Original Article

MORPHOMETRIC EVALUATION OF ACHILLES TENDON BY ULTRASOUND*

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Abstract

OBJECTIVE: The aim of this study was to determine the normal values of the tendon thickness in the anteroposterior dimension and width in the transverse dimension in our population, correlating them with gender, age ranges, race, ABO blood group and body mass index. MATERIALS AND METHODS: Ultrasonographic examination was employed to evaluate 100 Achilles tendons of 50 healthy volunteers in order to measure the tendons thickness in the anteroposterior dimension and width in the transverse dimension. All examinations were performed by the same sonographer, using an ultrasound equipment with a 10 MHz linear transducer. RESULTS: Among the 50 volunteers studied, 25 were men and 25 were women, ranging from 20 to 52 years (average 33.9 years). The tendons average width was 13.3 ± 1.0 mm in the female group and 14.4 ± 1.4 mm in the male group; the average thickness was 5.4 ± 0.5 mm in the female group and 5.6 ± 0.6 mm in the male group. These measurements were significantly lower in the female group ($p < 0.05$). There was no significant correlation between the tendon measurements and the age ranges, ABO blood groups and races. The tendon width was significantly higher in the overweight body mass index group than in the normal body mass index group. CONCLUSION: Mean values found in our study differ significantly from the majority of other studies in the literature, demonstrating the importance of creating our own standards employing tables based on our population in daily clinical practice.

Keywords: Achilles tendon; Ultrasound; Anatomy; Anthropometry.

INTRODUCTION

The Achilles tendon is the greatest and more resistant tendon of the human body and one of the most common sites of overuse injuries among athletes[(1)].

Up to few years ago, the radiological assessment of tendons was essentially based on low kV radiography that provides very few information[(2–5)]. In the great majority of times it can only indicate the site where there is an increase in soft tissues, irregularities in tendons contour or the presence of calcifications[(6–8)].

Presently, magnetic resonance imaging (MRI) and ultrasound (US) are the modalities of choice for tendons diseases diagnosis[(9–13)]. Some authors defend that the US presents a better spatial resolution then MRI, when studies obtained with more modern devices are compared[(14)]. This is due to the fact that tissues with few mobile protons emit little or no signal, therefore, tendons internal architecture is not well demonstrated by MRI[(8,15)]. US also has the advantadge of allowing the study of tendons in a real-time dynamic mode [(16–18)]. Other US advantages are: low cost, easy availability and the fact that, usually, during the examination, the comparison with the opposite side will be available[(12,17,19,20)].

For an Achilles tendon accurate US examination, it is essential to master the examination technique, to have knowledge about the normal anatomy of this tendon as well as a correct analysis of its dimensions[(21,22)].

In a research in the literature about Achilles tendon morphometry in normal patients, we could testify the poor worldwide availability of these data, including the inexistence of Brazilian studies demonstrating morphometric data of Achilles tendon of our population.

In this study, Achilles tendons of 50 volunteers (100 tendons) selected accordingly to rigorous inclusion and exclusion criteria were analyzed. The objectives were: to evaluate the Achilles tendon morphometry in adult, asymptomatic individuals, correlating these measurements with age ranges, sex, ABO blood group, race and body mass index and establishing normal Achilles tendons diameter referential values in a Brazilian population.

MATERIALS AND METHODS

A prospective study of 50 asymptomatic individuals (100 Achilles tendons) was performed, by means of ultrasonographic evaluation aiming at a morphometric analysis of both tendons in each individual.

Examinations were performed in the Hospital de Clínicas de Niterói, between August and December of 2003. The ultrasound equipment used was an Image Point HX (Hewlett-Packard; Andover, EUA) with a 10 MHz linear transducer.

Tendons B-mode, real-time US evaluations were performed in longitudinal and transversal planes. All the examinations were performed by the same sonographer, with previous informed consent signed by patients.

Dimensions were calculated from tendons transversal images obtained at the distal portion of the medial maleolus (Figure 1), the transversal and anteroposterior diameters being measured in each tendon (Figure 2).

At the day of examination, the patients received a brief explanation on the study, aiming at clarifying their doubts and answering questions about their expectations in relation to the examination.

Sedentary volunteers in the age range between 20 and 59 years and without previous history of trauma in the Achilles tendon region were included in the study. For this study purposes, "sedentary" are those individuals who have reported not being engaged in any regular physical activity with a minimum frequency of three times a week for the last two years. Individuals included in any of the following categories were excluded from this study:

a) Suffering from any known systemic e/or rheumatic disease;

b) prolonged use of corticosteroid during the last 12 months;

c) recent use (as least 30 days) of any quinolonic agent (antibiotic);

d) having sought medical assistance for treatment of any problem related to Achilles tendon.

The choice of these exclusion criteria has taken into consideration the significant relation between the concomitant occurrence of these conditions and an increase in the number of Achilles tendon lesions.

Besides the already mentioned information, the patients also have informed their sex, age, skin color, weight, height and ABO blood group. The use of the term "skin color" instead of "race" is due to the great miscegenation existent in Brazil and the poor relation between this phenotypic trace and the volunteers´ genotype.

Based on data about each individual weight and height, we have obtained the QI – Quetelet Index, sometimes called Body Mass Index (BMI), corresponding to the weight in kilograms divided by the height in meters squared [QI = (weight in kilograms)/(height in meters)^2][23]. The QI is an index utilized for indicating the weight status in relation to the height. For adults more than 20 years old, QI is divided into four categories: (1) slimness, QI < 18.5; (2) normal, QI between 18.5 and 24.9; (3) overweight, QI between 25.0 and 29.9; (4) obesity, QI > 30.0.

Regarding ages, the volunteers were distributed in the following age ranges: 20-39 years and 40-59 years. Regarding skin color, two groups were created: white and non-white (mulatos + blacks). No indian or asian volunteer was enrolled in our study.

Regarding ABO blood groups, considering the studies of Józsa *et al.*[24] and Kujala *et al.*[25], who have testified a greater incidence of O blood group patients among those with Achilles tendon lesions, we have divided our volunteers into two groups: "O" and "non-O" (A + B + AB) aiming at investigating a possible difference in the morphometry of tendons in both groups.

For statistical purposes, we have used arithmetic means, standard-deviatons and frequencies distribution. For comparison between tendons measurements and sex, age ranges, skin color, QI and ABO blood group, we have employed the Student's *t* test. For rating the grade of relation between age and Achilles tendon diameters, we have applied the Pearson's linear correlation coefficient (r). Probability significance level was 5% ($p < 0.05$).

The research project of the present study was approved under No. 147/03 by the Universidade Federal Fluminense Committee of Ethics in Research.

RESULTS

In a sample of 50 patients, 25 (50%) were female and 25 (50%), male. Ages ranged between 20 and 52 years, mean age 33.9 ± 8.54 years. Thirty-four patients were between 20 and 39 years old (68%) and 16, between 40 and 59 years old (32%). Regarding the skin color, 21 were white (42%) and 29 non-white (58%). Regarding the ABO blood group, 25 were O (50%), 18, A (36%), 5, B (10%) and 2 AB (4%). Regarding QI, 33 were normal (66%) and 17 were rated as overweight (34%).

The Student's *t* test was applied to verify possible significant differences between left and right tendons measurements. Both in comparisons between transversal diameters ($p = 0.063$) and anteroposterior diameters ($p = 0.735$), there was no statistically significant difference between left and right tendons. This result has allowed us to evaluate the sample (50 left tendons and 50 right tendons) as whole (100 tendons).

The Achilles tendons transversal diameters studied ranged between 11.0 and 16.7 mm, arithmetic mean 13.9 ± 1.4 mm. Considering only the female patients, the transversal diameters ranged between 11.1 and 15.4 mm, arithmetic mean 13.3 ± 1.0 mm; and considering the male patients, the transversal diameters ranged between 11.0 and 16.7 mm, arithmetic mean 14.4 ± 1.4 mm. The Achilles tendon anteroposterior diameters studied ranged between 4.1 and 6.9 mm, arithmetic mean 5.5 ± 0.6 mm. Considering only the female patients, the anteroposterior diameters ranged between 4.3 and 6.1 mm, arithmetic mean 5.4 ± 0.5 mm; considering the male patients, it ranged between 4.1 and 6.9 mm, arithmetic mean 5.6 ± 0.6 mm. The difference between the female and male groups was statistically significant both for the transversal (p = 0.001) and the anteroposterior (p = 0.035) diameters, with higher values in the male group.

Regarding the skin color, in the white group, the transversal diameter ranged between 11.0 and 16.7 mm, arithmetic mean 13.6 ± 1.4 mm; in the non-white group, it ranged between 11.1 and 16.7 mm, arithmetic mean 11.1 and 16.7 mm, arithmetic mean 14.0 ± 1.3 mm. The anteroposterior diameter in the white group ranged between 4.4 and 6.9 mm, arithmetic mean 5.4 ± 0.5 mm; in the non-white group, it ranged between 4.1 and 6.8 mm, arithmetic mean 5.5 ± 0.6 mm. There was no statistically significant difference between the mean transversal (p = 0.149) and anteroposterior (p = 0.229) diameters in white and non-white groups.

Regarding age range, in the group between 20 and 39 years, the transversal diameter ranged between 11.1 and 16.7 mm, arithmetic mean 13.8 ± 1.3 mm; in the group between 40 and 59 years, it ranged between 11.0 and 16.7 mm, arithmetic mean 14.0 ± 1.5 mm. The anteroposterior diameter, in the 20-39-year group, ranged between 4.4 and 6.9 mm, arithmetic mean 5.5 ± 0.5 mm; in the 40-59-year group, it ranged between 4.1 and 6.6 mm, arithmetic mean 5.4 ± 0.6 mm. There was no statistically significant difference between the mean transversal (p = 0.496) and anteroposterior (p = 0.911) diameters between the 20-39-year and the 40-59-year groups. Also, the linear correction coefficient (r) between ages and Achilles tendon diameters was calculated and no statistically significant correlation was demonstrated ($p > 0.05$).

Regarding QI, in the normal QI group, the transversal diameter ranged between 11.0 and 16.7 mm, arithmetic mean 13.6 ± 1.4 mm; in the overweight QI group, it ranged between 12.3 and 16.7 mm, arithmetic mean 14.3 ± 1.0 mm. The anteroposterior diameter, in the normal QI group, ranged between 4.1 and 6.8 mm, arithmetic mean 5.4 ± 0.5 mm; in the overweight QI, it ranged between 4.3 and 6.9 mm, arithmetic mean 5.6 ± 0.6 mm. The statistical difference was not significant between the mean transversal diameters (p = 0.013), with higher values in the overweight QI group.

Regarding ABO blood group, the transversal diameter in the O group ranged between 11.0 and 16.7 mm, arithmetic mean 13.8 ± 1.3 mm; in the non-O group, it ranged between de 11.1 and 16.7 mm, arithmetic mean 14.2 ± 0.8 mm. The anteroposterior diameter, in the O group, ranged between 4.4 and 6.8 mm, arithmetic mean 5.6 ± 0.5 mm; in the non-O group, it ranged between 4.1 and 6.9 mm, arithmetic mean 5.5 ± 0.5 mm. There was no statistically significant difference between the mean transversal (p = 0.712) and anteroposterior (p = 0.073) diameters in O and non-O groups.

Aiming at establishing the normal range of Achilles tendon measurements in our population, we have considered the arithmetic means ± two standard deviations. The values obtained for female and male patients are shown in Table 1.

DISCUSSION

The Achilles tendon morphometry evaluation by US has shown to be a simple, innocuous and easy method. Other US favorable aspects which also deserve to be mentioned are its lower cost and greater availability, as well as its non-invasiveness and absence of ionizing radiations. These characteristics, if analyzed as a whole, cause the US to become an ideal imaging modality for diagnosis and follow-up of conditions that alter the Achilles tendon morphometry like tendinopathies and investigation of xanthomas in patients with familial hypercholesterolemia.

In our study, we have opted for a more discerning patients selection to put aside the factors that could affect the tendons dimensions measurements, keeping the focus on the variables to be evaluated: sex, ABO blood group, skin color, age and body mass index.

As already observed by Yuzawa *et al.*[26] and Koivunen-Niemelä and Parkkola[27], who have studied respectively Japanese and Finnish Achilles tendons, the diameters in female patients were smaller than those in male patients, coinciding with our casuistic that has demonstrated a statistically significant difference both between anteroposterior and transversal diameters in these groups.

Regarding ABO blood groups, notwithstanding Józsa *et al.*[24] and Kujala *et al.*[25] findings on higher incidence of Achilles tendon lesions in O blood group patients, this fact seems not to be directly related to these tendons dimensions, since there was no statistically significant difference in their diameters when O and non-O volunteers groups were compared.

Studies performed in countries of different continents (Japan, USA, Germany, Holland and Finland) have demonstrated significant differences between Achilles tendon measurements of these different ethnic groups[8,26–31]. In our study comparing white and non-white groups, we have not found any statistically significant difference between them. Notwithstanding, it is important to note that our present population is a result of a great racial miscegenation and, in a certain way, its division into white and non-white groups is subjective and imprecise.

Regarding age range, there was no statistically significant difference arising from comparison between 20–39-year and 40–59-year volunteers groups; identical result was obtained with application of the linear correlation coefficient (r) between ages and Achilles tendon diameters. Therefore, we think the use of appropriate values for each age range for evaluating young and adult patients is clinically unnecessary, except for pediatric and elder patients who have not been included in this study.

Analyzing the correlation between QI and Achilles tendon measurements, we observe that there was no statistically significant difference between QI and tendons anteroposterior diameter, with higher values in the overweight QI group, but did between QI and transversal diameter, with higher values in the overweight QI group. Later studies investigating these measurements in obese QI groups will be able to define if this difference remains the same or even increases in a higher QI group.

The average normal values reported regarding Achilles tendon diameters vary considerably in different studies[8,26–31]. Comparing average values found in our study with those in the literature, we have observed that there was no statistically significant difference of the anteroposterior diameter in relation to the study of Steinmetz *et al.*[31], but did in relation to other studies, with higher values reported by Kallinen and Suominen[29], Koivunen-Niemelä and Parkolla[27], Liem *et al.*[30] and Van Holsbeeck and Introcaso[8], and lower values reported by Ebeling *et al.*[28] and Yuzawa *et al.*[26]. Regarding the transversal diameter, the values were different from those reported by Kallinen and Suominen[29], Ebeling *et al.*[28] and Van Holsbeeck and Introcaso[8], all of them with lower values in comparison with ours. Therefore, values reported by the greatest part of authors studying populations different from ours were not confirmed in our casuistic, emphasizing even more the necessity to establish our own population standards and reinforcing our criticism against the application of American and European tables in our daily clinical practice.

Finally, the Achilles tendon morphometry analysis by US is a simple, innocuous, easy, non-invasive and free from ionizing radiation. There was no statistically significant difference between the Achilles tendon anteroposterior and transversal diameters in relation to age range, ABO blood group and skin color. The overweight QI group presented significantly greater Achilles tendon transversal diameter than the normal QI group. Regarding sex, the Achilles tendon diameters were significantly smaller in female patients. Considering the average values found and their respective standard deviations, we have established the following normal ranges: 11.3 to 15.3 mm in transversal diameter and 4.4 to 6.4 mm in anteroposterior diameter for female patients and 11.6 to 17.2 mm in transversal diameter and 4.4 to 6.8 mm in anteroposterior diameter for male patients. And, considering the discordance between the average values found in our casuistic and those reported by the majority of studies in the literature, our conclusion is that the standardization and application of tables specific for our population is of great importance in the daily clinical practice.

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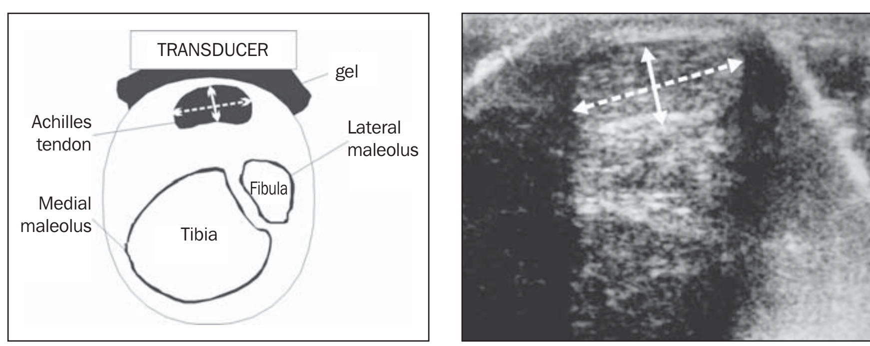
MORPHOMETRIC EVALUATION OF ACHILLES TENDON

Figuras e Tabela

Figure 1. Transducer positioning for checking measurements of Achilles tendon: transducer in transversal plane on the distal portion of the medial maleolus (MM).



A **B**

Figure 2. Diagram (**A**) and US transversal image (**B**) demonstrating checking method for Achilles tendon measurements. Continuous line: Anteroposterior diameter; dotted line: transversal diameter.

Table 1 Normal range values of Achilles tendon measurements according to sex.

Variable	Minimum (mm)	Maximum (mm)
Female patients		
Transversal diameter	11.3	15.3
Anteroposterior diameter	4.4	6.4
Male patients		
Transversal diameter	11.6	17.2
Anteroposterior diameter	4.4	6.8