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The Relationship Between Anaerobic Performance and Lower Extremity Volume and Mass in Female Athletes in Individual Sports and Team Sports

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Abstract

This study aims to analyze the relationship between anaerobic performance and leg and foot volume and mass in female athletes in individual sports and team sports. 90 female athletes who have been active in sports for at least three years voluntarily participated in the study. The average age of participants is 21. Frustum and Hanavan methods were used to calculate leg volume and mass, respectively. 20-meter sprint test and vertical jump test were carried out in order to determine anaerobic performance. SPSS 22.0 package program for Windows was used for descriptive statistics and correlation analysis of the obtained data. In this study it was demonstrated that leg volume and mass of female athletes varied in each sport and that right and left leg volume and mass of these athletes were fairly close. Leg volume and mass were higher in team sports athletes than individual sports athletes. In addition, vertical jump performance was better in individual sports athletes. Therewithal it was found very highly negative significant correlation between vertical jump and 20-meter speed values in individual and team sports. As a result it was found that leg volume and mass were higher in team sports athletes than individual sports athletes. Besides when the relationship between leg volume and mass and anaerobic performance is analyzed, a very high positive significance was found between 20 meter speed and right leg mass in boxers. In this way the development of both leg volumes and mass is therefore important for a better anaerobic performance for athletes.

Keywords: female athletes, lower extremity, anaerobic

1. Introduction

Nowadays, studies on sports that are unique to sports are better understood. By providing; the creation of new training techniques, injuries in this sport protect the necessary measures for protection. Leg volume, mass and leg muscle structure are important in almost every sports branch in order to protect against injury and also to perform better. Anaerobic performance is an important parameter for many sports and varies depending on age, gender, physical and physiological parameters. Anaerobic performance and strength values are directly proportional to femur and calf breadth, leg volume and mass (De Ste Croix, Armstrong, Chia, Welsman, Parsons, & Sharpe, 2000). Leg strength is a significant property in terms of speed and maximal speed (Chelly, & Denis, 2001). Athletes with a higher amount of muscle mass and cross section and a higher leg volume and mass display a better anaerobic performance (Staron et al., 2000). Various studies report that anaerobic performance and strength values increase in proportion to femur and calf breadth, leg, leg-muscle and fat-free leg volume. This is because a higher amount of muscle mass and fibers around the leg results in a higher strength (Ergen, Gambuli, Sardella, & Dal Monte, 1984; Ross, & Marfelle Jones, 1991). In the light of this information, it was desirable to investigate the relationship between the leg volume and mass of anaerobic performance of female athletes in. So that the differences in the anaerobic performance of the leg structures of female athletes would be observed. In this study it was aimed to see the relation of anaerobic performances of female athletes to leg volume and mass.

2. Method

2.1 Research Group

Out of 90 female sub-elite athletes participating in this study, 30 of them were engaged in individual sports (taekwondo n=10 height:181.20±1.81 weight:82.10±4.95; boxing n=10 height:176.30±1.76 weight:77.20±1.31; tennis n=10 height:180.00±1.49 weight:83.40±4.92), while 60 of them were engaged in team sports (volleyball n=20 height:181.15±3.06 weight:78.30±4.47; handball n=20 height:183.05±1.98 weight:76.55±2.23; football n=20 height:183.10±2.02 weight:76.60±1.63) were engaged in team sports. Average age of the participants is 21.06. Female athletes who have been active in sports for at least three years were attended to this research.

2.2 Data Collection Tools

After barefoot participants were asked to turn their back to a straight wall, a measuring tape was used to calculate their height. Their weight, on the other hand, was measured with TANITA BC601 (Japan) innerscan sensitive body analysis. Frustum and Hanavan methods were used to calculate leg volume and mass, respectively. 20-meter sprint test and vertical jump test were applied in order to determine anaerobic performance of the athletes.

2.3 Calculation of Leg Volume

Femur, calf and foot masses were measured in the present study. Firstly, we calculated the space between tibial line and inguinal fold on the femur. Secondly, we calculated the space between tibial line and medial malleolus line on the calf. Lastly, we used medial malleolus to measure the whole foot, as defined by Frustom model method (Ozkan & Kin Isler, 2010). While the subject was standing and keeping his legs open in shoulder width, femur mass was calculated by measuring the space between tibial line and inguinal fold by a range of 10% and with a sensitivity of ± 1 mm. Similarly, calf mass was calculated by measuring the space between tibial line and medial malleolus line by a range of 10% and with a sensitivity of ± 1 mm as the subject stood and kept his legs open in shoulder width (Sukul, Den Hoed, Johannes, Van Dolder, & Benda, 1993). Finally, foot mass was calculated in centimeters after medial malleolus was used to measure the whole foot and necessary drawings were completed (Mayrovitz, Sims, Litwio, & Pfister, 2005).

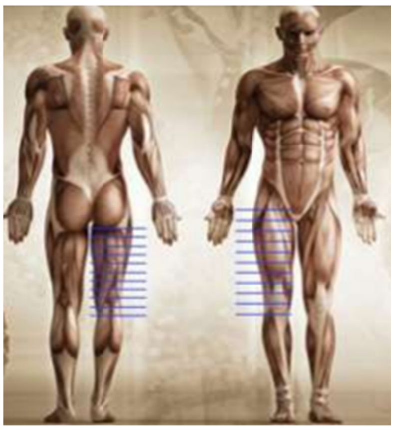

Figure 1. Circumference measurements by a range of 10% to calculate femur mass

Figure 2. Circumference measurements by a range of 10% to calculate calf mass

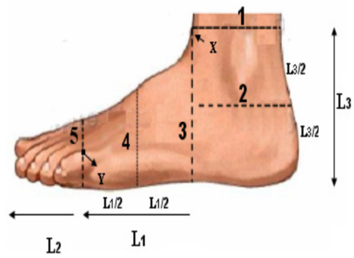

Figure 3. Calculation of foot volume

2.3.1 Calculation of Leg Mass

Leg mass was calculated by using femur, calf and feet measurement. First, the space between tibial line and inguinal fold and between tibial line and medial malleolus line were measured for femur and calf, respectively. Later, medial malleolus was used to measure the foot, as defined by Hanavan model method (Kwon, 1998). "Leg Volume and Mass Calculation Program" designed by Marangoz & Ozbalci (2017) was used as a calculation method.

2.4 Anaerobic Performance Evaluation (Vertical Jump Tests)

Vertical jump test (Sargent Jump) was performed on a straight wall. The subject reaches as far as possible without raising his/her feet from the ground. The distance between where s/he reaches and s/he can touch by jumping is measured in meters. Afterwards, anaerobic strength of the athletes is calculated using body weight and following formula (Formula 1) (Salles, Vasconcellos, Salles, Fonseca, & Dantas, 2012; Cicioglu, Gokdemir, & Erol, 1997).

$$P = \sqrt{4.9} \text{ X W X D}''$$

P = Anaerobic Strength

W = Body Weight (kg)

D" = Jumping Distance (m)

4.9 = Standard (sec) (1)

2.5 20-Meter Sprint Test

Smart Speed Photocell (USA) was used to calculate 20-meter sprint speed of the athletes on a 20-meter distance in the fitness center. The participants started the test 1 meter behind the starting photocell. Prior to the test, they were given 15 minutes for a warm-up session including jogging and stretching. Each participant performed the test twice with an interval of five minutes, and their best result was taken into account. The reliability coefficient of the test was reported as 0.74-0.97 (Ozkara, 2002).

2.6 Statistical Analyses

Statistical analysis of the data obtained showed that SPSS 22.0 package program was used and the results were evaluated at p<0.05 significance level. The normality test was performed to determine whether the data fit the normal distribution. The number of players surveyed in the survey is 90. Since this number is above 30, the Kolmogorov-Smirnov tabulation was used (Alpar, 2003). According to the Kolmogorov-Smirnov table, variables showed p>0.05; for this reason, parametric test Pearson Correlation test was applied to the variables.

3. Results

Table 1. Descriptive statistics of the athletes in study

	Team Sports (n=60)			**Individual Sports (n=30)**		
Variables	Volleyball (n=20)	Handball (n=20)	Football (n=20)	Boxing (n=10)	Taekwondo (n=10)	Tennis (n=10)
	x±sd	x±sd	x±sd	x±sd	x±sd	x±sd
Right Leg Volume	14036.41±1181.46	13621.77±1397.73	12108.21±2391.98	13767.37±2514.34	13422.41±1600.64	11440.74±2398.49
Left Leg Volume	13346.55±1253.09	13491.21±1307.79	11900.86±2503.47	13470.46±2653.79	13066.01±1812.54	11382.48±2427.19
Right Leg Mass	12.77±.71	13.02±1.15	12.02±1.72	13.12±1.86	12.18±1.00	11.59±1.92
Left Leg Mass	12.73±.89	12.99±1.22	11.96±2.03	13.10±1.65	12.11±1.29	11.32±2.12
Vertical Jump	83.54±3.36	90.06±8.39	69.18±14.36	77.87±8.72	79.63±13.70	74.65±4.51
20-meter Speed	3.41±.07	3.27±.12	3.44±.11	3.34±.18	3.48±.20	3.36±.14

Table 2. Pearson correlation comparisons among leg volume, leg mass, anaerobic strength and speed of female elite players in different team sports

			Right Leg Volume	Left Leg Volume	Right Leg Mass	Left Leg Mass	Vertical Jump
Volleyball (n=20)	Left Leg Volume	r	***.684*****				
	Right Leg Mass	r	***.706*****	***.983*****			
	Left Leg Mass	r	***.713*****	***.968*****	***.998*****		
	Vertical Jump	r	-.441	-.172	-.100	-.074	
	20-meter speed	r	-.149	-.057	.048	.087	***.838******
Handball (n=20)	Left Leg Volume	r	***.939*****				
	Right Leg Mass	r	***.913*****	***.998*****			
	Left Leg Mass	r	***.802*****	***.959*****	***.976*****		
	Vertical Jump	r	***.915******	***.721******	***.672*****	***.494****	
	20-meter speed	r	***-.920*****	***-.729*****	***-.681*****	***-.504****	***-1.000******
Football (n=20)	Left Leg Volume	r	***.987*****				
	Right Leg Mass	r	***.984*****	***.971*****			
	Left Leg Mass	r	***.992*****	***.997*****	***.988*****		
	Vertical Jump	r	-.230	-.237	-.399	-.296	
	20-meter speed	r	.044	-.055	.183	.027	***-.743*****
Team Sports (n=60)	Left Leg Volume	r	***.931*****				
	Right Leg Mass	r	***.917*****	***.970*****			
	Left Leg Mass	r	***.897*****	***.978*****	***.985*****		
	Vertical Jump	r	***.272****	.233	.152	.136	
	20-meter speed	r	***-.327****	***-.335*****	***-.261****	-.242	***-.715*****

Notes. *p<0.05 ** p<0.01 *** p<0.001

r: Interpretation of Pearson (r) correlation coefficient; 0.00-0.25 very weak, 0.26-0.49 weak, 0.50-0.69 middle, 0.70-0.89 high, 0.90-1.00 very high.

Table 3. Pearson correlation comparisons among leg volume, leg mass, anaerobic strength and speed of female elite players in different individual sports

			Right Leg Volume	Left Leg Volume	Right Leg Mass	Left Leg Mass	Vertical Jump
Boxing (n=10)	Left Leg Volume	r	***1.000*****				
	Right Leg Mass	r	***.972*****	***.965*****			
	Left Leg Mass	r	***.988*****	***.983*****	***.997*****		
	Vertical Jump	r	***-.964******	***-.955*****	***-.999******	***-.993******	
	20-meter speed	r	***.815*****	***.802*****	***.882*****	***.864*****	***-.888*****
Taekwondo (n=10)	Left Leg Volume	r	***.978*****				
	Right Leg Mass	r	***.995*****	***.955*****			
	Left Leg Mass	r	***.988*****	***.933*****	***.996*****		
	Vertical Jump	r	.026	.236	-.060	-.129	
	20-meter speed	r	-.089	-.297	-.007	.066	***-.996*****
Tennis (n=10)	Left Leg Volume	r	***1.000*****				
	Right Leg Mass	r	***.965*****	***.972*****			
	Left Leg Mass	r	***.983*****	***.987*****	***.997*****		
	Vertical Jump	r	-.461	-.483	***-.677****	-.617	
	20-meter speed	r	-.393	-.417	-.620	-.557	***.997*****
Individual Sports (n=30)	Left Leg Volume	r	***.993*****				
	Right Leg Mass	r	***.950*****	***.949*****			
	Left Leg Mass	r	***.962*****	***.956*****	***.989*****		
	Vertical Jump	r	-.263	-.216	**-.387***	-.347	
	20-meter speed	r	.179	.113	.083	.065	***-.572*****

Notes. $^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

r: Interpretation of Pearson (r) correlation coefficient; 0.00-0.25 very weak, 0.26-0.49 weak, 0.50-0.69 middle, 0.70-0.89 high, 0.90-1.00 very high.

4. Discussion and Conclusion

In this study it was found that leg volume and mass were higher in team sports athletes than individual sports athletes. Focusing on the relationship between leg volume and mass and anaerobic performances of female athletes, this study found significant correlations between right and left leg volume and mass for all sports. It was concluded that right and left leg volume and mass of the athletes participating in the study were quite close. While the highest leg volume and mass values were observed in volleyball players, the lowest leg volume and mass values were found in tennis players. In addition, a very highly positive significant correlation was found between 20-meter speed and right leg mass in boxers, which accounts for a higher 20-meter sprint speed performance in boxers with a higher amount of leg mass. However, it can also be noted that tennis and football players who had the lowest leg volume and mass displayed a poorer vertical jump performance. It is thus evident that leg volume and mass influences anaerobic performance.

Zorba et al. (2010) analyzed the relationship between leg volume, leg mass, anaerobic performance and leg strength, and reported that leg volume and mass played a decisive role in anaerobic performance of wrestlers and that a relationship was found between isometric leg strength and anaerobic performance, which overlaps the findings in this study.

Chelly et al. (2010) observed a significant correlation among body mass, total leg volume and femur mass based on 5-meter sprint speed results. They reported that 1 RM semi squat and 5 meter sprint speed performances are positively affected by total leg mass. Similarly, the present study found significant correlations between 20 meter sprint speed, leg volume and mass.

In their study on mountain climbers, Ozkan et al. (2010) demonstrated that fat-free body mass, leg volume and leg mass played an important role in the determination of anaerobic strength and capacity. Thus, it was underlined that body mass, leg volume and leg mass contributed to anaerobic performance in various sports.

Differing from other studies on this topic, Temfemo et al. (2009) analyzed some anthropometric values and vertical jump performances in adolescent males and females and reported that leg length and leg mass values of 14, 15 and 16-year-old males were higher compared to females. Additionally, vertical jump performances of males were better compared to females, too.

Aslan et al. (2011) focused on the relationship among body composition, anaerobic performance and back strength in sub-elite athletes. They reported that body weight, body fat percentage, height and back strength heavily influenced anaerobic performance. In addition, it was also observed in this study that leg volume and leg mass affected anaerobic performance.

In their analysis of the relationship between body structure and muscle strength, Markovic & Jaric (2007) found out that body weight influenced strength and anaerobic strength positively, while a high body weight created a negative effect on vertical jump performance.

Ostojic et al. (2006) found a strong correlation between body composition and anaerobic power and Silvestre et al. (2006) also found that there were significant correlations between body composition and vertical jump and anaerobic power.

Guder et al. (2016) found a significant correlation among leg volume, leg mass and anaerobic performance and leg strength in taekwondo players, overlapping the findings in the present study. In this study demonstrated that football and tennis players whose leg volume and mass were lower displayed a poorer anaerobic (vertical jump) performance.

Tas et al. (2013) benefited from vertical jump test in order to measure anaerobic performance and measured leg, femur and calf volume of the participants. They reported a significant correlation among anaerobic performance and leg, femur and calf volume as well as femur and calf breadth.

As the above-mentioned studies also indicate, the influence of leg volume and mass on the anaerobic performance was also proved in the present study. In this study leg volume and mass of female athletes varied in each sport and that right and left leg volume and mass of these athletes were found fairly close. When the relationship between leg volume and mass and anaerobic performance is analyzed, a very high positive significance was found between 20 meter speed and right leg mass in boxers. Therefore, it can be argued that 20 meter sprint test performances of boxers with a higher leg mass are remarkable. Additionally, tennis players and football players, who had the lowest leg volume and mass, displayed a poor vertical jump performance, indicating a correlation between leg volume and mass and anaerobic performance.

As a result it was found that leg volume and mass were higher in team sports athletes than individual sports athletes. In addition, vertical jump performance was better in individual sports athletes. Therewithal it was found very highly negative significant correlation between vertical jump and 20-meter speed values in individual sports and team sports. So it is important for athletes to improve both right and left leg strength for a better anaerobic performance. As a recommendation for subsequent studies it may also be helpful to measure leg strength and leg strength at the same time. In addition to the anaerobic performance measurements performed in this study, it is suggested that the aerobic performance of the athletes can also be measured in subsequent studies.

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