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The relationship of balance performance in young female national team wrestlers with strength, leg volume and anthropometric features.

Serkan İbis

School of Physical Education and Sports, Niğde University, Niğde, Turkey

Abstract

The purpose of the study was to determine the relationship of strength, leg volume, and anthropometric features of Turkish National Team Young Female wrestlers with balance performance. Totally 17 volunteer sportsmen with 18.43 ± 2.25 age average, 165.25 ± 6.90 cm height average, 61.37 ± 8.24 weight average, 22.22 ± 1.63 kg/m^2 Body Mass Index (BMI), and 51.25 ± 6.93 kg Free Fat Mass (FFM) participated into the study. Leg and foot volume of the sportsmen participated into the study were evaluated using Frustum method, their leg strengths were evaluated using leg dynamometer, and balance performances were evaluated using Biodex Balance System. Balance performances were measured on double feet as dynamic and static. Spearman Correlation Analysis test as a non-parametric test was used for the statistical analysis of the data. A positive relationship was determined between leg strength and static balance (r=0.735 p<0.001), dynamic balance (r=0.690 p<0.003), leg volume (r=0.692 p<0.003), foot volume (r=0.735 p<0.001) and BMI (r=0.508 p<0.012); between static balance and dynamic balance (r=0.572 p<0.05), leg volume (r=0.87 p<0.01), foot volume (r=0.841 p<0.01) and FFM (r=0.626 p<0.001), and dynamic balance and leg volume (r=0.583 p<0.05), leg volume (r=0.575 p<0.05), BMI (r=0.646 p<0.05) and FFM (r=0.529 p<0.005) in female wrestlers. Consequently, it was concluded that increase at wrestlers' strength, leg volume and foot volume positively affected balance skill, strength and leg volumes were required to be developed at an adequate level in wrestling in which balance was essential. Moreover, it was also determined that associating the balance performance with FFM instead of BMI would be more correct.

Keywords: Wrestling, Strength, Balance, Leg strength, Leg volume, Anthropometric features.

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Introduction

Balance is the process of neuron-muscle coordination including the protection of balance point's location through constant feedbacks received from visual, auditory and neural senses [1,2]. Balance can be simply defined as the protection of balance point and supporting sole of the body [3]. Balance can be categorized as dynamic and static as well as under different conditions (standing on one leg, two legs). Providing and protecting the balance includes sensory information obtained from visual, vestibular and somatosensory responses. And these are affected from coordination, joint-movement distance and strength [4,5]. Furthermore, balance is also associated with age, gender, balance points and anthropometric structure (such as height, weight, BMI) [2,6]. The increase at weight and adipose tissue is one of the important factors causing decrease at body balance [7,8].

Balance plays an important role in providing several daily activities such as sitting, standing and walking as well as being an essential factor in order to increase sportive performance and present skills in complicated movements [9-12]. A high balance is necessary to achieve motoric and physical improvement features effectively which are the necessities of sportive performance [13-15]. In providing and protecting balance, muscle tonus, muscle strength, muscle resistance and joint movement flexibility are very efficient [16,17]. The previous studies have revealed that strength of especially lower extremity muscle group (ankle, hip and leg) is really important in presenting the balance skill [18-20].

The maximal strength a muscle can create is related to the cross-sectional area of the muscle [21,22]. The previous studies indicated that the volume, mass, cross-section area and fat-free volume rate in muscles creating the leg area affected performance and strength value [23]. Especially in people with low muscle mass, the possibility for the muscle responses to produce bio-mechanic failure can cause balance performance's being affected negatively [7,8,24]. Considering the aforementioned information, the purpose of the study was determined as the relationship of female wrestlers' balance skills with leg volume, foot volume and some anthropometric structures.

Material and Method

Totally 16 volunteer sportswomen in wrestling young national team participated into the study. Age average of the female wrestlers participated into the study was 18.43 ± 2.25 years, their height average was 165.25 ± 6.90 cm, their weight average was 61.37 ± 8.24, and their BMI average was 22.22 ± 1.63 kg/m^2. The female wrestlers participated into the study were informed about the study, and disclosure and permission forms were obtained. The height of the female wrestlers participated into the study was measured using standard steel stadiotmeter as barefoot with 0.1 sensitivity, their body weight and Body Mass Index (BMI) were measured with Tanita BC-418 Segmental Body Analysis System (Tanita Corporation, Tokyo, Japan) without any metals on the body as barefoot (Table 1).

Balance measurement

Biodex Balance System (Biodex, Inc, Shirley, New York) was used for the balance measurement in the study. Biodex balance device includes a moveable platform enabling the participant to stand firm and move front-back and both sides. Among the balance indexes taken, general balance index (OA) talent is accepted as the best indicator. High OA index value indicates much loss of balance. “0 degree” balance scores indicate the possible maximum balance. The platform has mobility degree between 0 and 12. Whereas 12 is the most stable platform, 0 is the most moveable one. In this research, static balance and 2nd degree dynamic balance tests were used. The tests were performed on two feet as standing on a straight position. The tests were repeated three times for 30 second periods with 10 second resting breaks. Before the tests, one each retry test for 10 seconds was performed to the sportsmen in order to let them introduce and adapt static and dynamic balance tests. The participants were asked not to move and talk during the testing period. Tests of the participants who lost their balance were restarted.

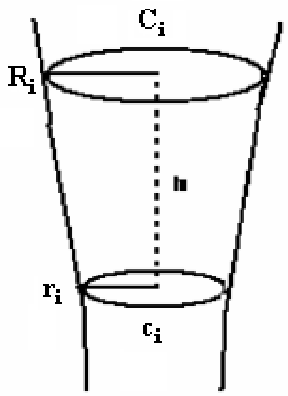

Figure 1. Calculation of leg volume.

Calculation of leg volume

Femur, calf and foot were exposed to volume measurements. After determining the distance between tibial point and inguinal fold for the femur, the distance between tibial point and medial malleolus for the calf and the distance between medial malleolus and whole foot for the foot, the measurements were performed as Frustum model defined. Subsequent to the measurement of the distance between tibial point and inguinal fold in terms of the femur volume, and the distance between tibial point and medial malleolus in terms of the calf volume with 10% interims, the volume of the parts were calculated according to Frust sign model (Formula 1) which were taken with 10% interims then, total volume of femur (Formula 2) and calf (Formula 3) were calculated adding the volume of all parts [25,26] (Figure 1).

$$R_i = \frac{c_i}{2\pi},\ r_i = \frac{c_i}{2\pi} \quad (1)$$

$$V_u = \sum_{i=1}^{10} \frac{\pi}{3} h(R_i^2 + R_i r_i + r_i^2) \quad (2)$$

$$V_b = \sum_{i=1}^{10} \frac{\pi}{3} h(R_i^2 + R_i r_i + r_i^2) \quad (3)$$

Vu=Femur Volume; Vb=Calf Volume; Ri=Radius of 10% piece’s broad part; ri=Radius of 10% piece’s narrow part; Ci=Diameter of 10% piece’s broad part; ci=Diameter of 10% piece’s narrow part; h=The distance between 10% piece’s broad part and narrow part.

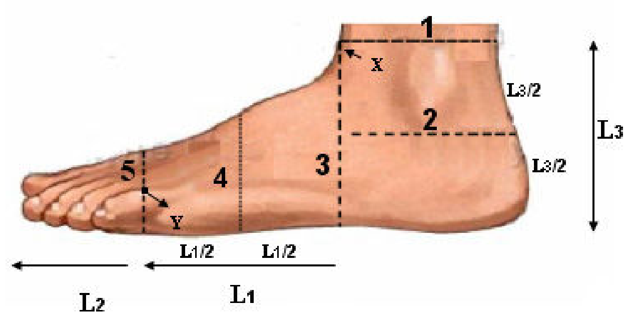

Figure 2. Calculation of foot volume.

Calculation of foot volume

Whereas the elliptic area calculation of the cross-section area (Si) in each part was carried out through Equation 4, the volumes including the areas limited in subsequent parts were calculated using Frustum model. In terms of the foot volume, the hi,ı+1 distance indicated the distance between the sequential parts (Equation 5); the value of height (h) beginning from line number 1 to thenar was L3/2 that changes from one foot to another. The h value from the 3rd part to the 4th was L1/2 changing from one foot to other. Whereas volume of the 5th part was calculated elliptic parabolic Equation 6, total foot volume was calculated adding volumes of all parts 5 (Equation 6) [26,27] (Figure 2).

$$S_i = \prod W_i D_i / 4 \quad (4)$$

$$V_i = (h_{i.I+1}/3)\{S_i + S_{i+1} + (S_i S_{i+1})^{1/2}\} \quad (5)$$

$V_5 = \prod L_2 W_5 D_5 / 8$ (6)

Si=Cross section area; Wi=Maximum width; Di=Maximum depth; Vi=Volume; hi=Height; V5=Total foot volume

Foot volume was possible to be defined with necessary charts between thenar and medial malleolus, or as described above, volume of each parts were calculated and added to the total, and so the total volume of the foot was calculated (Formula 7).

Va=V1+ V2 +V3 +V4+V5 (7)

Va= Foot volume; V1= Volume of the first area; V2= Volume of the second area; V3= Volume of the third area; V4= Volume of the fourth area; V5= Volume of the fifth area

Measurement of leg strength

Leg strength of female wrestlers was measured using leg dynamometer. While the experiments were standing on the dynamometer as slightly bent from the knees, upright and looking straight ahead, dynamometer was adjusted as the bar below the knee and providing arms to be kept straight. The test was performed in a way pushing above from the legs, and the highest value obtained from two trials performed at 30 second intervals was recorded as the maximal leg strength as kg.

Statistical analysis of the data

In data analysis, arithmetic average and Standard Deviation (SD) values were calculated together with the descriptive statistics. In order to determine the relationship between dynamic-static balance, leg and foot volume, Body Mass Index (BMI) and Total Fat Rate (TFR) in female wrestlers, Spearman Correlation Analysis as a non-parametric test was used. All analyses were carried out using SPSS21.0 (SPSS Inc., Chicago, IL), and the significance level of the study was determined as 0.001 and 0.005.

Results

In Table 2, whereas relationship was determined between leg strength and static balance (r=0.735 p<0.001), dynamic balance (r=0.690 p<0.003), leg strength (r=0.692 p<0.003), foot volume (r=0.735 p<0.001) and BMI (r=0.508 p<0.012); no relationship was determined between TFO and FFM and leg strength. A positive relationship was found between static balance and leg strength(r=0.687 p<0.01), foot volume (r=0.841 p<0.01) and FFM (r=0.626 p<0.009). A positive relationship was also determined between dynamic balance and leg strength (r=0.583 p<0.05), foot volume (r=0.575 p<0.05), BMI (r=0.646 p<0.05) and FFM (r=0.529 p<0.035). No significant relationship was specified between static balance and BMI and TFO, and dynamic balance and TYO (p>0.05).

Table 1. Physical properties of young female wrestlers.

Variables	Minimum	Maximum	Mean ± Sd
Age (years)	16.00	24.00	18.43 ± 2.25
Height (cm)	153.00	181.00	165.25 ± 6.90
Body Weight (kg)	51.00	80.00	61.37 ± 8.24
Training Age (years)	7.00	20.00	13.31 ± 2.77
Static Balance	0.20	1.00	0.60 ± 0.21
Dynamic Balance	1.00	2.40	1.48 ± 0.39
Leg Volume	8518.00	15123.00	11706 ± 1948
Foot Volume	559.00	893.00	738 ± 77
BMI(kg/m^2)	19.20	24.40	22.22 ± 1.63
TYO (%)	12.70	21.70	16.45 ± 2.56
FFM (%)	42.70	69.00	51.25 ± 6.93
Leg strength (kg)	59.00	117.00	91.15 ± 13.70

Table 2. Correlation between the leg volume and leg mass, leg strenght of the participants and their balance results.

	Variables	Static Balance	Dynamic Balance	Leg Volume	Foot Volume	BMI	TFO	FFM
Static Balance	Correlation Coefficient†							
	P value							
Dynamic Balance	Correlation Coefficient†	0.572†						
	P value	0.02						
Leg Volume	Correlation Coefficient†	0.687††	0.583†					
	P value	0.00	0.02					
Foot Volume	Correlation Coefficient†	0.841††	0.575†	0.865††				
	P value	0.00	0.02	0.00				
BMI (kg/m2)	Correlation Coefficient†	0.34	0.646†	0.670††	0.521†			
	P value	0.19	0.01	0.01	0.04			

TFO (%)	Correlation Coefficient†	0.31	0.40	0.24	0.39	0.36		
	P value	0.22	0.13	0.37	133.00	0.17		
FFM (kg)	Correlation Coefficient†	0.626††	0.529†	0.848††	0.695††	0.643††	-0.07	
	P value	0.01	0.04	0.00	0.00	0.01	0.80	
Leg strength (kg)	Correlation Coefficient†	0.735††	0.690††	0.692††	0.735††	0.508†	0.24	0.610†
	P value	0.00	0.00	0.00	0.00	0.04	0.38	0.01

††Correlation is significant at (p<0.01) level, †Correlation is significant at (p<0.05)level
†Non-parametric Spearman correlation analysis

Discussion and Conclusion

In order to obtain the required level of performance in wrestling, high level of endurance, strength, flexibility, velocity, promptness reaction and strategy as well as a well-developed balance are needed [28]. Too much foot movements in wrestling causes balance performance to gain more importance in this branch. Muscle strength is essential in providing the balance [16,17]. It has been known that muscle's ability for producing the maximum strength is related to cross-sectional area of the muscle [21,22]. In this study, a positive relationship was determined between static balance and dynamic balance, and leg strength and leg volume. In this study, as well, it was determined that better dynamic balance in sportsmen with high leg strength and leg volume was associated with the increase at muscle strength. Increase at muscle strength provides the improvement between intramuscular and intermuscular coordination. Depending upon this, increase at functioning capacity of the flexor and extensor muscles in a synergist and antagonist way provides increase in balance performance [29].

Muehlbauer et al. mentioned in their study they carried out upon healthy individuals in different age categories that there was a significant relationship between balance and lower extremity muscle strength [30]. In their study upon young males, Young et al. determined that the strength which increased as result of the strength exercises positively affected static and dynamic balance [31]. In their study upon 16 young weight-lifters, Siriphorn and Chamonchant stated that strength in lower extremity muscles increased and balance skill developed as result of a 8-week Wii balance exercise [32]. In this study of Siriphorn and Chamonchant, it was possible to consider that the development in balance depended upon the strength increase at lower extremity muscles. In their study upon the children, Lowes et al. indicated that the increase at strength and flexibility in lower extremity muscles developed the balance skill [33]. In the study of Mohammadi et al. upon young male athletes, 6-week strength trainings performed for leg muscles created increase at leg strength and improvements in dynamic and static balance [34]. Ibiş et al. have detected through a work about women volleyballers that the volume of athletes' legs and their balance performance increase parallel to each other. They express that with the increase of leg volume, the strength of muscle increases and this situation improves the balance performance [35]. Çelenk et al. have detected through a work they performed on elite athletes that the strength of quadriceps muscle increases balance performance [5]. Moraru et al. found in their study upon 31 children at 10-12 age interval that children who regularly exercised higher strength and balance skills rather than the ones who did not regularly exercise, and exercise created increase at strength and balance skills [36]. In their study, Atay and Başaran mentioned that decrease at strength negatively affected the balance skill, and increased fall tendency [37]. In the study comparing the children sedentary children and the children doing judo, Witkowski et al. revealed that balance skills of the children doing judo were better. It was possible to consider that increase at strength was efficient upon high balance skills of the children doing judo [38].

Aforementioned studies had a quality supporting the hypothesis we established, and supported that balance skill developed in parallel to the development in strength. Moreover, this development in balance could be associated with the increase at motor unit contraction velocity and muscle coordination occurred in lower extremity muscles depending upon the increase at muscle strength. One of the important factors affecting the balance includes anthropometric features. The studies carried out before proved that balance was associated with the anthropometric features [39-41]. The studies in the literature revealed that increase at BMI, fat accumulation, and body weight was an important factor in presenting the balance performance. In the study we carried out, a positive relationship was determined between static balance and FFM (r=0.626 p<0.009), and dynamic balance and BMI (r=0.646 p<0.05) and FFM (r=0.529 p<0.035). In their study upon sedentary female and males, Maria et al. mentioned that BMI increase at obese individuals of both genders decreased balance skill [42]. In their study, Greve et al. proved that increase at BMI and body weight negatively affected balance performance [43]. In the studies of Ledin and Odkvist, and Mcgraw et al., obese individuals with over 30 kg/m^2 BMI protected their balances for a shorter period rather than the ones who were not obese [44,45].

In their study, Hue et al. stated that body weight was 50% responsible for presenting the balance skill [46]. In their study, Ledin and Odkvist, and Voight et al. mentioned that 20% weight increase negatively affected balance skill [44,47]. In the study carried out upon obese young and adult individuals, Ledin, Mcgraw et al. and Berringan et al. indicated that increase at fat accumulation in the body caused deteriorations in presenting the balance skill [44,45,48]. Kerkiz et al. have detected through a work on women with the ages of 30-35 that with a BMI increase, balance performance decreases [49]. Stachon et al. carried out a study upon female judoists, and stated that increase at body weight was associated with the increase at fat rate, and muscle mass and skeleton solidity were not as significant [50]. When the literature was reviewed, it was noticed that there was a negative relationship between balance performance and BMI in the studies carried out upon sedentary individuals [41-44,47]. In our study, however, a positive relationship was found between balance performance and BMI. This positive relationship could be expressed with high FFM rate depending upon the study carried out upon a group doing sports. Consequently, when high TFR rate in sedentary individuals and high FFM rate in sportsmen, it was possible to mention that comparing the balance performance with BMI rate in sedentary individuals and with FFM rate in sportsmen was correct. Furthermore, leg strength and leg volume were considered to be significant factors in balance performance.

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*Correspondence to:

Serkan İbis

School of Physical Education and Sports

Niğde University

Turkey