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Ultrasonographic Measurements of the Achilles Tendon Thickness of Men and Women Athletes in Olympic Weightlifting

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Abstract

Objectives: The study aims to investigate the Achilles tendon thickness of men, women athletes in Olympic weightlifting and sedentary individuals.

Methods: This research study was conducted on 4 groups, comprising of athletes in Olympic weightlifting (n= 25 men, n=25 women) and sedentary individuals (n=25 men, n=25 women), aged 18-19 years. Ultrasonography was performed on the Achilles tendon of the two limbs of 100 individuals.

Results: The mean thickness of the Achilles tendon was significantly larger in the athletes than in the sedentary individuals. No correlation was found between the age, height, body weight of the athletes and the thickness of the Achilles tendon.

Conclusion: In conclusion, we state that in addition to the following hypertrophic development of the Achilles tendon in athletes in weightlifting, future studies including force parameters may be beneficial.

Keywords: Achilles tendon, Olympic weightlifting, ultrasonography

1. Introduction

The Achilles Tendon (AT) is the largest and thickest tendon in human body. AT injuries are highly common in individuals maintaining sports activities. Training faults, weak ankle flexibility and inadequate tendon force cause an increased risk in injuries of the tendon (Gibbon et al. 2000). As a result of abuse, peritendinitis, tendinous and tendon tearing might develop (Karjalainen et al.). For the last two decades, the incidence of tendon tearing has increased (Maffulli et al. 1999). The morphologic characteristics and normal variations in anatomy with respect to sports injuries are well described in the literature. Dense connective tissue undergoes unique changes in some general diseases (Steinmetz et al. 1988) and even in the normal ageing process (Crouse et al. 1972). Mean values reported for the thickness of the Achilles tendon (ATT) measurements differ considerably (from 4.2 to 7.1 mm) in different studies (Fornage 1986, Kallinen and Suominen 1994, Koivunen-Niemela et al. 1993, Steinmetz et al. 1988). Body stature, height and even ethnic factors have been suggested as factors influencing tendon thickness (Bude et al. 1993, Koivunen-Niemela et al. 1993). Little is known about how the AT responds to physical activity in humans. Magnusson and Kjaer (2003) and Ying et al., (2003) suggested that long-term exercise would cause an increase in thickness of the AT, while Hansen et al., (2003) found no such effects of long-term training. Fredberg et al., (2007) found no influence of short-term physical activity on the thickness of the AT. Since the AT is slight in structure and easy to reach, Ultrasonography (US) is an ideal imaging method to observe and study the tendon (Kalebo et al. 1992, Gibbon et al. 2000).

We couldn't reach out any studies on the ATT of athletes in Olympic weightlifting.

By using ultrasonographic imaging, the study aims to analyze ATT differences between men (MAOW) and women (WAOW) athletes in Olympic weightlifting, and sedentary individuals.

2. Materials and Methods

This research study was conducted on four groups. Two groups included 25 men athletes aged 18-19 years (MAOW) and 25 women athletes aged 18-19 years (WAOW) in olympic weightlifting, who attended national and international competitions and have been doing trainings regularly for the last 2 years. The other two groups included 25 men and 25 women healthy sedentary individuals, who have never done sports actively. Table 1 shows demographic data of the study groups.

The study was approved by the Studies Except Medicine Medical Devices Ethics Committee in the university of Necmettin Erbakan, Meram Medical Faculty (dated 19/09/2018 and numbered 1481). All procedures followed in the study were in compliance with the ethics committee approval. All participants in the study were physically examined by a specialist. After physical examination, all participants were informed regarding the study.

The study criteria for the MAOW and WAOW were as follows: 1- training weightlifting at least for the last two years at a national team athlete level. 2- training weightlifting at least 5 days a week during this period. 3- having no right-left AT injuries in the last 4 months. 4- having no surgical AT operation.

The study criteria for the sedentary individuals were as follows: 1- having no sports training before. 2- having no right-left AT injuries in the last 4 months. 3- having no surgical AT operation.

AT US imaging of the MAOW and WAOW was conducted by a specialist radiologist. For the US examination, a Siemens acuson X 300 (Germany) US machine with an electronic 10 MHz linear transducer (VF10-S) was used in the study. US scanning for AT was performed on both ankles in prone position while feet hanged freely over the end of the examination couch. The thickness was measured in the longitudinal plane. The measurements were taken at a point 3 cm proximal to the insertion of the tendon to the calcaneus. Why this was area was chosen for the measurement was because of data indicating that the midportion of the AT, measured 2- to 7-cm proximal to its calcaneal insertion, is most prone to clinical and radiological Achilles tendinopathy (van Sterkenburg et al. 2011).

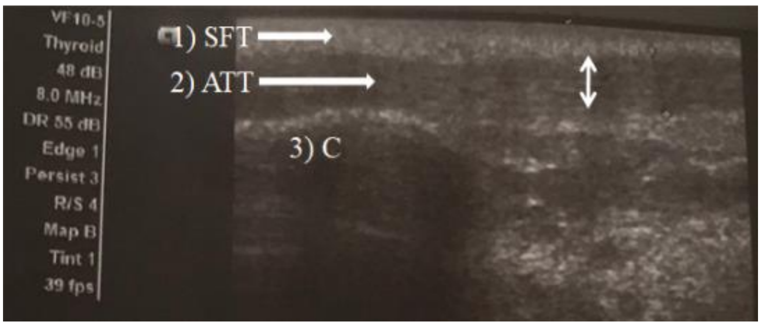

Figure 1. 1) SFT (Subcutaneous fat tissue), 2) ATT (Achilles tendon), 3) C (Calcaneus), tendon thickness was measured from longitudinal sonograms of the AT with the aid of a grayscale profile and, 30-mm proximal to the superior aspect of the calcaneus

3. Statistical Analysis

The analysis of the morphometric data obtained from the study was conducted by an SPSS 23.0 statistics software. Whether the data corresponded to normal mean values was tested. The data for the age, body weight, body mass index and training years were in normal value range, thus, unpaired t test was used. However, since other parameters range normally, one of non-parametric tests, Mann-Whitney U test was used. Pearson Correlation test was also used to express the correlations between age, height, body weight, body mass index, training years and ATT measurements. All the results obtained were shown in charts.

4. Results

Table 1 shows the data of study groups regarding age, height, weight, body mass index and training years. After all participants of the study were examined for AT and ultrasonography images were studied by a specialist, no pathological finding was observed.

Table 1. Morphometric body measurements, ages and training years of the participants in the study (Mean ±SD)

Features	Groups			
	Men		Women	
	MAOW (n 25)	Control (n 25)	WAOW (n 25)	Control (n 25)
Age (year)	18,00±1.63	18.48±0,96	18,16±0,74	18,36±0,75
Height (cm)	174.60±4,68	173,00±6,28	160,96±6,63	162,96±5,04
Body weight (kg)	77,00±10,61	73,12±8,93	58,08±8,73	57,48±7,89
BMI (kg/m^2)	25,23±3,23	24,10±2,75	22,48±2,91	21,59±2,35
Training years	4,5±1,3	-	4,5±1,47	-

BMI: Body mass index

Table 2 shows mean, right, left ATT measurements of the MAOW, WAOW and control groups.

We observed that mean, right, left ATT measurements of MAOW and WAOW in the study group were higher than mean, right, left ATT measurements of men and women control groups. (Table 2).

Table 2. Mean- right- left ATT of the participants in MAOW, WAOW and control groups (cm)

Groups		Right ATT	Left ATT	Mean ATT
MAOW (n 25)	Mean	,572	,572	,572
	Std. Deviation	,1173	,1173	,117
Control (n 25)	Mean	,492	,484	,488
	Std. Deviation	,0812	,0688	,074
WAOW (n 25)	Mean	,528	,528	,528
	Std. Deviation	,1061	,1061	,1061
Control (n 25)	Mean	,420	,416	,418
	Std. Deviation	,0764	,0746	,075

ATT: Achilles tendon thickness

Right-left and mean ATT measurements of the study groups are given in Table 3.

According to the analysis in which right-left and mean ATT measurements were carried out by non-parametric tests, MAOW and WAOW's right-left and mean ATT measurements were significantly higher than the ATT of men and women (P<0,001).

Table 3. The comparison of right-left and mean ATT measurements of MAOW, WAOW and control groups

Tendon Groups		Mean Rank	Sum of Ranks	Z	P
Right ATT	MAOW (n 25)	30,58	764,50	-2,62	**,001**
	Control (n 25)	20,42	510,50		
Left ATT	MAOW (n 25)	31,14	778,50	-2,93	**,000**
	Control (n 25)	19,86	496,50		
Mean ATT	MAOW (n 25)	30,78	769,50	-2,72	**,001**
	Control (n 25)	20,22	769,50		
Right ATT	WAOW (n 25)	32,96	824,00	-3,81	**,000**
	Control (n 25)	18,04	451,00		
Left ATT	WAOW (n 25)	33,28	832,00	-3,978	**,000**
	Control (n 25)	17,72	443,00		
Mean ATT	WAOW (n 25)	33,18	829,50	-3,91	**,000**
	Control (n 25)	17,82	445,50		

ATT: Achilless tendon thickness, p<0,001.

Pearson Correlation parameter was used to analyze ATT variables and age, height, body weight, body mass index and training years data of the groups. According to the analysis, there was a significant correlation (p<0,05) between body mass index and right-left and mean ATT measurements of the MAOW. In addition, a significant correlation was found between training time and right-left and mean ATT of WAOW. (P<0,05). Apart from body mass index of MAOW and training time of WAOW, no statistically significant correlation was found among other parameters of the groups (p>0,05) (Table 4).

Table 4. The correlation between right-left-mean ATT measurements and age, height, body weight, body mass index and training years of the groups

Features		MAOW (n 25)			WAOW (n 25)		
		Right ATT	Left ATT	Mean ATT	Right ATT	Left ATT	Mean ATT
Age (years)	Pearson Correlation	,109	,109	,109	,257	,257	,257
	P	,605	,605	,605	,215	,215	,215
Height (cm)	Pearson Correlation	,041	,041	,041	,339	,339	,339
	p	,844	,844	,844	,097	,097	,097
Body Weight (kg)	Pearson Correlation	,395	,395	,395	,177	,177	,177
	p	,051	,051	,051	,397	,397	,397
BMI (kg/m²)	Pearson Correlation	,411*	,411*	,411*	,051	,051	,051
	p	**,041**	**,041**	**,041**	,808	,808	,808
Training years	Pearson Correlation	,067	,067	,067	,409*	,409*	,409*
	p	,750	,750	,750	**,043**	**,043**	**,043**
		Control (men n= 25)			**Control (**women n 25)		
Age (years)	Pearson Correlation	,371	,184	,289	,086	,032	,028
	p	,068	,379	,161	,681	,878	,895
Height (cm)	Pearson Correlation	,049	,116	,081	,035	,101	,068
	p	,816	,582	,702	,870	,630	,746
Body Weight (kg)	Pearson Correlation	,039	,078	,058	,053	,064	,059
	p	,854	,711	,785	,803	,760	,780
BMI (kg/m²)	Pearson Correlation	,069	,146	,106	,042	,016	,030
	p	,743	,487	,615	,842	,938	,888

BMI: Body muscle index, ATT: Achilless tendon thickness * p<0,05

5. Discussion

High-resolution US is an ideal imaging tool for initial investigation of the Achilles tendon. This is because the Achilles tendon is a superficial structure and is easily accessible by high-resolution US, which provides detailed images and has a high accuracy in the assessment of the tendon (Kalebo et al. 1992, Gibbon et al. 1999). In our study using US imaging, we examined ATT of MAOW and WAOW aged 18-19 years by comparison with sedentary individuals. Although we found no quantitative differences in right-left ATT measurements of the MAOW and WAOW, there was a slight quantitative difference in right-left ATT measurements of the individuals in the control group. In studies including ATT of gymnastics athletes and sedentary individuals (Emerson et al. 2010) and men and women individuals into running trainings (Ying et al. 2003), the researchers reported that no statistically significant difference was found between dominant and non-dominant AT. Moreover, owing to same loads on both feet AT in running trainings, it was reported that ATT measurements might have been equal (Ying et al. 2003). Olympic weightlifting is branch of sports in which snatch and clean-and-jerk techniques are widely used (Burdett 1982) and these movements mostly include symmetrical movements (except the second phase of jerk) (Urso 2014). From the point of the view of the fact that the loads on AT of both feet are equal during snatch and jerk movements, we consider that ATT of MAOW and WAOW was the same for this reason. We are of the opinion that the quantitative difference in ATT measurements of the sedentary individuals result from an asymmetrical development as a result of dominant feet use in daily life.

In the studies focusing on ATT of men and women athletes, mean ATT of the athletes was reported as 4,52 mm in football Brushøj et al., (2006), 5,20 mm in athletics Hırschmüller et al., (2012), 5,30 mm in gymnastics Emerson et al., (2010), and some other studies reported that the tendon thickness of the individuals who are into sports and training was higher than those of sedentary individuals (Ying et al. 2003, Emerson et al. 2010, Kallinen and Suominen 1994). In compliance with the literature, we found that ATT of MAOW and WAOW was higher than those of sedentary individuals. We also realized that ATT of the MAOW in our study had a higher ATT measurement than those of athletes included in the studies of Brushøj et al., (2006), Emerson et al., (2010), Hirschmüller et al., (2012). Furthermore, the ATT of WAOW in our study had the same size ATT of athlete and exercise groups in the study of Hırschmüller et al., (2012) and Ying et al., (2003), whereas our ATT measurement was smaller than those of gymnastics athletes in the study group of Emerson et al., (2010). We consider that these differences might be resulted not only from demographic differences and different imaging protocols, but also from differences in branches of sports.

In former studies, it was reported that there was a positive correlation between aging and tendon degeneration (Maffulli et al. 2000, Yamada et al. 2003). They also expressed that they observed a decline in the density and size of collagen fibrils of the AT by aging, however, an increase in the fibril concentration of the tendon was observed Strocchi et al., (1991). As a result of this change, they concluded that the tendon renovates itself continually, causing tendon hypertrophy (Kallinen and Suominen 1994, Gibbon et al. 1999). Therefore, it is observed that elder people have thicker tendons. In their study including the ATT observations of 267 healthy individuals, Koivunen-Niemela and K Parkkola (1995) reported that the tendon thickness increases by age and that they observed a close relation between age and tendon thickness. Pan and Ying (2006) observed the AT of 40 individuals at different ages in their study and concluded that ATT of elder individuals was higher than those of younger individuals, however, they also reported that they observed no correlations between age and ATT (p>0,05). In another study including 100 different AT observations, it was reported that there existed no correlations between age and ATT (Patel and Labib 2018). In our study including 100 participants consisting of athletes in Olympic weightlifting and sedentary individuals, we observed no correlation between age and ATT (p>0,05). This result made us think that future studies focusing on the investigation of ATT might need to include more athletes with different age groups. Moreover, we also noted that the mean age of the sedentary individuals in our study was younger than the mean age of the study groups in the studies of Koivunen-Niemela and K Parkkola (1995), and Pan and Ying (2006), and that their ATT measurement was smaller in compliance with the literature. However, though the mean age of our study group was younger than the mean age of the MAOW of the study of Pan and Ying (2006), our study group surprisingly had a higher ATT. This made us consider that this finding results from the effects of athletic performance on AT.

In the study examining mean ATT of healthy individuals with different age and height the researchers noted that the thickness of the tendon is higher in taller individuals, thus, they reported a positive correlation between age and height (Koivunen-Niemelä and Parkkola 1995). Again in another study, a positive correlation between ATT and height of healthy individuals was reported Patel and Labib (2018). In a study investigating AT morphometry of Chinese individuals, it was reported that mean ATT of the Chinese (5.23±0.45 mm) was smaller than those of the Caucasians and that this difference resulted from the height differences between these races (Yıng et al. 2003). Pang and Ying (2006) reported that they found no correlations between ATT and height of healthy individuals with different age. Similarly, we also found no correlations between ATT and height of the individuals participated in our study. We found that ATT measurements of the study group of Patel and Labib (2018) was lower than those of athlete and sedentary groups in our study. We also found that ATT measurements of the study group of Ying et al., (2003) was lower by 0,5 mm than our MAOW group and was higher by 0,4 mm than men sedentary individual group in our study.

ATT measurements of the study groups of Koivunen-Niemela and K Parkkola (1995)] were found to be higher than those of both our athlete and sedentary individual groups. In particular, it was quite surprising to figure out that kids group had a higher ATT than those of our men and women sedentary individuals. We are of the opinion that the obtained differences might result from racial differences as well as mean height difference.

In previous studies, a positive correlation between ATT and body weight was reported Koivunen-Niemela and K Parkkola (1995), Aktürk et al., (2007). Furthermore, Patel and Labib (2018) reported in their study that the AT has a positive correlation with body weight and BMI. For all groups in our study, we couldn’t find any positive correlations between body weight and ATT, however, we found BMI and ATT of the MAOW were correlated. Body mass index is a parameter defined by WHO to determine body weight divided by height in meter (kg/m^2). How BMI rates define the body weight of a person is as follows: lower than 18,5 kg/m^2 low weight, 18,5-24,9 kg/m^2 normal body weight, 25-29,9 kg/m^2 overweight, higher than 30 kg/m^2 obese, higher than 40 kg/m^2 morbid obese (WHO 1997). In their study, Wearing et al., (2012) reported that as a result of obesity, ATT (4,5 mm) of individuals with 95,9 kg body weight and 30 kg/m^2 BMI, was higher than those of individuals with 65,6 kg body weight and 21,3 kg/m^2 BMI, thus, they found ATT increased by obesity. Although BMI of the MAOW in our study was lower than BMI of the obese individuals in the study of Wearing et al., (2012), it was surprising to figure out that MAOW had a higher ATT. We consider that the difference seems to result from the hypertrophic effect, rather than BMI, of Olympic weightlifting on AT.

In studies including experimental animals, physical training leads a hypertrophic effect on AT of the animals (Sommer 1987). Olympic weightlifting trainings are known to bring about hypertrophy in lower limb muscles and tendons along with a higher level of stiffness (Kubo et al. 2007, İnce 2019). In addition, athletic activities provide a hypertrophic effect on ATT and cross-sectional area of elder and athletic individuals (Kallinen and Suominen 1994, Emerson et al. 2010, Milgrom et al. 2014). When we compare ATT measurements of athletes in Olympic weightlifting and sedentary individuals, we might say that long-term physical trainings cause a hypertrophic effect of AT of the athletes. Nevertheless, though there was no correlation between total weightlifting training years of MAOW and ATT, we observed a correlation between total weightlifting training years of WAOW and ATT.

In their study including elder individuals Reeves et al., (2003) reported that 14-week long weightlifting trainings do not cause an increase in the cross sectional area of patellar tendon. Kubo et al., (2001) and Kubo et al., (2002) also reported that following 8-12-week long isometric force trainings do not lead an increase in the cross sectional areas of patellar and AT. Moreover, the researchers Urlando and Hawkins (2007) noted that there is a positive correlation between hypertrophic development in AT and force parameters. Though the training years of MAOW and WAOW in our study was the same (4,5 years), the reason for the absence of a correlation between total weightlifting training years of MAOW and ATT seems likely to result from the fact that different trainings for men and women athletes are preferred in training sessions.

In conclusion, we are of the opinion that in addition to the following hypertrophic developments of AT in MAOW and WAOW by carrying out regular imaging at different times, future studies including force parameters may be beneficial. Moreover, for the observed deficiencies in force parameters, we estimate that the addition of special trainings to improve force parameters of AT into general Olympic weightlifting programs may contribute to the athletic feat of athletes in Olympic weightlifting.

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