Ultrasonographic Measurement of the Achilles and Supraspinatus Tendon Thicknesses in Patients with Chronic Lead Exposure

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ABSTRACT

Objective: *The study aimed to assess tendon thickness in patients with chronic occupational lead exposure by using ultrasonography.*
Methods: *Twenty-seven male workers (mean age 32.9 ± 6.2 years, range 25−44 years) with occupational lead exposure and 27 age- and body mass index (BMI)-matched healthy male subjects (mean age 33.1 ± 5.6 years, range 25−44 years) were enrolled. Ultrasonographic measurements were obtained from the supraspinatus and Achilles tendons by using a linear probe (5−10 MHz).*
Results: *Mean Achilles tendon values at long axis (*$p = 0.034$*) and tendon cross-sectional area (*$p = 0.013$*) were significantly smaller in the lead-exposed group than the control group. On the other hand, no significant difference was found regarding the thickness of the supraspinatus tendon (*$p > 0.05$*).*
Conclusion: *Our preliminary results imply that subjects with occupational lead exposure have smaller Achilles tendons than healthy subjects. Chronic lead exposure may affect the tendons due to reduction of collagen synthesis. Further studies are definitely needed to confirm our initial findings.*

Keywords: Achilles tendon, lead exposure, occupational disease, supraspinatus tendon, ultrasound

Medición Ultrasonográfica del Grosor del Tendón de Aquiles y el Tendón Supraespinoso en Pacientes con Exposición Crónica al Plomo

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RESUMEN

Objetivo: *El estudio tuvo por objetivo evaluar el grosor del tendón en pacientes con exposición ocupacional crónica al plomo mediante el uso de la ultrasonografía.*
Métodos: *Se alistaron veintisiete trabajadores varones (edad promedio 32.9 ± 6.2 años, rango 25−44 años) con exposición ocupacional al plomo, y 27 sujetos sanos pareados por edad e índice de masa corporal (IMC) (edad promedio 33.1 ± 5.6 años, rango 25−44 años). Se obtuvieron medidas ultrasonográficas de los tendones de Aquiles y supraespinosos utilizando una sonda lineal (5−10 MHz).*
Resultados: *Los valores promedio del tendón de Aquiles en el eje largo (*$p = 0.034$*) y el área transversal del tendón (*$p = 0.013$*) fueron significativamente menores en el grupo de expuestos al plomo que en el grupo de control. Por otro lado, no se encontraron diferencias significativas en relación con el grosor del tendón supraespinoso (*$p > 0.05$*).*
Conclusión: *Nuestros resultados preliminares implican que los sujetos con exposición ocupacional al plomo tienen tendones de Aquiles más pequeños que los sujetos sanos. La exposición crónica al plomo puede afectar los tendones debido a la reducción de la síntesis de colágeno. Definitivamente se necesitan más estudios para confirmar nuestros hallazgos iniciales.*

Palabras claves: Tendón de Aquiles, exposición al plomo, enfermedad profesional, tendón supraespinoso, ultrasonido

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INTRODUCTION

Chronic lead toxicity is a common health problem which mostly occurs due to occupational exposure. As the majority of lead (approximately 90% in adults) is stored in bony tissues, its intoxication causes various pathological changes in the human skeleton (1, 2). Moreover, the lead stored in bone may be mobilized by physiological and pathological states such as pregnancy, lactation and osteoporosis (1) and cause some toxic effects in other tissues. It has been shown that lead exposure impairs collagen synthesis *via* inhibiting hydroxylation and/or endothelial growth factor (2).

Type I collagen is the most abundant component of the tendons (3). Therefore, the aim of this study was to explore the possible impact of occupational lead exposure on the tendons. However, to our best knowledge, ultrasonographic tendon evaluation in subjects with chronic lead exposure has not been studied until now. In this regard, we have taken supraspinatus and Achilles tendons as representing the upper and lower limbs and used ultrasonography which has been shown to be a valid and reliable imaging tool for tendon evaluations (4, 5).

SUBJECTS AND METHODS

Twenty-seven male workers (aged 25–44 years) with occupational lead exposure from small-scale industries, who were repeatedly exposed to lead fumes or lead stearate powder, and 27 age- and body mass index (BMI)-matched healthy male workers from factories that did not use lead as product materials were enrolled in our study. Subjects who had osteoarthritis or inflammatory arthritis, any other vocational heavy metal exposure and previous shoulder/ankle trauma or surgery were excluded. The study procedure was explained to each patient who gave informed consent before being included in the study. Local Ethics Committee approved the study protocol.

Demographic and clinical characteristics of the subjects such as age, weight, height, BMI, occupation, exposure duration to lead and smoking habits were recorded. Serum lead levels were determined from venous blood specimens. Ethylene diamine tetraacetic acid (EDTA)-containing tubes were used for collecting blood samples. Inductively coupled plasma mass spectrometry was used to detect blood and hair lead concentrations.

Ultrasonographic measurements were performed by using a linear probe (5–10 MHz; Mindray Bio-Medical Electronics Company, Shenzhen, China). Measurement for the Achilles tendon was performed from a posterior approach while the subjects were lying in the prone position and the ankle joints were kept in a neutral or slightly dorsiflexed position. The probe was placed in the transverse position on the Achilles tendon at the level of the inferior margin of medial malleolus (Fig. A). Short/long axis diameters and cross-sectional area (CSA) of the tendon were measured from the nondominant side (Fig. B). The supraspinatus tendon measurements were carried out while the subjects were seated and their arms were placed on the ipsilateral iliac wing (shoulders internally rotated and elbows flexed). Axial tendon thicknesses were measured again from the nondominant sides.

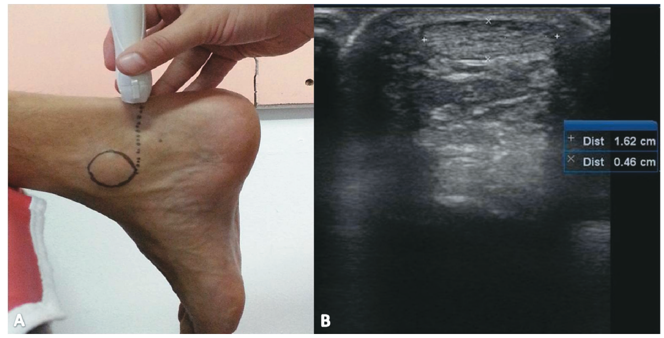

Figure: **A)** Picture illustrating patient positioning during the Achilles tendon measurement. **B)** Ultrasound image (axial view) showing Achilles tendon measurements.

Statistical analysis

Statistical Package for Social Sciences (SPSS) 15.0 software was used for the statistical analysis. Kolmogrov-Smirnov test was used for testing if the parameters displayed normal distribution. Mean values and percentages between the two groups were compared by using paired *t*-test and Chi-squared test, where appropriate. Pearson rank test was used for correlation coefficients. Statistical significance was set at $p < 0.05$.

RESULTS

Demographic and clinical characteristics of the subjects are summarized in Table 1. Tendon measurements are given in Table 2. While the supraspinatus tendon thicknesses were similar between the groups, mean Achilles tendon measurements – long axis ($p = 0.034$) and CSA ($p = 0.013$) – were found to be smaller in the lead exposed group. Achilles tendon CSA measurements were positively correlated with height (r = 0.522, $p = 0.005$) in the exposed group, and with weight (r = 0.472, $p = 0.013$) and height (r = 0.475, $p = 0.012$) in the control group. Any other correlation between the tendon measurements and the clinical characteristics of the subjects were otherwise not present in either group.

Table 1: Main characteristics of the subjects

	Patients (n = 27)	Controls (n = 27)	*p*
Age (years)	32.9 ± 6.2	33.1 ± 5.6	0.542
Weight (kg)	79.3 ± 10.4	79.8 ± 11.8	0.711
Height (cm)	174.5 ± 6.1	175.6 ± 7.6	0.100
Body mass index (kg/m^2)	26.0 ± 3.2	25.9 ± 3.2	0.769
Serum lead level (µg/dL)	26.3 ± 14.1	–	
Hair lead level (µg/g)	25.9 ± 26.7	–	
Exposure duration (years)	3.8 ± 3.7	–	
Smokers	17 (63 %)	13 (48 %)	0.291

The values are given as mean ± SD or n (%)

Table 2: Comparison of tendon measurements

	Patients (n = 27)	Controls (n = 27)	*p*
Achilles tendon short axis (mm)	4.3 ± 0.7	4.4 ± 0.6	0.519
Achilles tendon long axis (mm)	14.9 ± 1.2	15.8 ± 1.6	**0.034**
Achilles tendon CSA (mm^2)	50.3 ± 7.1	54.4 ± 8.7	**0.013**
Supraspinatus tendon length thickness (mm)	5.4 ± 0.7	5.3 ± 0.5	0.397

The values are given as mean ± SD or n (%). Significant *p*-values are shown in bold.
CSA: cross-sectional area

DISCUSSION

In this study, we tried to find out whether the supraspinatus and Achilles tendon thicknesses of subjects with chronic occupational lead exposure were different than those of controls. Overall, we have found that those subjects with lead exposure had smaller Achilles tendons.

Lead is stored mainly in the bony tissues as well as nails and hair after inhalation through the respiratory tract or absorption *via* the gastrointestinal tract (1, 2). It causes osteoporosis with high bone turnover, whereby it disturbs calcium absorption and vitamin D metabolism (6−8). Furthermore, collagen synthesis is decreased by lead, and epidermal growth factor and protein kinase C were suggested as the common modulator of these effects (9). Various studies also on human synovial cells, chick bone or mouse fibroblast cultures have confirmed that the collagen synthesis is impaired by lead (10−12).

According to our results, subjects with occupational lead exposure had smaller Achilles tendons. Since the groups were age, gender and BMI-matched, our results support that this difference could possibly be attributed to the inhibition of collagen synthesis by lead. However, whether this difference is also associated with histological abnormalities needs to be further studied. Since the tendons have limited blood supply and hypovascular zones, our finding of decreased size may be an early harbinger of future tendinopathies such as ruptures (13). Considering the fact that the Achilles tendon bears significant weight and serves as one of the most important components of the gait cycle, our finding is noteworthy and necessitates further studies as regards the functionality and quality of life of relevant subjects.

In contrast to Achilles tendon measurements, no significant difference was found with the supraspinatus tendon. However, since the thickness of the Achilles tendon was also not different between the groups, our finding might actually – and consistently as well – imply that lead intoxication has a particular type of an adverse effect on tendon morphology (decreasing width rather than thickness). On the other hand, the lack of supraspinatus tendon width and CSA measurements does, for sure, cloud this conclusion. In this respect, future studies need to look at tendon measurements not only confined to thickness.

Other than our sample size, an important limitation of this study would be the lack of urinary pyridinoline measurements which could have indirectly reflected collagen damage (14) and predicted tibia-bone lead content (15).

To conclude, in light of these preliminary results, we suggest that subjects with occupational lead exposure have smaller Achilles tendons than healthy subjects. Further studies with larger samples are definitely awaited to confirm these initial findings, and histological assessments need to be undertaken to clarify tendon damage and long-term follow-up for rupture risk.

DISCLOSURES

Financial disclosure statements have been obtained, and no conflicts of interest have been reported by the authors or by any individuals in control of the content of this article.

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