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Correlations of Anthropometric and Body Composition Variables with the Performance of Young Elite Weightlifters

by
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The aim of this study was to evaluate the correlations of anthropometric and body composition variables with the performance (i.e., snatch; clean & jerk; front squat; back squat) of Iranian elite weightlifters. Forty-two subjects (mean ± SD of age 16.21 ± 3.22 years) volunteered to participate in the study.

All subjects competed at the Iranian National Championship. Anthropometric and body composition variables, including height, sitting height, cormic index, lean body mass (LBM), body mass index (BMI), modified BMI (by the cormic index), %fat, shoulder circumference, chest circumference, WHR (wrist to hip ratio), as well as performance of weightlifters (i.e., snatch; clean & jerk; front squat; back squat) were measured.

Results showed that the snatch and clean & jerk records significantly correlated with height, sitting height, weight, shoulder and chest circumference, LBM, BMI; whereas we showed negative correlations between the snatch and clean & jerk records with the %fat as well as WHR values. Results also showed that the snatch and clean & jerk records significantly correlated with body mass index (BMI) (r= 0.357, and r= 0.374; p<0.05); however there was no relationship between snatch and clean & jerk records and the modified body mass index (MBMI).

According to the results, it was concluded that there was strong correlations existing between weightlifter performance and the anthropometric and body composition variables. Also, it is recommended that the cormic index (CI) is a corrective factor for BMI values.

Keywords: Body mass index, clean & jerk, cormic index, snatch, weightlifters

Introduction

Body composition, the main component of health related fitness, refers to the relative amounts of fat and tissues devoid of fat, or fat free mass (i.e., muscle, bone and water). Basically the human body is composed of body fat mass (FM) and fat free mass (FFM) (Siahkouhian et al., 2006; Baumgartner et al., 2003; Wang et al., 2001). This two-compartment model, which divides the body into FM and FFM, was the primary method used in the study of the relationship between body composition and physical performance (Houtkooper and Going, 1994).

The terms fat-free mass and lean body mass are often incorrectly used interchangeably. Fat-free mass contains no lipids, whereas lean body mass includes approximately 2% to 3% and 5% to 8% fat, for men and women, respectively (Heyward & Stolarczyk, 1996). The percent body fat (%BF), referred to as relative body fat, is obtained by dividing the fat mass by the total body weight. The average %BF is 15% for men and 23% for women (Jackson and Pollock, 1985).

Body mass index (BMI) is a statistical measure of the weight of an individual scaled according to height. It is a practical anthropometric parameter generally accepted as a useful way to measure the body fat in adults and it is defined as the individual's body weight (kg) divided by the square of their height (m). Ratio between sitting to standing height is called Cormic index, which is used to modify the body mass index values among different populations.cormic index is the most common bi-variate index of body shape. Collins et al. (2000) used cormic

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index to standardize body mass index values (Collins et al. 2000). It is a measure of the relative length of trunk and lower limb and it varies between populations and groups. The relationship between BMI and cormic index was shown by the report of research carried out on 158 subjects of rural non-Europeans (95men and 63women) by Pleasant in 1986 (Adeyemi et al., 2009).

It has been established that, in the sport of Olympic weightlifting (OL), the relationship between lifting performance and body mass is not linear. This relationship has been frequently studied in OL (Cleather, 2006). To determine the extent to which age and body mass of elite Olympic weightlifters are related to and predictive of indirect estimates of absolute and relative muscular power, Thé and Ploutz-Snyder showed that all predictor variables were significantly ($p<0.05$) predictive of the dependent variables, but the magnitude of associations and extent of predictive ability were significantly ($p<0.05$) higher among males versus females. According to these results, they concluded that the extent to which age and body mass explain differences in muscular power differs between female and male masters weightlifters, but the rate of decline ($\%.yr^{-1}$) in power with advancing age is similar, and is in agreement with previous reports for world record holders (Thé and Ploutz-Snyder, 2003).

Stone et al. (2005) administered a study research aimed to assess the relationship of maximum strength to weightlifting ability using established scaling methods. Their study results indicated that when collectively considering scaling methods, maximum strength is strongly related to weightlifting performance, independent of body mass and height differences. Furthermore, men are stronger than women even when body mass and height are obviated by scaling methods (Stone et al., 2005).

Since the problems in comparing the performances of Olympic weightlifters arise from the fact that the relationship between body weight and weightlifting results is not linear, Kauhanen et al. (2002) examined this relationship by using a non-parametric curve fitting technique of robust locally weighted regression (LOWESS) on relatively large data sets of weightlifting results made in top international competitions. Their study results have shown that the existing handicapping formulas commonly used in normalizing the performances of Olympic weightlifters did not yield satisfactory results when applied to the present data. It was concluded that the devised formulas may provide objective means for the evaluation of performances of male weightlifters, regardless of their body weights, ages, or performance levels (Kauhanen et al., 2002).

To assess factors that limit human muscle strength and growth, Lincoln et al. (2000) examined the relationship between performance and body dimensions in the world weightlifting champions of 1993-1997. Their findings suggest a nearly constant fraction of body mass is devoted to muscle in lighter lifters and a lesser fraction in heavier lifters. Analysis also suggests that contractile tissue comprises ~30% less body mass in female champions (Lincoln et al., 2000).

Marković and Sekulić (2006) administered the study to examine 1) if lifting performance in both the weightlifting (WL) and power lifting (PL) scale with body mass (M) was in line with the theory of geometric similarity, and 2) whether there are any gender differences in the allometric relationship between lifting performance and body size. This was performed by analyzing ten best WL and PL total results for each weight class, except for super heavyweight, achieved during 2000-2003. Results of the data analyses indicate that 1) women's WL and men's PL scale for M are in line with the theory of geometric similarity, 2) both WL and PL mass exponents are gender-specific, probably due to gender differences in body composition, 3) WL and PL results scale differently for M, possibly due to their structural and functional differences. However, the obtained mass exponents do not provide size-independent indices of lifting performances, since the algometric model exhibits a favorable bias toward middleweight lifters in most lifting data analyzed. Due to possible deviations from presumption of geometric similarity among lifters, future studies on scaling lifting performance should use fat-free mass and height as indices of body size. However, Fry et al. (2006) used physical dimensions and body composition, muscular strength and power, flexibility, and gross motor control field tests to identify physical and performance variables that discriminate elite American junior-aged male weightlifters from nonelite performers. Five variables significantly contributed to the discriminant analysis. Body mass index accounted for 23.13% of the total variance, followed by vertical jump (22.78%), relative fat (18.09%), grip strength (14.43%) and torso angle during an overhead squat (0.92%). The use of these five easily administered field tests is potentially useful as a screening tool for elite American junior male weightlifters (Fry et al., 2006).

According to these controversial results, the purpose of this study was to evaluate the correlations of anthropometric and body composition variables with performance (i.e., snatch; clean & jerk; front squat; back squat) of Iranian elite weightlifters.

Methods

Experimental design and subjects

Forty-two young elite male weightlifters who volunteered to participate in the study read and signed an informed consent document prepared and approved by the Board for Protection of Human Rights affiliated to the University of Mohaghegh Ardabili. They were healthy volunteers with no history of cardiovascular disease, orthopedic problems, or other medical conditions that would contraindicate exercise (n=42; mean (SD): age 16.21 (3.22) years, height 166.71 (8.65) cm, weight 68.27 (20.51) kg). All the subjects were professional weight lifters with an average of four years lifting experience in the weightlifting championships.

Procedure

The subjects completed a 15 minute warm up at 60–75% of their personal records, before physical test protocols were performed. Each training session was conducted and monitored by the investigators. Subjects were encouraged to exert maximal effort on all tests. Following the initial evaluations, subjects were instructed to maintain the same level of physical activity throughout the study.

Anthropometric and body composition variable measurements

To estimate the percentage of body fat, the three points skinfold measurement (Chest, Abdomen, and Thigh) was taken on the right side. Measurements were taken when the skin was dry, and not overheated. To eliminate inter-observer variability, only one highly trained investigator performed these procedures. The Lafayette standard caliper was used to measure the skin-fold thickness in millimeters. Body density was then determined using the equation of Jackson and Pollock (9). Relative body fat was calculated using the Siri equation (23). All anthropometric and body composition variables were measured 14 hours after the last training session. We used Pollock and Wilmore (20) methods for measuring anthropometric values.

Bare footed standing heights were measured to the nearest centimeter using Seca stadiometer-model 216. To measure the height, the subjects stood erect with their backs touching the stadiometer, their arms held laterally by their sides and their two feet closely apposed. The weight of each subject was measured to the nearest kilograms using Seca scale. Sitting heights (SH) were measured after sitting on a standard laboratory stool of a known height placed against the stadiometer. Each subject was made to sit upright with their head at eye-ear plane. The sitting height was then obtained by subtracting the height of the stool from the reading on the stadiometer. The shoulder, chest, waist at the level of iliac crest, and hip circumferences were measured to the nearest centimeter using tape rule, while the subject was standing erect. The body mass index (BMI) was calculated from the height (m) and weight (kg) [weight/height ^{2}], while the cormic index was calculated from the sitting and standing heights [sitting height/standing height×100].

Lifting performance record measurements

Snatch, clean & jerk, front squat and back squat records of all weightlifters were measured during the last pre-competition microcycle. During normal training, consisting of two workouts per day, each weightlifter warmed-up for 15-20 min and then took part in the recording process. All lifting exercises were performed under supervision of three international level judgers.

Statistical analysis

The data were analyzed using descriptive and inferential statistics for anthropometric, body composition and performance variables. Pearson correlation coefficient (r) was analyzed for understanding the overall relationship between the anthropometric, body composition and performance variables. Graphical model of Bland-Altman (1999) method was used for evaluating the agreement between BMI and modified BMI, by the Cormic index. All data were tested for normality using Kolmogorov-Smirnov test.

Table 1

Anthropometric, body composition and performance characteristics of the subjects

Variables	Means ± SD
Age (year)	16.21±3.22
Height (cm)	166.71±8.65
Sitting Height (cm)	81.14± 4.85
Weight (kg)	68.27±20.51
Body fat (%)	20.39± 12.02
Lean body mass (kg)	52.61±12.26
WHR (%)	0.87±0.005
BMI (kg/m^2)	24.23±6.19
Modified BMI (kg/m^2)	19.54±1.25
Shoulder circumference (cm)	107.88±12.93
Chest circumference (cm)	90.02±13.02
Snatch record (kg)	73.75±32.69
Clean & Jerk record (kg)	91.00±43.75
Front Squat record (kg)	109.48±48.09
Back squat record (kg)	139.77±75.13

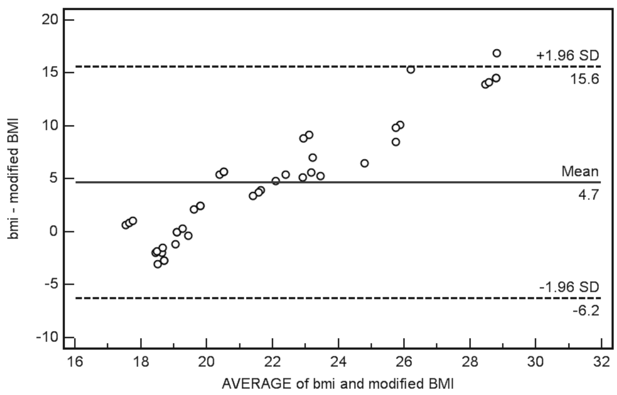

Figure 1

Comparison of the predicted body mass indices by anthropometric and body composition analyses

Results

Two subjects experienced tendonitis in their forearm and knee joints. After medical evaluation and physician clearance, both subjects chose to withdraw from the study. The mean values of the anthropometric and body composition characteristics of those who completed the study are listed in Table 1.

Examination of Pearson correlation coefficient revealed significant positive correlations of height, weight, sitting height, LBM, BMI, shoulder circumference and chest circumference with the snatch, clean & jerk, front squat and back squat records. Results also showed negative, but not significant, correlations among %fat and WHR with the snatch and clean & jerk records. Despite positive correlations with BMI, the modified BMI (by the Cormic index) had no significant correlation with the snatch and clean & jerk records (Table 2).

Results showed that there was no agreement existing between BMI and modified BMI, by means of thecormic index (19.54±1.25 vs. 24.23±6.19; Figure 1).

Discussion

Body composition is a well studied parameter of fitness in athletes. A low body fat percentage has been shown to improve performance in endurance activities, while a large muscle mass is important during strength and power events (Heyward & Stolarczyk, 1996). Despite only a negative tendency towards significance with %fat and WHR, analysis of results revealed significant positive correlations of body composition and anthropometric variables with the performance of young elite male weightlifters. Strong positive correlation between weightlifters' performance and shoulder and chest circum-

Table 2

Correlation coefficient among anthropometric, body composition and performance variables

Variables	Snatch	Clean & Jerk	Front squat	Back squat
Height	0.544**	0.519**	0.501***	0.482***
Sitting Height	0.562***	0.563***	0.584***	0.506***
Weight	0.450**	0.459**	0.511***	0.465**
Body fat	-0.244	-0.235	-0.180	-0.183
LBM	0.888***	0.885***	0.897***	0.836***
WHR	-0.220	-0.194	-0.148	-0.142
BMI	0.375*	0.374*	0.442**	0.393**
Modified BMI	0.163	0.204	0.267	0.159
Shoulder circumference	0.544***	0.544***	0.741***	0.674***
Chest circumference	0.544**	0.544***	0.571***	0.507***

. Correlation is significant at the level of $p < 0.05$; **. Correlation is significant at the level of $p < 0.01$; *. Correlation is significant at the level of $p < 0.001$*

ferences implies that these parameters are major determinants in the sport of weightlifting.

We showed negative correlations of %fat and WHR with the performance of weightlifters. This result was in contrast with findings of Stone et al. (2005), who assessed the relationship of maximum strength to weightlifting ability using established scaling methods. Their results indicated that maximum strength is strongly related to weightlifting performance, independent of body mass and height differences. Also, regarding relationship between body weight and weightlifting abilities, Kauhanen et al. (2002) showed that the devised formulas may provide objective means for the evaluation of performances of male weightlifters, regardless of their body weights, ages or performance levels.

The results of the present study, while not congruent with those obtained by Stone et al. (2005) and Kauhanen et al. (2002), agree with the Lincoln et al. (2000) findings who showed that maximum weight lifted by the elite weightlifters varied almost exactly with height squared ($Ht^{2.16}$), suggesting that muscle mass scaled almost exactly with height cubed ($Ht^{3.16}$) and that muscle cross-sectional area was closely correlated with body height, possibly because height and the numbers of muscle fibers in cross-section are determined by a common factor during maturation. The ratio of weight lifted to mean body cross-sectional area was approximately constant for bodyweight classes ≤ 83 kg for men, and decreased abruptly for higher weight classes. Their findings suggest a nearly constant fraction of body mass devoted to muscle in lighter lifters and a lesser fraction in heavier lifters.

Negative correlations of %fat and WHR with the performance of the subjects is notable, although it was not significant, which may be due to the relatively small subject number and magnitude of standard deviations. It should also be noted that weightlifting is a power and strength-based sport and it is obvious that increased body composition and anthropometric variables, such as sitting height, LBM, and shoulder and chest circumference as muscularity indicators, results in increased performance.

The body mass index and the cormic index, which are the major and most common bivariate indices of physical conditioning (Norgan, 1994), as well as the most common body size descriptor, have been shown by several authors to have sexual and age differences. It has been noted in the past that the normal body mass index ranges between 20kg/m^2 – 25kg/m^2 in the post-pubertal male population. Our results showed that despite significant correlations with BMI, the modified BMI (by the cormic index) had no significant correlation with performance of the young elite male weightlifters. In other words, when the predicted BMI [weight (kg)/height^2 (m)] was modified by the cormic index, the trunk role appeared to be dominant in the prediction. The results also showed that the mean values of BMI obtained by the traditional method [weight (kg)/height^2 (m)] were greater than that obtained by the modified BMI (cormic index). According to our study results, and in contrast with findings of Fry et al. (2006), it appears that BMI overestimates the body composition values of weightlifters and is not a good predictor for weightlifter's performance. Present study showed that the trunk size mainly contributed to the weightlifter's performance and not the lower limb.

In conclusion, the results of this study showed that there is a strong correlation between body composition variables (except for %fat and WHR) and weightlifters performance. The cormic index (CI) is a useful corrective factor for BMI values and should be further assessed with future studies in male weightlifters.

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