Sonographic Assessment of Tendo Calcaneus Thickness in a Nigerian Population

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Abstract

Aim: We aimed to determine tendo calcaneus thickness (TCT) and its relationships with body mass index (BMI), fasting blood sugar, and age and to determine gender impact on TCT in a Nigerian population. **Materials and Methods:** The present study adopted a cross-sectional descriptive research design to assess the TCT of 264 adult participants of a Nigerian population aged 30 years and above. A gray-scale high-resolution ultrasound machine, Sonoace 5500, manufactured by Medicol in Korea, with a 10 MHz transducer was used to obtain the sonographic measurements of the tendo calcaneus. The study was carried out at Assurance Medical Diagnostic and Research Center, Calabar. The weight and height of the participants were measured using an electronic weighing scale and meter rule, respectively. Only participants/volunteers who gave their informed consent for the study were included in the study. Ethical approval for the study was obtained from the Human Research and Ethical Committee of Assurance Medical Diagnostic and Research Center, Calabar, Cross River State. Statistical analysis was done using SPSS software version 16.0 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA). **Results:** A strong positive correlation was obtained between TCT and gender ($r = 0.72$; $P < 0.05$); TCT also had a positive relationship with BMI ($r = 0.421$; $P < 0.05$). The male had significantly thicker tendo calcaneus (5.8 ± 1.4 mm) than their female (5.1 ± 1.6 mm) counterpart ($P < 0.05$). **Conclusion:** Results of the present study show that TCT is gender specific and may be useful in cardiovascular risk stratification due to its relationship with BMI, weight, and age, which are known risk factors of tendinopathy and cardiovascular disease.

Keywords: Tendinopathy, tendo calcaneus, thickness, ultrasound

Introduction

The tendo calcaneus, otherwise known as the Achilles tendon, is the thickest and strongest tendon in humans, albeit it is one of the most vulnerable tendons to overuse injuries.[1,2] The tendo calcaneus forms the distal insertion of three muscles and transmits loads generated by the gastrocnemius and soleus muscles to the calcaneus.[3] Unlike other tendons, this has no true sheathe; rather, it is surrounded by a paratendon, which functions as an elastic sleeve that allows it to move freely within the surrounding tissues.[4] Loss of the elasticity of this elastic sleeve within the tendon had been suggested to be one of the causes of pain on the tendons and heel pain.[5-7] One of the indications for imaging of the plantar aponeurosis and tendo calcaneus is the assessment of the anatomical integrity of these tissues.[8] Daily physical activities predispose the Achilles tendon to excessive strain and tear, leading to dysfunctional mechanisms, disability, and reduced productivity.[9] This is very important in athletes engaged in running and jumping as ruptures of these tissues either complete or partial are common in competitive athletes.[8,10,11]

Tendon tear and thickening usually result from overuse and from sporting events and some systemic disease pathways such as diabetes mellitus.[1,12,13] Achilles tendinosis usually involves the midportion of the tendon and sometimes, the insertion known as enthesopathy. Although enthesopathy may be seen in advanced age, it is also associated with arthritis such as gout and the seronegative spondyloarthritides.[9] This and Achilles tendinosis are known risk factors of calf muscles tear. Tendo calcaneus is typically investigated with imaging tests

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Figure 1: Sonographic technique for measuring tendo calcaneus thickness

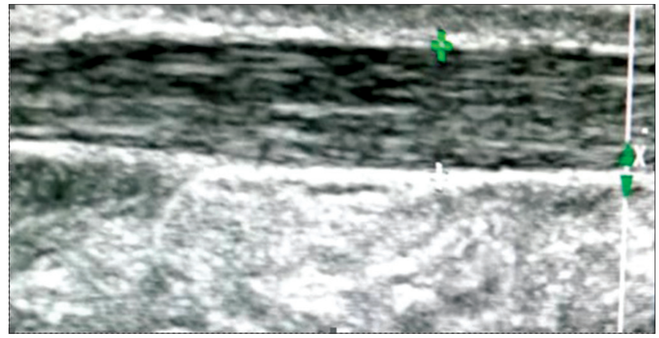

Figure 2: Sonogram of the tendo calcaneus with caliper indicating thickness (anteroposterior diameter)

such as ultrasound, which is very sensitive in characterizing morphological and textural changes of tissues. Ultrasound is nonionizing, is less expensive, and can identify subtle tendon fibril disorganization and partial thickness tear.[14,15]

A thickened Achilles tendon had been identified in participants with high low-density lipid cholesterol.[16] This happens as a result of lipid deposition within the substance of the Achilles tendon, a condition known as xanthomas, which is a clinical correlate with atherosclerosis, a known risk factor of cardiovascular disease.[13] Systemic factors such as hypertension, diabetes, obesity, and aging and extrinsic factors such as mechanical stress and disproportionate load transmission may also cause thickening or tear of this tendon.[9,14,17] Tsouli *et al*.,[2] in their study, reported a significant correlation between tendo calcaneus thickness (TCT) and carotid intima–media thickness.

Quantification of human soft tissues could be very useful in diagnosis,[6,18] and the knowledge of the morphometry of the tendo calcaneus would be a useful screening tool in the assessment of its anatomical integrity. This study investigated TCT and its relationships with body mass index (BMI), age, and gender in a typical Nigerian population.

Materials and Methods

The present study adopted a cross-sectional descriptive research design. A total of 264 adult participants, 30 years and above, were recruited for this study from Assurance Medical Diagnostic and Research center, Calabar, Cross River State between February and July 2019. A gray-scale high-resolution ultrasound machine, Sonoace 5500, manufactured by Medicol in Korea, with a 10 MHz transducer was used to obtain the sonographic measurements. The fasting blood sugar (FBS) levels were measured using a digital glucose meter, Accu-Check Active with serial number GG03111364 (Roche Group, UK). FBS levels of participants were assessed to rule out diabetes. Only participants with normal blood sugar levels were included in the study. The weight and height of the participants were measured using an electronic weighing scale and meter rule, respectively. The age and gender of the participants were also recorded. All diabetic patients and those with FBS >120 mg/dl were excluded from the study. On arrival to the imaging room, the participants were well received, and the procedures of the examination were explained to them. Only participants/volunteers who gave their informed consent for the study were included in the study. Ethical approval for the study was obtained from the Human Research and Ethical Committee of Assurance Medical Diagnostic and Research Center, Calabar, Cross River State.

Measurement of TCT was done according to standard protocols.[19] Patients lay prone on the examination couch, with legs extended beyond the couch. Each ankle was flexed slightly up to 90° to facilitate contact between the probe and the tendon [Figure 1]. Ultrasound gel was applied to the ridge of the tendon. The probe was orientated perpendicular to the ridge of the tendon. Scanning of the tendon was done longitudinally along the tendon until a good image of the tendon was displayed. Measurement of the thickness of the tendon was taken 2 cm proximal to its calcaneal insertion at the level of the medial malleolus. The anteroposterior diameter of the tendon represented the TCT [Figure 2]. Both tendons were measured, and the mean value was recorded.

Statistical analyses

The data obtained were categorized by age, gender, and BMI. Descriptive statistics were used to determine the means and ranges of the various variables measured. The TCT between males and females was compared using the Student's *t*-test. Pearson's correlation was used to ascertain the relationship of the TCT with age, gender, and BMI. Analysis of variance (ANOVA) was conducted to compare TCTs across age categories. All statistical analyses were done using SPSS software version 16.0 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA) with the level of significance set at $P < 0.05$.

Results

The TCT was 5.8 ± 1.4 mm in males, while that of females was 5.1 ± 1.6 mm [Table 2]. The Student's *t*-test showed a significant difference in TCT between males and females ($P < 0.05$).

Table 1: Variation of the thickness of tendo calcaneus (tendo calcaneus thickness) between males and females of the same age group

Age group	Males, mean±SD (mm)	*n*	Females, mean±SD (mm)	*n*	*P*
30-39	5.9±0.3	22	5.0±0.3	20	0.001
40-49	5.4±0.2	43	5.0±0.1	46	0.000
50-59	5.9±0.5	105	5.3±0.2	107	0.003
60-69	6.3±0.3	162	5.3±0.4	159	0.002
70-79	6.3±0.4	30	4.7±0.3	26	0.001

SD: Standard deviation

Table 2: Correlation (*r*) of tendo calcaneus thickness with age, body mass index, and fasting blood sugar

Pearson's correlation	Age	BMI	FBS
r	0.084	0.421	0.003
P	0.743	0.022	0.664

TCT: Tendo calcaneus thickness, BMI: Body mass index, FBS: Fasting blood sugar

ANOVA showed a significant difference ($P = 0.001$) in the mean TCT among the different age groups after controlling for age and BMI [Table 1].

Discussion

Current evidences have shown that in the tendo calcaneus, apart from its roles in dynamic events and load transmission to the calcaneus,[4] its thickness may serve as a useful index in explaining a coexistent disability, and also in characterizing the tendo calcaneus integrity. In the present study, TCT was 5.8 ± 1.4 mm in male and 5.1 ± 1.6 mm in females, with the males having significantly higher values than their female counterparts. This difference remained significant after adjustment of values for age and BMI. The observed gender-specific difference may be underlain by anatomical and hormonal factors such as the estrogen in male, which promotes body build. This was explained by Leblanc *et al*.,[20] where they confirmed a gender-dependent difference in tendon thickness. In addition, the males are more engaged in rigorous physical activities, which may contribute to higher muscle strength and thickness of the tendo calcaneus in this group. This also corroborates the findings of Egwu *et al*.[21]

Our findings confirm the results of Junyent *et al*.,[19] in a study conducted on adult Barcelonans. Their work revealed that the TCT measured 5.7 mm in males >45 years, while thickness for Barcelonan women aged 50 and above was 4.9 mm. A similar work by Ying *et al*.[22] on the adult Chinese population showed that the TCT in their study was 5.23 mm. This also was at variance with the present study. However, such variations can be expected and may be underlain by racial and environmental factors.[23-25] The implication of the above findings is that ethnicity and body status could be considered when assessing the thickness of tendons. Udoh *et al*. and Min-Seob *et al*.,[12,14] in their works, noted that tendon in the presence of pathological processes such as diabetes shows altered morphology, with a substantial increase in TCT.

A positive correlation was observed between TCT and BMI [Table 2], suggesting that higher BMI may have a significant impact on the thickness of tendo calcaneus. This may affect the elasticity and load transmission by the tendon, especially in dynamic events, exposing it to tear. BMI, being a function of an individual's weight, may influence load transmission to the calcaneus. This means that higher BMI values may cause thickening to the tendo calcaneus and threaten its structural integrity. The implication of this is that increased BMI may affect the load-bearing ability of tendo calcaneus, and so this factor should be considered when choosing physical activities, especially those that involve repetitive stress. Since the thickness of the tendo calcaneus affects its vulnerability to injury,[9,14] this understanding can be useful in the planning of events and prevention of injuries and other conditions related to the Achilles tendon.

The thickness of tendo calcaneus in the present study did not increase with age. Rather, at age 70 and above, the TCT was lower than the mean for both genders. Another study has shown that, with advancing age, especially in strenuous physical activities involving the Achilles tendon, degeneration (wear and tear) may occur in the tendon over time, and this may be due to a reduction in the size and density of collagen fibrils.[19] This reduction in the collagen fibril size and density lowers the mechanical strength of the tendo calcaneus and increases its propensity to injury.[9] This understanding may be useful to inform lifestyle modification, which may help reduce the incidence of tendon tear. This is a plausible finding in view of the support function that the tendo calcaneus plays in skeletal physiology.[19] Alteration in the size of these tissues during routine investigations could warrant further investigations into possible clinical correlates such as tendinopathy, atherosclerosis, and cardiovascular disease. The findings of the present study could be considered baseline when assessing the anatomical integrity of the tendo calcaneus and pathological stability of this tendon.

Conclusion

Results of the present study show that TCT is gender specific and ranges from 4.5 mm to 6.5 mm in the study population. These values might serve as a baseline when assessing the anatomical integrity and morphometry of the tendo calcaneus. Furthermore, TCT may be useful in cardiovascular risk stratification due to its relationship with BMI, which is a known risk factor of tendinopathy and cardiovascular disease.

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Conflicts of interest

There are no conflicts of interest.

References

1. Sobhani S, Dekker R, Postema K, Dijkstra PU. Epidemiology of ankle and foot overuse injuries in sports: A systematic review. Scand J Med Sci Sports 2013;23:669-86.
2. Tsouli SG, Kiortsis DN, Argyropoulou MI, Mikhailidis DP, Elisaf MS. Pathogenesis, detection and treatment of Achilles tendon xanthomas. Eur J Clin Invest 2005;35:236-44.
3. Paavola M, Paakkala T, Kannus P, Järvinen M. Ultrasonography in the differential diagnosis of Achilles tendon injuries and related disorders. A comparison between pre-operative ultrasonography and surgical findings. Acta Radiol 1998;39:612-9.
4. Hess GW. Achilles tendon rupture: A review of etiology, population, anatomy, risk factors, and injury prevention. Foot Ankle Spec 2010;3:29-32.
5. Rome K, Campbell RS, Flint AA, Haslock I. Ultrasonic heel pad thickness measurements: A preliminary study. Br J Radiol 1998;71:1149-52.
6. Udoh BE, Archibong BE, Egong AE. Sonographic assessment of heel pad thickness in patients with poorly controlled diabetes. J Diagn Med Sonogr 2019;35:374-9.
7. Ozdemir H, Söyüncü Y, Ozgörgen M, Dabak K. Effects of changes in heel fat pad thickness and elasticity on heel pain. J Am Podiatr Med Assoc 2004;94:47-52.
8. Udoh BE, Ezeokpo BC, Ugwu AC, Ohagwu CC. Plantar aponeurosis thickness among Nigerians. World J Med Sci 2009;4:61-4.
9. Li HY, Hua YH. Achilles tendinopathy: Current concepts about the basic science and clinical treatments. Biomed Res Int 2016;2016.
10. Leach R, Jones R, Silva T. Rupture of the plantar fascia in athletes. J Bone Joint Surg Am 1978;60:537-9.
11. Pai VS. Rupture of the plantar fascia. J Foot Ankle Surg 1996;35:39-40.
12. Okorie CK, Ogbole GI, Owolabi MO, Ogun O, Adeyinka A, Ogunniyi A. Role of diffusion-weighted imaging in acute stroke management using low-field magnetic resonance imaging in resource-limited settings. West Afr J Radiol 2015;22:61-6.
13. Hashimoto T, Minami Y, Kakizaki R, Shimohama T, Tojo T, Ako J, *et al*. Achilles tendon thickening is associated with disease severity and plague vulnerability in patients with coronary disease. J Clin Lipidol 2019;13:194-200.
14. Min-Seob, K, Min-Seob K, Se-Jung Y, Yun-Hyeong C, Suk-Min H, Jong-Kwan P, *et al*. The correlation between achilles tendon thickness and cardiovascular risk factors. J Lipid Atheroscler 2013;2:77-83.
15. Raikin SM, Garras DN, Krapchev PV. Achilles tendon injuries in a United States population. Foot Ankle Int 2013;34:475-80.
16. Wang B, Zhang Q, Lin L, Pan LL, He CY, Wan XX, *et al*. Association of Achilles tendon thickness and LDL-cholesterol levels in patients with hypercholesterolemia. Lipids Health Dis 2018;17:131.
17. Ferrières J, Lambert J, Lussier-Cacan S, Davignon J. Coronary artery disease in heterozygous familial hypercholesterolemia patients with the same LDL receptor gene mutation. Circulation 1995;92:290-5.
18. Sopher R, Nixon J, McGinnis E, Gefen A. The influence of foot posture, support stiffness, heel pad loading and tissue mechanical properties on biomechanical factors associated with a risk of heel ulceration. J Mech Behav Biomed Mater 2011;4:572-82.
19. Junyent M, Gilabert R, Zambón D, Núñez I, Vela M, Civeira F, *et al*. The use of Achilles tendon sonography to distinguish familial hypercholesterolemia from other genetic dyslipidemias. Arterioscler Thromb Vasc Biol 2005;25:2203-8.
20. Leblanc DR, Schneider M, Angele P, Vollmer G, Docheva D. The effect of estrogen on tendon and ligament metabolism and function. J Steroid Biochem Mol Biol 2017;172:106-16.
21. Egwu OA, Anibeze CI, Akpuaka FC, Udoh BE. Activity-related differences in the thickness of Achilles' tendon among four different occupational groups in Nigeria: An ultrasound based study. Bangladesh J Med Sci 2012;12:103-11.
22. Ying M, Yeung E, Li B, Li W, Lui M, Tsoi CW. Sonographic evaluation of the size of Achilles tendon: The effect of exercise and dominance of the ankle. Ultrasound Med Biol 2003;29:637-42.
23. Kallinen M, Suominen H. Ultrasonographic measurements of the Achilles tendon in elderly athletes and sedentary men. Acta Radiol 1994;35:560-3.
24. Koivunen-Niemelä T, Parkkola K. Anatomy of the Achilles tendon (tendo calcaneus) with respect to tendon thickness measurements. Surg Radiol Anat 1995;17:263-8
25. Bude RO, Adler RS, Bassett DR. Diagnosis of Achilles tendon xanthoma in patients with heterozygous familial hypercholesterolemia: MR vs sonography. AJR Am J Roentgenol 1994;162:913-7.