

# Measurements of the calcaneal tendon in the first year of life\*

*Medidas do tendão do calcâneo no primeiro ano de vida*

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**Abstract** **OBJECTIVE:** To determine the thickness and width of the calcaneal tendon (Achilles tendon) in both male and female, eutrophic children at 2, 6, 9 and 12 months of age. **MATERIALS AND METHODS:** The present prospective and descriptive study included 38 boys and 31 girls. Measurements of the tendons were performed by means of ultrasonography, with a linear, 14-MHz probe, at the level of the medial malleolus. **RESULTS:** Tendon thicknesses observed in the boys were 2.4 mm, 2.3 mm, 2.4 mm, and 2.4 mm, respectively at 2, 6, 9 and 12 months. Widths were, respectively, 6.0 mm, 6.4 mm, 6.7 mm and 7.1 mm. In the girls, the tendon thicknesses observed at 2, 6 and 9 months were 2.4 mm, and 2.5 mm at 12 months. Widths were, respectively, 5.7 mm, 6.2 mm, 6.5 mm and 6.5 mm. **CONCLUSION:** No difference was observed in the calcaneal tendon thickness between boys and girls along the first year of their lives; however, width measurements demonstrated differences.

*Keywords:* Calcaneal tendon; Ultrasonography; Children.

**Resumo** **OBJETIVO:** Determinar as espessuras e larguras dos tendões do calcâneo (tendão de Aquiles) em crianças eutróficas de ambos os gêneros, aos 2, 6, 9 e 12 meses de idade. **MATERIAIS E MÉTODOS:** Fizeram parte deste estudo prospectivo e descritivo 38 meninos e 31 meninas. As medidas dos tendões foram obtidas por meio de ultrassonografia, utilizando transdutor linear de 14 MHz, na altura do maléolo medial. **RESULTADOS:** Verificou-se que as espessuras dos tendões nos meninos foram de 2,4 mm, 2,3 mm, 2,4 mm e 2,4 mm, aos 2, 6, 9 e 12 meses, respectivamente. As larguras do tendão do calcâneo foram de 6,0 mm, 6,4 mm, 6,7 mm e 7,1 mm, respectivamente. Nas meninas, as espessuras obtidas aos 2, 6 e 9 meses foram de 2,4 mm, e aos 12 meses encontrou-se o valor de 2,5 mm. As quatro medidas da largura foram de 5,7 mm, 6,2 mm, 6,5 mm e 6,5 mm, respectivamente. **CONCLUSÃO:** Não houve diferença na espessura do tendão do calcâneo ao longo do primeiro ano de vida para ambos os gêneros, entretanto, houve diferença nas medidas da largura.

*Unitermos:* Tendão do calcâneo; Ultrassonografia; Crianças.

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## INTRODUCTION

The soleus and gastrocnemius are located in the superficial group of the posterior crural muscles. Both muscles insert into the calcaneus - one of the seven tarsal

bones - by means of the calcaneal tendon, also called the Achilles tendon. This can be easily palpated and visualized by imaging resources, since it is a superficial structure<sup>(1)</sup>.

A previous study has found significantly thicker calcaneal tendons in children above 3 years of age with a history of familial hypercholesterolemia, than in those included in a control group<sup>(2)</sup>. According to the authors, the cause for such thickening was the abnormal development of fat deposits (xanthomas) in the respective tendon. Another study developed with adults, has found thicker calcaneal tendons in individuals with familial hypercholesterolemia and myocardial ischemia as compared with other individuals also with familial hypercholesterolemia, however with

no myocardial ischemia, independently of age<sup>(3)</sup>. Therefore, it is possible that persons with relatively thick calcaneal tendons are more susceptible to cardiac ischemia than persons with thinner ones<sup>(4)</sup>. Thus, this is the relevance of data on measurements of the calcaneal tendon in children, as an early treatment could avoid future complications of this condition.

No study was found in literature with measurements of thickness and width of calcaneal tendons in children up to 12 months of age. Therefore the need to fill in this knowledge gap was the motivating factor leading to the present research.

The objective of this study was to determine the thickness and width of the calcaneal tendons by means of ultrasonography in both male and female eutrophic chil-

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dren at 2, 6, 9 and 12 months of age, and define their normality intervals.

## MATERIALS AND METHODS

The present study was evaluated by the Committee for Ethics in Research of the author's Institution and, after approval the guardians of the participating children signed a Term of Free and Informed Consent. The sample of the present study included all the children undergoing follow-up in the Ambulatory of Growth and Development of the Institution. All of them were born in the period between November 25, 2005 and July 5, 2006, and participated in the study with their parents' consent. The children, in a total of 88, 44 boys and 44 girls, were followed-up for a one-year period, with measurement of their height and weight at 2, 6, 9 and 12 months of age.

Weight and height were measured at each one of those months. Based on these measurements, the body mass index (BMI) – weight (kg)/height<sup>2</sup> (m) – was calculated for each of the children. Along the follow-up, some of the children were excluded because of malnutrition or obesity as a result of the BMI calculation. Six boys were excluded: three for malnutrition and three for obesity. Thirteen girls were excluded; six of them for malnutrition, six for obesity and one with both malnutrition and obesity at the different phases of the study. Therefore, 38 boys (76 tendons) and 31 girls (62 tendons) remained in the study group.

In these same periods, the thickness and width of left and right calcaneal tendons were measured by means of ultrasonography, always by the same radiologist with experience in musculoskeletal ultrasonography. During the examination, each child was placed in ventral decubitus on an examination table, with both feet suspended. The feet were kept at a 90° angle relative to the legs, in order to facilitate the contact between the probe and the tendon (Figure 1). Cross sectional images were obtained at the level of the medial malleolus, allowing the measurement of the thickness and width of the calcaneal tendons. An EnVisor HD unit (Philips; Eindhoven, Holland) coupled with a 14-MHz linear probe was utilized for the measurements.



**Figure 1.** Method for measurement of the calcaneal tendon. The probe is transversely placed at the level of the medial malleolus.

Sample descriptive data were separately obtained for each gender, and represented by mean and standard deviation. Means and standard deviations were calculated for thickness and width of the calcaneal tendons for all of the children at 2, 6, 9, and 12 months of age. An analysis of variance was undertaken in order to verify possible

differences among tendons measurements along the months. Normality intervals for the tendons measurements were delimited utilizing an amplitude of plus or minus two standard deviations from the average measures.

## RESULTS

Table 1 presents a comparison between boys and girls measurements for weight, height and BMI. Student's *t*-test was utilized to evaluate statistically significant differences. Statistically significant differences were found for the weight and height variables at 2, 6, 9 and 12 months, as well as for BMI at 2, 9 and 12 months.

Among the 38 boys (76 tendons) kept in the research, one did not have the calcaneal tendon measurements at 9 months, another one at 9 and 12 months, and a third one at 2, 9, and 12 months. Among the remaining 31 girls (62 tendons), three did not have the measurements of the tendons taken at 2 months, one at 6 months, another one at 9 months, and two others did not have the measurements taken at 12 months. An eighth girl did not have the tendon measures taken at 9 and 12 months.

Student's *t*-test was utilized to evaluate statistically significant differences between the left and right calcaneal tendons thickness and width of the same tendons on both

**Table 1** Comparison of weight and height measurements and body mass index between boys and girls.

Variable	Boys		Girls	
	<i>n</i>	Mean ± SD	<i>n</i>	Mean ± SD
Weight at birth (kg)	38	3.263 ± 0.374	31	3.123 ± 0.322
Weight at 2 months (kg)*	38	5.575 ± 0.505	31	5.124 ± 0.553
Weight at 6 months (kg)*	38	7.979 ± 0.644	31	7.389 ± 0.722
Weight at 9 months (kg)*	38	8.964 ± 0.782	31	8.250 ± 0.778
Weight at 12 months (kg)*	38	9.759 ± 0.883	31	8.927 ± 0.783
Height at birth (cm)	38	49.7 ± 1.89	31	49.0 ± 1.53
Height at 2 months (cm)†	38	58.1 ± 2.22	31	56.7 ± 1.86
Height at 6 months (cm)†	38	67.5 ± 2.08	31	65.8 ± 2.09
Height at 9 months (cm)*	38	72.1 ± 2.22	31	70.3 ± 1.83
Height at 12 months (cm)†	38	75.9 ± 2.26	31	74.3 ± 2.11
BMI at birth (kg/m <sup>2</sup> )	38	13.2 ± 1.0	31	13.1 ± 0.9
BMI at 2 months (kg/m <sup>2</sup> )‡	38	16.5 ± 1.0	31	15.9 ± 1.0
BMI at 6 months (kg/m <sup>2</sup> )	38	17.5 ± 1.2	31	17.0 ± 1.1
BMI at 9 months (kg/m <sup>2</sup> )‡	38	17.2 ± 0.9	31	16.7 ± 1.0
BMI at 12 months (kg/m <sup>2</sup> )*	38	16.9 ± 0.9	31	16.1 ± 0.9

\* *p* < 0.001; † *p* < 0.01; ‡ *p* < 0.05. BMI, body mass index; *n*, number of children; SD, standard deviation.

sides, for both male and female children at all ages studied. There was no statistically significant difference between the thickness of left and right tendons for the boys ( $p = 0.810; 0.610; 0.841$  and  $0.461$  at 2, 6, 9 e 12 months of age, respectively) and neither for the girls ( $p = 0.282; 0.486; 0.577$  and  $0.870$  at 2, 6, 9 e 12 months of age respectively). Also, there was no statistically significant difference between left and right tendons width for the boys ( $p = 0.071; 0.808; 0.944$  and  $0.642$  at 2, 6, 9 e 12 months of age) and for the girls ( $p = 0.818; 0.669, 0.517$  and  $0.653$  at 2, 6, 9 and 12 months of age). These results allowed joining the left and right calcaneal tendons into a single tendon sample for each gender and age.

Table 2 presents the measures of the calcaneal tendons for both boys and girls, side by side. Student's *t*-test demonstrated a statistically significant difference between genders only for width at 12 months. An analysis of variance was undertaken for determining statistically significant variations of tendon dimensions between boys and girls along the months. No difference

for the variable thickness along the months was observed in the boys. As regards the width, differences were found between means of all four months studied. No difference for the variable thickness along the months was observed in the girls. As regards to the width, differences were found between averages from the second to the sixth month and from the sixth to the ninth month. However no statistically significant difference was found between the ninth and the twelfth month. The normality intervals obtained for both boys and girls are shown on Table 3.

**DISCUSSION**

When measuring the calcaneal tendon of a child and values are higher than the normality intervals, it is possible that there are, for example, xanthomas in this tendon, and that the child presents familial hypercholesterolemia<sup>(2)</sup>. If that is the case, a treatment could be immediately started, avoiding future problems resulting from such condition.

Several previous, cross sectional studies have measured the calcaneal tendons in adults, however without separating data according to gender<sup>(5-9)</sup>. Among the studies reviewed in the literature, only the study by Mello et al. has been developed in Brazil. This cross sectional study, was developed with individuals aged above 20, and presented measurements of tendon width and thickness for both genders<sup>(10)</sup>. No record was found in the literature about measurements of calcaneal tendon in children up to 12 months of age, except for a cross sectional study developed by Bialik et al.<sup>(11)</sup>. However, these authors measured only the length of the tendons and not the width and thickness. In this sense, the present study innovates, and may contribute to a more comprehensive knowledge of the normal growth standard for the calcaneal tendon.

Bialik et al. have obtained two measurements for the length of the calcaneal tendon (from the muscle-tendon junction to insertion into the calcaneus): one with the foot in dorsiflexion, and the other with the foot in plantar flexion. The average age of the children, who were not separated by gender, was 4 months (amplitude from 2 weeks to 12 months). In dorsiflexion, the mean tendon length was 37 mm, and in plantar flexion, the mean tendon length was 30.1 mm. A positive correlation between age and tendon length<sup>(11)</sup> was also observed. The study developed by Mello et al. with adults has demonstrated differences in tendon thickness and width between male and female individuals, with higher values for the male group<sup>(10)</sup>. However, data from the present study demonstrate that during the first year of life there is no statistically significant difference in the mean calcaneal tendon thickness between boys and girls. As regards the tendon width, it increases along the months, with statistically higher values for the boys, only at 12 months.

Brushøj et al. have evaluated the reproducibility of measurements obtained by two observers, for the calcaneal tendons, and for the tendons of the tibialis anterior and the flexor hallucis longus muscles in adults. Among these three tendons, the one presenting the smallest interobserver variation was the calcaneal tendon<sup>(12)</sup>. In spite of such smaller variability in measurements

**Table 2** Measures of the calcaneal tendon in both boys and girls.

Variable	Boys		Girls	
	n	Mean ± SD	n	Mean ± SD
Thickness of the tendon at 2 months	74	2.4 ± 0.3	56	2.4 ± 0.3
Thickness of the tendon at 6 months	76	2.3 ± 0.4	60	2.4 ± 0.3
Thickness of the tendon at 9 months	70	2.4 ± 0.4	58	2.4 ± 0.3
Thickness of the tendon at 12 months	72	2.4 ± 0.3	56	2.5 ± 0.3
Width of the tendon at 2 months	74	6.0 ± 0.7	56	5.7 ± 0.6
Width of the tendon at 6 months	76	6.4 ± 0.9	60	6.2 ± 0.7
Width of the tendon at 9 months	70	6.7 ± 0.7	58	6.5 ± 0.9
Width of the tendon at 12 months*	72	7.1 ± 0.7	56	6.5 ± 0.7

Tendon measures in millimeters. \*  $p < 0.001$ . n, number of tendons evaluated; SD, standard deviation.

**Table 3** Normality intervals for the calcaneal tendons for both genders.

Variable	Boys		Girls	
	Minimum	Maximum	Minimum	Maximum
Thickness of the tendon at 2 months	1.8	3.0	1.8	3.0
Thickness of the tendon at 6 months	1.5	3.1	1.8	3.0
Thickness of the tendon at 9 months	1.6	3.2	1.8	3.0
Thickness of the tendon at 12 months	1.8	3.0	1.9	3.1
Width of the tendon at 2 months	4.6	7.4	4.5	6.9
Width of the tendon at 6 months	4.6	8.2	4.8	7.6
Width of the tendon at 9 months	5.3	8.1	4.7	8.3
Width of the tendon at 12 months	5.7	8.5	5.1	7.9

Tendon measures in millimeters.

of the calcaneal tendon, in the present study with children, all the measurements were performed by a single radiologist. In the study by Brushøj et al., the intraobserver reproducibility has been also evaluated. Again, the tendon with smallest variation was the calcaneal. Additionally, according to these authors, small variations in tendon measurements obtained by ultrasonography may be caused by the pressure applied by the transducer on the tendon surrounding structures, or by the positioning of the transducer at different angles<sup>(12)</sup>. In the present study, the transducer was always perpendicularly positioned in relation to the calcaneal tendon. Bialik et al. have measured different lengths of the calcaneal tendon, according to the foot positioning in the sagittal plane, that is, in dorsiflexion or plantar flexion<sup>(11)</sup>. This means that small movements of the foot probably generate small changes in thickness and width of the tendon. In the present study, the foot remained perpendicularly positioned in relation to the leg.

The calcaneal tendon measurements may vary because of causes besides the formation of xanthomas, such as trauma or inflammation generally caused by high-

level sport practice<sup>(6,13)</sup>. However, considering that the present study was performed with infants  $\leq 12$  months of age, it is unlikely that such factors have played a role in the alteration of tendon dimensions.

As a prospect of future studies, the authors envision performing a study with children up to 12 months of age, comparing the calcaneal tendon measurements between children with normal cholesterol levels, and children with familial hypercholesterolemia. Finally, as a conclusion, the present study demonstrates that in the first year of life the thickness of the calcaneal tendon remains stable for both genders, and that the tendon width increases progressively during the first year of life, with normality standards being established in the present study.

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