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Body composition and torso muscle strength relationship in athletes

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Summary. The purpose of this study is to investigate the relationship between body composition and torso isokinetic muscle strength among athletes and compare the parameters between both genders. The study was conducted on 76 female and 162 male athletes from various sports branches. Their body composition measurements were taken by the multifrequency bioelectric impedance analysis (Tanita MC-980, 1000 kH, Tokyo, Japan), whereas the torso flexor-extensor and the torso right-left rotator muscle strength by Isokinetic Dynamometer (D.& R. Ferstl GmbH, Hemau, Germany). The body fat percentage, fat mass, torso fat mass and torso fat percentage in female athletes were measured to be higher than the male ones, whereas their lean mass, muscle mass, torso muscle mass and whole torso isokinetic muscle strength values were lower (p>0.05). It was determined that there was a medium to high level of inverse relationship between fat percentage, fat mass, torso fat mass, torso fat percentage and torso muscle strength in all athletes (p<0.05). Moreover, there was a medium to high level of direct relationship between lean body mass, muscle mass, torso muscle mass and torso muscle strength (p<0.05). Female athletes had higher rate of body fat, and lower rate of muscle mass and torso muscle strength than male athletes, and the body composition parameters in all athletes were associated with the torso muscle strength. Therefore, we suggest that the athletes' training should not only focus on increasing the body muscle strength, but also include special sessions for increasing the muscle mass and optimizing the body fat percentage of male and female athletes. Body composition of the athletes should be monitored regularly with a focus on these parameters.

Keywords: Bioelectrical Impedance, Gender, Isokinetic, Nutrition, Performance, Sport.

Introduction

Body composition is one of the most important parameters that affect athletic performance, and is composed of various components such as lean body mass, body fat mass and body fat percentage. While the lean body mass being an important parameter for increasing athletic strength, power and speed; the body fat mass is one of the main components impacting athletic performance particularly in strength and agility category sports involving antigravity exertion (1, 2).

Body composition parameters are affected by many factors such as age, height and gender, and, it is suggested that this is associated with the normal growing/development process (3,4,5). Besides, body composition and athletic performance are related, and the role of body composition varies depending on the type of sports that require certain energy usage. Various studies suggest that there is a relationship between body composition parameters and aerobic and anaerobic capacity (5-8).

Muscle strength is another important parameter that affects athletic performance (1,9,10). While the entire body muscle strength contributes to the athletic performance, torso muscles which are composed of anterior, posterior and oblique core muscles are important for both postural stability and sports performance. It has been stated that there is a relationship between the strength of the aforementioned muscles and extremity muscles. This relationship contributes to the transmission of strength to the lower and upper extremities of the body, and directly affects sports performance (11-13).

Body composition and muscle strength not only affects each other, but they also directly affect sports performance (14,15). In one of the papers studying the relationship between body composition and muscle strength, it is suggested that there is a negative relationship between body fat mass and knee isokinteic muscle strength, and a positive relationship between lean body mass and knee isokinetic muscle strength (14). Since it is known that lean body mass is composed of muscles, bones, tendon tissues and water; a relationship between lean body mass and muscle strength is deemed likely (15). In the light of this information, we hypothesize that the entire body fat and lean mass as well as segmental fat and muscles mass that are obtained from body composition measurements should affect partial muscle strength. Despite studies investigating the relationship between entire body fat and lean mass, and muscle strength (13,16,17), and between the anthropometric variables with the upper and lower extremities muscle strength (18,19), we have not come across any papers studying this relationship with a focus on the torso in elite athletes. Therefore, the main purpose of our study is to investigate the relationship between the entire and segmental body composition parameters, and torso isokinetic muscle strength in elite athletes. The secondary purpose is to make the same comparison based on gender.

Material and methods

This study was conducted at the Athlete Health Training and Research Center. A total of 417 athletes from different sports branches were invited to this study. 238 elite athletes who are competing at an international level, 76 of which were female and 162 male met the selection criteria and were included in the study (Athletics=60, Gymnastics=19, Wrestling=37, Weight Lifting=27, Archery=19, Tekwandoo=47, Tennis=9, Triathlon=5, Swimming=32). The selection criteria were as follows; not to have any systemic problems, to be doing her/his sport branch at least for three years and at least one hour-five days a week, to cooperate in following the study parameters and to volunteer to participating in the study. The exclusion criteria were; not meeting any of the selection criteria, having sustained acute or chronic sports injuries/disease, having prosthetics, being or possibility of being pregnant, menstruating, and having an acute or chronic disease related to the muscle/skeleton system. The athletes who have volunteered to participate in the study have signed consent forms following a briefing on the details of the tests. Approvals for conducting the tests were received from University Social and Human Sciences Ethics Committee (2018/07;304). The tests were in compliance with the Helsinki Declaration 2008 Regulations.

During the first day of the study, the demographic profiles of the participants were recorded. Then, multifrequency bioelectric impedance analysis (MF-BIA) measurements were taken after a minimum 8 hour fasting period. During the second day, the isokinetic muscle strength measurements of torso flexor-extensor and right-left rotator muscles were taken minimum 2 hours after breakfast.

The general characteristics and body composition measurements of the athletes based on gender distribution is provided in Table 1. The all athletes' characteristics have been recorded as: age 18.1±1.8 years, weight 68.0±13.0 kg, height 172.9±8.7 cm and body mass index 22.7±3.4 kg/m². The male athletes had an age range of 18.3±1.8 years, weight of 72.0±12.4 kg, height of 176.2±6.9 cm and body mass index of 23.2±3.5 kg/m², whereas the female athletes had the age of 17.7±1.7 years, weight of 59.5±10.0 kg, height of 166.0±8.0 cm and body mass index of 21.5±3.1 kg/m² (Table 1). The distribution of these characteristics based on the sports branches are provided in Table 2.

Evaluation of Body Composition

The evaluation of the body composition of athletes was done by MF-BIA (Tanita MC-980, 1000 kH, Tokyo, Japan; 0.1 accuracy). 24 hours prior to testing, the athletes were asked not to perform intense physical activities and not to consume excessive diuretic beverages such as tea or coffee. Any metal objects on the ath-

Table 1. Distribution of Antropometric Characteristics and Body Composition measurements of Athletes based on gender

	Female (n=76)	Male (n=162)	z	p	Total (n=238)
Age (Years)	17.7±1.7	18.3±1.8	-1.956	0.052	18.1±1.8
Body Weight (kg)	59.5±10.0	72.0±12.4	-7.715	**0.000****	68.0±13.0
Height (cm)	166.0±8.0	176.2±6.9	-10.086	**0.000****	172.9±8.7
BMI (kg/m²)	21.5±3.1	23.2±3.5	-3.461	**0.001****	22.7±3.4

*Values are given by Mean± Standard Deviation, BMI: Body Mass Index, **p:<0.01.*

Table 2. Distribution of Sports Branches Based on Gender

	Female (n=76)	Male (n=162)	Total (n=238)
	Number (%)	Number (%)	Number (%)
Athletics	33 (20.4)	44 (16.8)	60 (14.4)
Gymnastics	7 (9.2)	12 (7.4)	19 (8.0)
Wrestling	-	37 (22.8)	37 (15.5)
Wight lifting	10 (13.2)	17 (10.5)	27 (11.3)
Archery	3 (3.9)	16 (9.9)	19 (8.0)
Taekwondo	27 (35.5)	20 (12.3)	47 (19.7)
Tennis	8 (10.5)	1 (0.6)	9 (3.8)
Triathlon	1 (1.3)	4 (2.5)	5 (2.1)
Swimming	10 (13.2)	22 (13.6)	32 (13.4)
Total	**76 (100)**	**162 (100)**	**238 (100)**

letes had to be removed for the testing. The tests were performed after a minimum 8 hours of fasting and the athletes that did not meet this requirement were excluded. The testing was done barefoot with the participant standing up with the entire bottom of the feet in contact with the metal plates of the device. The testing gave out measurements' data related to body weight, body fat percentage, fat mass, lean body mass and muscle mass parameters; and moreover, torso muscle mass, torso fat mass and torso fat percentage parameters within the category of segmental body analysis.

Isokinetic Torso Muscle Strength Testing

Torso flexor and extensor strength assessment was performed by an isokinetic dynamometer (IsoMed 2000; D&R Ferstl, Hemnau, Germany). Prior to each testing, all participants were asked to warm-up for 10 minutes on a stationary bicycle ergometer by the cadence was kept at a constant 60-70 rpm. Subsequently, a submaximal warm-up on the isokinetic device was completed for each task by started with five concentric repetitions at a speed of 120°/s and followed by five repetitions of 90°/s for familiarization. Torso flexor and extensor strength assessment was performed by five repetitions at a speed of 60°/s and 150°/s isokinetically. The participants were fixed in sitting position wearing girdles at the shanks, thighs, and shoulders. The point of rotation of the device was verified by a laser pointing at the upper part of the iliac crest. Each participant has completed two trials of testing with five repetitions, starting with the torso flexion and a subsequent torso extension ranging between 30° felxion to 30° extension. The torso was in the upright position with the hip angled at 90°, which afterwards ranging between 55°- 115°. Similarly, there were two trials with five repetitions for the isokinetic testing of torso rotation. Range of trunk rotation movement assessment was based on a range of 35° left-35° right, corresponding to a longitudinal axis, neutral zero method. Participants were securely fixed on the knee and hip angled at 90°, respectively. Thus, the movement of the hips or knees was restricted. Data was exported and processed by an external software. Total amount of work (TW) (Joule), peak torque (PT) [Newtonmeter-(Nm)] for each isokinetic assessment was analyzed and the data were normalized for lean body mass (PT/W) [Nm/(kg)] (20).

Data Analysis

SPSS 20 (Statistical Package for Social Sciences Inc. Chicago, IL, ABD) statistics software was used for the evaluation of the data obtained from our study. The definition of the distribution of variables was made using visual (histogram, probability graphs) and analytic (Kolmogorov-Smirnov test) methods. For the comparison of genders, Independent Samples t test was used for normal distribution of variables, whereas Mann Whitney U test was used for the abnormal distribution. For the assessment of the relationship between variables, Pearson Correlation Analysis was used for normal distribution and Spearman Correlation Anaysis was used for cases where at least one variable was not within the normal distribution. The definitive statistical analyses were conducted for all variables and the variables were presented as mathematical average±standard deviation. The significance rate of the statistical analysis was defined as p<0.05.

Results

The antropometric characteristics and body composition measurements of the athletes including their distribution by gender is provided in Table 1. Accordingly, the body weight, height and body mass index values of female athletes were lower than male ones (p<0,05), whereas the ages in both gender groups were similar (p>0,05) (Table 1).

The distribution of body composition, segmental body analysis and isokinetic muscle strength measurements of athletes based on gender are provided in Table 3. Regarding the body composition parameters and segmental body analysis parameters in female athletes, body fat percentage, fat mass, torso fat mass and torso fat percentage values were higher that male athletes, whereas lean mass, muscle mass and torso muscle mass as well as entire torso isokinetic muscle strength values were lower in comparison (p>0,05) (Table 3).

The muscle strength and body composition relationship of the all athletes is provided in Table 4. A negative relationship at a medium to high rate between the body fat percentage, fat mass, torso fat mass and

Table 3. Distribution of Body Composition, Segmental Body Analysis and Isokinetic Muscle Strength Measurements of Athletes Based on Gender

		Female (n=76)	Male (n=162)	*z*	*p*	Total (n=238)
Body Composition Parameters	**Body fat percentage (%)**	23.6±5.5	13.9±5.1	13.081	**0.000****	17.0±6.9
	Fat Mass (kg)	14.3±5.1	10.4±5.3	5.374	**0.000****	11.6±5.6
	Fat Free Mass (kg)	45.1±6.2	61.6±8.8	-14.711	**0.000****	56.3±11.1
	Muscle Mass (kg)	42.8±5.9	58.5±8.3	-14.698	**0.000****	53.5±10.6
Segmental Body Analysis Parameters	**Torso Muscle Mass (kg)**	24.8±3.1	31.7±4.0	-13.183	**0.000****	29.5±4.9
	Torso Fat Mass (kg)	6.1±2.5	4.9±3.1	2.791	**0.006****	5.3±2.9
	Torso Fat Percentage (%)	18.3±5.4	12.4±5.4	7.885	**0.000****	14.2±6.1
Isokinetic Torso Muscle Strength Measurement Parameters	**60°/sec Flexion PT/W (Nm/kg)**	2.10±0.50	2.70±0.60	-7.661	**0.000****	2.60±0.50
	60°/sec Flexion TW (Joule)	341.6±88.1	505.8±120.8	-10.587	**0.000****	453.4±135.1
	60°/sec Extension PT/W (Nm/kg)	3.2±0.8	4.1±1.1	-7.348	**0.000****	4.10±1.0
	60°/sec Extension TW (Joule)	639.0±193.6	1016.9±354.2	-8.703	**0.000****	896.2±358.0
	150°/sec Flexion PT/W (Nm/kg)	2.2±0.5	2.3±0.4	-2.615	**0.010****	2.2±0.4
	150°/sec Flexion TW (Joule)	192.2±74.1	505.8±120.8	-10.532	**0.000****	287.0±115.0
	150°/sec Extension PT/W (Nm/kg)	2.5±0.8	3.6±1.1	-8.691	**0.000****	3.5±1.2
	150°/sec Extension TW (Joule)	408.0±179.8	760.1±321.0	-8.921	**0.000****	647.7±327.5
	60°/sec Right Rotation PT/W (Nm/kg)	2.0±0.5	2.5±0.5	-9.639	**0.000****	2.3±0.5
	60°/sec Right Rotation TW (Joule)	351.0±86.9	577.5±157.0	-11.747	**0.000****	505.2±174.1
	60°/sec Left Rotation PT/W (Nm/kg)	1.9±0.4	3.5±16.29	-9.441	**0.000****	2.3±0.5
	60°/sec Left Rotation TW (Joule)	329.0±82.2	547.9±142.9	-12.410	**0.000****	478.0±162.6
	150°/sec Right Rotation PT/W (Nm/kg)	1.7±0.4	2.3±0.5	-12.871	**0.000****	2.2±0.6
	150°/sec Right Rotation TW (Joule)	277.8±81.0	509.9±143.0	-13.178	**0.000****	277.8±81.0
	150°/sec Left Rotation PT/W (Nm/kg)	1.6±0.4	2.9±12.1	-12.210	**0.000****	2.1±0.6
	150°/sec Left Rotation TW (Joule)	252.8±79.0	464.6±125.2	-13.525	**0.000****	397.0±149.7

*Values are given by Mean± Standard Deviation, PT: Peak Torque; W: Weight, TW: Total Work, **p*:<0.01.

torso fat percentage; and torso muscle strength has been identified (p<0,05). A positive relationship at a medium to high rate between lean body mass, muscle mass and torso muscle mass; and torso muscle strength has been identified (p<0,05) (Table 4).

The muscle strength and body composition relationship of the female athletes is provided in Table 5. A positive relationship at a low to high rate between the body fat percentage, fat mass, torso fat mass, torso fat percentage, lean body mass, muscle mass and torso

Table 4. Correlation Between the Isokinetic Muscle Strength / Body Composition and Segmental Body Analysis in all Athletes

Isokinetic Torso Muscle Strength Measurement Parameters of all athletes		*Body composition and segmental body analysis data of all athletes*						
		Body fat percentage (%)	**Fat Mass (kg)**	**Fat Free Mass (kg)**	**Muscle Mass (kg)**	**Torso Muscle Mass (kg)**	**Torso Fat Mass (kg)**	**Torso Fat Percentage (%)**
60°/sec Flexion PT/W (Nm/kg)	**p**	0.000	0.000	0.000	0.000	0.000	0.005	0.000
	r	-0.404**	-0.248**	0.369**	0.369**	0.356**	-0.183*	-0.306**
60°/sec Flexion TW (Joule)	**p**	0.000	0.799	0.000	0.000	0.000	0.092	0.049
	r	-0.285**	0.017	0.787**	0.787**	0.787**	0.110	-0.128*
60°/sec Extension PT/W (Nm/kg)	**p**	0.000	0.000	0.000	0.000	0.000	0.004	0.000
	r	-0.402**	-0.226**	0.800**	0.463**	0.437**	-0.187*	-0.331**
60°/sec Extension TW (Joule)	**p**	0.000	0.159	0.000	0.000	0.000	0.002	0.045
	r	-0.278**	0.092	0.760**	0.761**	0.760**	-0.197**	-0.130*
150°/sec Flexion PT/W (Nm/kg)	**p**	0.000	0.000	0.486	0.484	0.354	0.000	0.000
	r	-0.430**	-0.480**	-0.045	-0.046	-0.060	-0.444**	-0.422**
150°/sec Flexion TW (Joule)	**p**	0.000	0.303	0.000	0.000	0.000	0.329	0.011
	r	-0.305**	0.067	0.746**	0.746**	0.746**	0.064	-0.164*
150°/sec Extension PT/W (Nm/kg)	**p**	0.000	0.001	0.000	0.000	0.000	0.025	0.000
	r	-0.414**	-0.208**	0.534**	0.534**	0.511**	-0.146*	-0.311**
150°/sec Extension TW (Joule)	**p**	0.000	0.229	0.000	0.000	0.000	0.004	0.015
	r	-0.290**	0.078	0.718**	0.718**	0.718**	-0.185**	-0.158*
60°/sec Right Rotation PT/W (Nm/kg)	**p**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	r	-0.453**	-0.306**	0.380**	0.380**	0.344**	-0.264**	-0.385**
60°/sec Right Rotation TW (Joule)	**p**	0.000	0.214	0.000	0.000	0.000	0.213	0.011
	r	-0.308**	0.081	0.809**	0.809**	0.809**	0.081	-0.165*
60°/sec Left Rotation PT/W (Nm/kg)	**p**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	r	-0.459**	-0.303**	0.435**	0.435**	0.401**	-0.264**	-0.389**
60°/sec Left Rotation TW (Joule)	**p**	0.000	0.361	0.000	0.000	0.000	0.231	0.012
	r	-0.308**	0.059	0.804**	0.804**	0.804**	0.078	-0.162*
150°/sec Right Rotation PT/W (Nm/kg)	**p**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	r	-0.537**	-0.336**	0.534**	0.534**	0.534**	-0.276**	-0.440**
150°/sec Right Rotation TW (Joule)	**p**	0.000	0.631	0.000	0.000	0.000	0.633	0.001
	r	-0.368**	0.031	0.812**	0.812**	0.812**	0.031	-0.214*
150°/sec Left Rotation PT/W (Nm/kg)	**p**	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	r	-0.506**	-0.323**	0.512**	0.512**	0.470**	-0.265**	-0.417**
150°/sec Left Rotation TW (Joule)	**p**	0.000	0.724	0.000	0.000	0.000	0.036	0.002
	r	-0.355**	0.023	0.811**	0.811**	0.811**	-0.136*	-0.204*

*p<0.05, **p<0.01, (PT: Peak Torque; W: Weight, TW: Total Work)

muscle mass; and torso muscle strength has been identified (p<0,05) (Table 5).

The muscle strength and body composition relationship of the male athletes is provided in Table 6. A negligible relationship at low rate between the body fat percentage, fat mass, torso fat mass and torso fat percentage; and torso muscle strength has been identified. A positive relationship at a medium to high rate between lean body mass, muscle mass and torso muscle mass; and torso muscle strength has been identified (p<0,05) (Table 6).

Discussion

At the end of our study focusing on the comparison of the entire and segmental body composition parameters with torso muscle strength based on

Table 5. Correlation Between the Isokinetic Muscle Strength / Body Composition and Segmental Body Analysis in Female Athletes

Isokinetic Torso Muscle Strength Measurement Parameters of female athletes		*Body composition and segmental body analysis data of female athletes*						
		Body fat percentage (%)	**Fat Mass (kg)**	**Fat Free Mass (kg)**	**Muscle Mass (kg)**	**Torso Muscle Mass (kg)**	**Torso Fat Mass (kg)**	**Torso Fat Percentage (%)**
60°/sec Flexion PT/W (Nm/kg)	**p**	0,002	0,000	0,000	0,000	0,000	0,000	0,001
	r	0,356**	0,550**	0,604**	0,604**	0,617**	0,523**	0,376**
60°/sec Flexion TW (Joule)	**p**	0,650	0,811	0,796	0,798	0,836	0,765	0,712
	r	-0,053	-0,028	0,030	0,030	0,024	-0,035	-0,043
60°/sec Extension PT/W (Nm/kg)	**p**	0,001	0,000	0,000	0,000	0,000	0,000	0,000
	r	0,387*	0,579**	0,612**	0,612**	0,625**	0,563**	0,428**
60°/sec Extension TW (Joule)	**p**	0,039	0,001	0,000	0,000	0,000	0,005	0,058
	r	0,237*	0,390**	0,506**	0,506**	0,537**	0,319**	0,218
150°/sec Flexion PT/W (Nm/kg)	**p**	0,088	0,101	0,496	0,497	0,580	0,042	0,031
	r	-0,197	-0,190	-0,079	-0,079	-0,065	-0,234*	-0,247*
150°/sec Flexion TW (Joule)	**p**	0,041	0,001	0,000	0,000	0,000	0,005	0,048
	r	0,235*	0,380**	0,467**	0,467**	0,474**	0,317**	0,228*
150°/sec Extension PT/W (Nm/kg)	**p**	0,015	0,002	0,007	0,007	0,005	0,003	0,001
	r	0,279*	0,358**	0,307**	0,307**	0,316*	0,338**	0,367*
150°/sec Extension TW (Joule)	**p**	0,004	0,000	0,000	0,000	0,000	0,000	0,000
	r	-0,323**	-0,429**	-0,415**	-0,415**	-0,428**	-0,400**	-0,478**
60°/sec Right Rotation PT/W (Nm/kg)	**p**	0,002	0,000	0,000	0,000	0,000	0,000	0,003
	r	0,347**	0,579**	0,513**	0,513**	0,547**	0,474**	0,339*
60°/sec Right Rotation TW (Joule)	**p**	0,033	0,001	0,001	0,001	0,000	0,004	0,056
	r	0,245*	0,380**	0,367**	0,367**	0,394**	0,326**	0,220
60°/sec Left Rotation PT/W (Nm/kg)	**p**	0,923	0,949	0,916	0,916	0,774	0,813	0,637
	r	-0,011	-0,007	0,012	0,012	0,034	-0,028	-0,055
60°/sec Left Rotation TW (Joule)	**p**	0,064	0,001	0,009	0,009	0,003	0,007	0,150
	r	0,213	0,365**	0,296**	0,296**	0,339**	0,305**	0,167
150°/sec Right Rotation PT/W (Nm/kg)	**p**	0,047	0,001	0,000	0,000	0,000	0,005	0,000
	r	0,228*	0,376**	0,430**	0,430**	0,473**	0,319**	0,465**
150°/sec Right Rotation TW (Joule)	**p**	0,176	0,154	0,240	0,241	0,413	0,061	0,188
	r	-0,157	-0,165	-0,136	-0,136	-0,095	-0,216	0,153
150°/sec Left Rotation PT/W (Nm/kg)	**p**	0,002	0,000	0,000	0,000	0,000	0,000	0,005
	r	0,263**	0,476**	0,458**	0,458**	0,468**	0,430**	0,322**
150°/sec Left Rotation TW (Joule)	**p**	0,035	0,001	0,000	0,000	0,000	0,011	0,073
	r	0,242**	0,359**	0,415**	0,415**	0,447**	0,291*	0,207

*p<0.05, **p<0.01, (PT: Peak Torque; W: Weight, TW: Total Work)

genders, and evaluation of the relationship between the obtained parameters; we have determined that the female athletes have higher fat content as compared to the male ones, whereas have lower muscle mass and torso muscle strength. Moreover, a relationship between the body composition parameters and torso muscle strength of athletes has been identified. As the body fat percentage, fat mass, torso fat mass and torso fat percentage increases, the isokinetic muscle strength decreases. Whereas, as the lean body mass, muscle mass and torso muscle mass increases, torso isokinetic muscle strength increases as well. When this relationship investigates based on genders, while the body fat percentage, fat mass, torso fat mass and torso fat percentage relate with the torso muscle strength positively in female athletes; there is not any relationship in male

Table 6. Correlation Between the Isokinetic Muscle Strength / Body Composition and Segmental Body Analysis in Male Athletes

Isokinetic Torso Muscle Strength Measurement Parameters of male athletes		*Body composition and segmental body analysis data of male athletes*						
		Body fat percentage (%)	**Fat Mass (kg)**	**Fat Free Mass (kg)**	**Muscle Mass (kg)**	**Torso Muscle Mass (kg)**	**Torso Fat Mass (kg)**	**Torso Fat Percentage (%)**
60°/sec Flexion PT/W (Nm/kg)	**p**	0,018	0,000	0,000	0,000	0,000	0,000	0,001
	r	0,186*	0,314**	0,599**	0,599**	0,601**	0,361**	0,248*
60°/sec Flexion TW (Joule)	**p**	0,001	0,044	0,730	0,730	0,698	0,142	0,040
	r	-0,249*	-0,158*	0,027	0,027	0,031	-0,116	-0,162*
60°/sec Extension PT/W (Nm/kg)	**p**	0,410	0,010	0,000	0,000	0,000	0,001	0,100
	r	0,065	0,202*	0,624**	0,624**	0,621**	0,251*	0,130
60°/sec Extension TW (Joule)	**p**	0,071	0,001	0,000	0,000	0,000	0,000	0,000
	r	0,142	0,260**	0,693**	0,693**	0,664**	0,374**	0,347**
150°/sec Flexion PT/W (Nm/kg)	**p**	0,077	0,651	0,000	0,000	0,001	0,722	0,204
	r	-0,139	-0,036	0,279**	0,280**	0,250*	0,028	-0,100
150°/sec Flexion TW (Joule)	**p**	0,370	0,000	0,000	0,000	0,000	0,000	0,058
	r	0,071	0,302**	0,658**	0,658**	0,623**	0,340**	0,149
150°/sec Extension PT/W (Nm/kg)	**p**	0,635	0,048	0,000	0,000	0,000	0,002	0,602
	r	-0,038	0,155*	0,527**	0,527**	0,519**	0,247**	0,041
150°/sec Extension TW (Joule)	**p**	0,000	0,000	0,038	0,038	0,023	0,000	0,000
	r	-0,475**	-0,459**	-0,163*	-0,163*	-0,179*	-0,403**	-0,403**
60°/sec Right Rotation PT/W (Nm/kg)	**p**	0,694	0,052	0,000	0,000	0,000	0,014	0,321
	r	0,031	0,153	0,553**	0,552**	0,553**	0,193*	0,079
60°/sec Right Rotation TW (Joule)	**p**	0,260	0,000	0,000	0,000	0,000	0,000	0,067
	r	0,089	0,309**	0,648**	0,648**	0,637**	0,347**	0,144
60°/sec Left Rotation PT/W (Nm/kg)	**p**	0,073	0,653	0,000	0,000	0,000	0,881	0,277
	r	-0,141	-0,036	0,329**	0,329**	0,309**	-0,012	-0,086
60°/sec Left Rotation TW (Joule)	**p**	0,458	0,000	0,000	0,000	0,000	0,000	0,156
	r	0,059	0,291**	0,615**	0,615**	0,623**	0,331**	0,112
150°/sec Right Rotation PT/W (Nm/kg)	**p**	0,002	0,000	0,000	0,000	0,000	0,000	0,000
	r	0,245*	0,376**	0,611**	0,611**	0,595**	0,386**	0,283**
150°/sec Right Rotation TW (Joule)	**p**	0,079	0,133	0,889	0,890	0,646	0,144	0,119
	r	-0,138	-0,119	-0,011	-0,011	-0,036	-0,115	-0,123
150°/sec Left Rotation PT/W (Nm/kg)	**p**	0,021	0,000	0,000	0,000	0,000	0,000	0,008
	r	0,182*	0,325**	0,664**	0,664**	0,645**	0,324**	0,207**
150°/sec Left Rotation TW (Joule)	**p**	0,010	0,000	0,000	0,000	0,000	0,000	0,000
	r	0,202*	0,392**	0,692**	0,692**	0,669**	0,410**	0,279**

*p<0.05, **p<0.01, (PT: Peak Torque; W: Weight, TW: Total Work)

athletes. Also, a positive relationship between the fat free mass, muscle mass and torso muscle mass; and the torso muscle strength of athletes has been identified.

The antropometric parameters may vary based on gender. The difference associated between the genders are attributed to normal growth process, and it is accepted that antropometric, morphological and functional performances generally increase with age (16,21). In a study performed on Fencing athletes, it was determined that female athletes having same ages of their male peers, were shorter and weighed less. Similarly, in a study on soccer players, female athletes were also shorter and weighed less than male ones, but both genders had similar body mass indices (22). Smiliar to other studies, our study indicates that female athletes have less height and weight measurements than males, however, we also determined that their body mass index was lower than male athletes as opposed to other studies. We think that this difference in the body mass index values between the genders is related to the type of sports they participate in.

Other studies on athletes and people with sedentary lifestyles suggest that the females have higher average body fat percentage than male individuals (3,23). We have also determined in our study that female athletes have higher body fat percentage and fat mass than male ones. Studies show that fat storage regions between genders vary; women store more fat in the gluteal-femoral region, whereas men store more fat in the visceral depot (3). Our study suggests that female athletes have higher torso fat mass and torso fat percentage than male ones. We did not collect any data related to the gluteal region; however, we think that the reason in higher values of torso fat mass and torso fat percentage in women as opposed to the other literatures' findings are due to the fact that the participants in our study are athletes. The increase in body fat percentage and consequently the body fat mass negatively impacts sports performance as they are retained as "dead weight" in athletes particularly in sports requiring agility and antigravitational movements (1,2). Therefore, it might be interpreted that female athletes are expected to have lower sports performance than male ones (24).

Muscle strength is correlated with age, height, body weight and gender (25). In a study performed on elite athletes, it was determined that the physical performance of female athletes was lower than male ones (24). Another study suggests that the lateral core muscle strength in female athletes were lower than male ones as well (26). In our study, we have concluded that the lean mass, muscle mass and torso muscle mass as well as the entire torso isokinetic muscle strength values in female athletes were lower than male ones. We think that this is also the reason why the torso muscle strength in female athletes are lower than male ones as also suggested in other studies similar to ours.

Body composition parameters and muscle strength are the most important indicators of sports performance and there is a correlation between body composition parameters and muscle strength (16,17,27). Studies suggest that muscle strength tends to decrease as the body fat percentage increases (16,17). Our study reached conclusions similar to other studies suggesting that the torso muscle strength tends to decrease as the body fat percentage, fat mass, torso fat mass and torso fat percentage increase. Similarly, there are studies suggesting that muscle strength tends to increase as the lean body mass increases, and there is a positive medium level correlation between lean body mass / muscle mass and torso muscle strength. In a study performed on healthy individuals with a sedentary lifestyle, it was determined that there is a correlation between regional muscle mass and the muscle strength in that area. Moreover, the upper extremity muscle strength increases as the muscle mass in this area increases (28). Similary, our study concludes that the torso muscle strength in athletes increases in parallel to the torso muscle mass.

As a result of our study, as the body fat percentage, fat mass, torso fat mass and torso fat percentage increases, the isokinetic muscle strength also increases in female athletes. Also, nearly there is not any relationship between the body fat percentage, fat mass, torso fat mass and torso fat percentage with the torso isokinetic muscle strength in male athletes. These results are an interesting aspect of our study. We think that fat mass may have a weight effect and increase muscle strength in female athletes who have weak muscle strength (29). Also male athletes' strength may not have been associated with fat mass due to the high muscle mass and muscle strength.

As a limitation of our study, we have not evaluated this relationship on a control group of individuals with a sedentary lifestyle. However, we think that our study offers invaluable information as it was conducted on athletes, included an assessment of the torso muscles that directly affect athletic performance and included the identification of the correlation between body composition and torso muscles. More studies are needed in which various age groups and specific to sports branches are involved and, comparisons are made with a control group composed of healthy individuals.

Conclusion

As a result, it was determined that female athletes contain more body fat and have less muscle mass and torso muscle strength as compared to male athletes. Moreover, a correlation has been found between the torso muscle strength and body composition parameters, which are known to influence athletic performance. We suggest that athletic performance can be increased by lowering the body fat percentage, increasing lean body mass and increasing core muscle strength. Therefore, the exercise routines of athletes should also include special programs for male and female athletes tailored for increasing muscle mass and optimizing body fat percentage in addition to their standard torso muscle mass improvement trainings. Body composition measurements of the athletes should also be monitored at the same time.

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