±3.94	r=0.303, P=0.104	r=0.293, P=0.117
	Internal	27.20±5.44	r=-0.034, P=0.858	r=-0.039, P=0.840
	External	23.13±5.17	r=0.288, P=0.122	r=0.273, P=0.145
Leg Power (Cm)	High Jump (Cm)	35.77±13.21	* r=0.390, P=0.033	* r=0.385, P=0.035
	Length Jump (Cm)	175.83±14.45	r=0.133, P=0.484	r=0.141, P=0.457

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

So, the young elite male weightlifters' performance Snatch and Clean and Jerk was significantly correlated with their anthropometric and physiological parameters.

4-DISCUSSION

In order to find more suitable ways for talent identification and performance predicting, the present study attempted to investigate the relationship between the young elite boys' anthropometric/physiological parameters and their performance in Snatch as well as in Clean and Jerk. Our results showed that, in anthropometric parameters, the Clean and Jerk performance of young elite male weightlifters is positively correlated with their weight, height, BMI, sitting height, arm span, head circumference, chest circumference, waist circumference, hips circumference, humerus length, forearm length, palm length, shoulder width, lumbar width, humerus circumference, elbow circumference, forearm circumference, wrist circumference, palm circumference, first finger length, second finger length, third finger length, fourth finger length, fifth finger length, tight length, tibia length, foot length, tight circumference, knee circumference, tibia circumference, ankle circumference, tight width, ankle width, foot width, and Snatch performance. In contrast, there was a negative significant relationship between biceps fat and Snatch as well as in Clean and Jerk performance of young elite male weightlifters. Furthermore, our results showed that, in physiological parameters, Snatch performance of young elite male weightlifters was significantly correlated with right hand strength, left hand strength, leg strength, and leg power (high jump).

These findings are in line with those of Chernogorov et al. (17), Vidal Perez et al. (32), Chaabene et al. (19), Musser et al. (27), Khaled (15), Siahkouhian and Hedayatneja (16), Fry et al. (33), Carlock et al. (31), whereas our findings are inconsistent with those of Lockie et al. (34). Chernogorov et al. (17) revealed that the performance growth of professional weightlifters is significantly correlated with their anthropometric and physiological characteristics. Vidal Perez et al. showed that performance index female weightlifters in the Snatch and Clean and Jerk were positively correlated with their leg length and the maximum speed in the snatch. In male weightlifters, a positive correlation was observed between the length of the tibia, the average speed of the barbell, and the barbell. Muscle mass percentage was positively related to performance index in both techniques. Also, the relative length of the upper limb had a negative correlation with the performance index (32). Chaabane et al. showed that there is a significant relationship between anthropometric characteristics, body composition, physical fitness, and performance in Olympic weightlifters (19). Musser et al. found a relationship between having a long trunk and thighs in international professional female weightlifters and their ability to lift a heavier load in a Snatch movement (27). Khaled demonstrated that anthropometric measurements and physical patterns, body composition, and physical ability help in the selection of talented adolescent weightlifters (15). Siahkouhian and Hedayatneja showed that anthropometric variables and body composition and flexibility have significant correlations with Snatch as well as Clean and Jerk records of weightlifting (16). Fry et al. observed that elite youth Olympic weightlifters had higher levels (moderate to large effect sizes) of lean mass, lower percent body fat, shorter arms, tibia, and trunk than non-elite youth weightlifters (33). Carlock et al. showed that physical characteristics and vertical jump strength are positively correlated with weightlifting performance (31). However, Lockie et al. found no relationship between men's leg and arm length and barbell speed in strength-based sports such as weightlifting (34). These inconsistencies can be attributed to the difference in athletes' ages and genders, and their elite and non-elite levels in different studies.

According to our findings, the increase in weight, BMI, length and circumference of limbs (35), shoulder and waist width lead to an increase in Snatch and Clean and Jerk performance and an improvement in weightlifting performance. Moreover, the increase in right and left hand strength, leg strength and leg power (high jump) in weightlifting lead to an increase in Snatch and Clean and Jerk performance in weightlifting. The increase in the strength of the right and left hand led to an increase in the grip strength of the bar, which plays an important role in weightlifting (35). The increase in leg strength and power led to an increase in Snatch and Clean and Jerk in weightlifting performance (33**).** In the present study, the increase in fat in the biceps muscle area led to a decrease in muscle strength and had a negative effect on the performance of Snatch and Clean and Jerk performance in weightlifting. In other words, the increase in fat percentage of the biceps muscle led to a decrease in muscle mass in the biceps region leading to a decrease in the weightlifting performance of Snatch and Clean and Jerk.

4-1- Limitations of the Study

Some limitations of the study included the lack of permission on the part of some athletes for measuring anthropometric and physiological parameters and lack of control on the participants' sleep the night before the test.

5- Ethical consideration

All measurements were performed twice. This study was approved by the Ethics Committee of the Medical University of Ardabil (IR.ARUMS.REC.1398.186), according to the Helsinki Declaration regarding human research. All weightlifters and their coaches were informed about the purposes and methods of the study and written informed consents were obtained from the athletes, coaches and parents before participating in the study.

6- CONCLUSION

Overall, in anthropometric parameters, the Clean and Jerk performance of young elite male weightlifters positively correlated with weight, height, BMI, sitting height, arm span, head circumference, chest circumference, waist circumference, hips circumference, humerus length, forearm length, palm length, shoulder width, lumbar width, humerus circumference, elbow circumference, forearm circumference, wrist circumference, palm circumference, first finger length, second finger length, third finger length, fourth finger length, fifth finger length, tight length, tibia length, foot length, tight circumference, knee circumference, tibia circumference, ankle circumference, tight width, ankle width, foot width, and their Snatch performance. In contrast, biceps fat had a significant negative correlation with the Snatch as well the Clean and Jerk performance of young elite male weightlifters. Also, our results demonstrated that, in physiological parameters of right hand strength, left hand strength, leg strength, and leg power (high jump) had a significant positive correlation with the Snatch performance of young elite male weightlifters. The results of this study are useful for helping educators to design and teach training programs. It can also be beneficial for the authorities, practitioners, educators and parents to achieve optimum performance and better results without wasting time, energy, and financial resources.

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