Evaluation and Surveillance of Lateral Elbow Tendinopathy in Manual Workers: Identifying Elbows at Risk

CME Credits

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Abstract

Background: Manual workers are at risk of developing lateral elbow tendinopathy (LET). We aimed to validate the hypothesis that asymptomatic elbows of manual workers with LET are more likely to have positive physical examination results and morpho-mechanical changes on elbow ultrasonography compared to healthy individuals. **Methods:** This cross-sectional case–control study included 30 manual workers with unilateral LET (LET group) and 30 age- and sex-matched healthy volunteers (control group). Demographic data collection and functional evaluation were performed using the Disabilities of the Arm, Shoulder, and Hand; Patient-Rated Tennis Elbow Evaluation; and European Quality of Life Five-Dimensions questionnaires. Physical examination of the elbows and evaluation of the common extensor tendon (CET) with B-mode morphology ultrasonography and Young's modulus elastography were performed. The LET-unaffected and LET-affected elbows in the LET group were compared with the elbows in the control group. **Results:** The LET-unaffected elbows in the LET group had a higher prevalence of positive chair test results and focal hypoechoic change and microcalcification on ultrasonography than those in the control group ($P < 0.05$, 0.005, and 0.05, respectively). In addition, LET-affected elbows showed higher focal hypoechoic change, microcalcification, erosive cortex, and neovascularity than elbows in the control group ($P < 0.001$, 0.001, 0.005, and 0.001, respectively). The unaffected and affected elbows showed greater CET thickness than those in the control group ($P < 0.05$ and 0.005). **Conclusion:** The unaffected elbows of manual workers with unilateral LET should be considered at risk of LET. We proposed a risk assessment and surveillance protocol based on chair test results and abnormal ultrasonographic findings.

Keywords: Elbow tendinopathy, occupational health, risk assessment, tennis elbow, ultrasonography

Introduction

Lateral elbow tendinopathy (LET), a common work-related musculoskeletal disorder (WRMSD), can lead to significant impairment, persistent pain, poor prognoses, and reduced productivity among manual workers.[1] Its prevalence in manual workers is approximately 21%, much higher than the 1%–3% observed in the general population.[2,3] Manual workers are particularly at risk of bilateral LET due to occupational risk factors such as strenuous work, manual tasks, repetitive motions, and work with vibrating tools.[4,5] These risk factors are often difficult to modify and can cause repetitive microtrauma to the common extensor tendon (CET) in both elbows.[6]

Without appropriate rest, tendon healing is impaired, resulting in altered intratendinous characteristics, including asymptomatic calcification and scarring, as well as clinical symptoms and signs of LET.[7,8] The functional status and ultrasonographic findings of the affected and unaffected elbows of manual workers with unilateral LET are expected to be different from those of the general population. Hence, a comprehensive understanding regarding differences

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in (i) tendon characteristics between manual workers' elbows and those of the general population and (ii) the affected and unaffected elbows among manual workers with LET is important to improve occupational health management practices, such as screening.

LET is diagnosed based on the clinical presentation of lateral elbow pain, with confirmation through physical examination, including palpation of the lateral elbow epicondyle and Cozen's and Maudsley's tests.[9] In addition, imaging modalities are beneficial as adjunct diagnostic tools for LET, and ultrasonography is the preferred technique according to the consensus recommendation of the European Society of Musculoskeletal Radiology.[10] Typical findings of LET on B-mode ultrasonography include focal hypoechoic changes in the deep layer of the CET, focal cortical irregularities in the lateral humeral epicondyle, calcified lesions, hyperechoic changes, and a partial tear within the CET.[11,12] Shear wave elastography has recently been used to estimate the mechanical properties of soft tissues in the region of interest (ROI). In addition, it provides supporting evidence for LET diagnoses. The CET in patients with lateral elbow epicondylitis reportedly showed decreased shear wave speed and Young's modulus compared with that of healthy volunteers.[13,14]

Highly sensitive physical and ultrasonographic examinations have been used as diagnostic and screening tools in athletes at risk of shoulder or knee injuries[15,16] and may also be useful for developing programs to screen manual workers for LET risk. We believe that asymptomatic elbows of manual workers with unilateral LET need to be screened; however, studies on subclinical alterations of tendon tissues in these elbows are required to support this argument. Furthermore, ultrasonography of manual workers with chronic LET often reveals CET thickening, focal hypoechoic changes, and microcalcification, suggesting that its biomechanical properties may be altered compared to the CET in elbows of the general population.

Considering that the LET-unaffected elbows of manual workers are at risk of LET, we hypothesized that asymptomatic and LET-affected elbows of manual workers with unilateral LET both have a higher prevalence of positive physical examination results and morpho-mechanical changes in elbow ultrasonography than those of healthy individuals. In addition, both elbows of manual workers with unilateral LET demonstrate greater Young's modulus or thickness than those of the controls. Therefore, this study aimed to evaluate the functional status, physical examination, and sonographic findings of the elbows of manual workers with unilateral LET and to compare them with those of healthy controls.

Material and Methods

Study design and participants

This study utilized a cross-sectional case–control design to compare manual workers with unilateral LET (LET group) and age- and sex-matched healthy volunteers (control group) with no history of lateral elbow pain. The study protocol was approved by the Research Ethics Committee of the (Blinded for Review, National Taiwan University Hospital) Hospital (approval no. 201910071RINB, approval date: Dec. 3, 2019.) and conducted following the Declaration of Helsinki guidelines.[17]

Participants in the LET group were recruited from the Department of Orthopaedic Surgery and Occupational Medicine Outpatient Clinic at the (Blinded for Review) Hospital Yun-Lin branch between January and November 2020. The inclusion criteria for the LET group were as follows: (i) intermittent activity-dependent pain in a single elbow around the lateral epicondyle for >4 months; (ii) positive findings in at least one of three physical examinations, including palpation of the lateral elbow epicondyle and Cozen's and Maudsley's tests;[11] and (iii) physical exposure according to the International SALTSA criteria[18] proposed by a joint program for working life research in Europe to standardize the reporting of upper limb work-related musculoskeletal disorders (WRMDs) for repetitive movements (same action more than twice per minute for >4 h/workday) and/or forceful movements (manipulating loads >4 kg). Control group participants were recruited from volunteers and charity workers at the (Blinded for Review) Hospital Yun-Lin branch and were age- and sex-matched to the LET group.

Exclusion criteria for the LET and control groups included patients having (i) pain in both elbows; (ii) any elbow with a recent (within 3 months) open wound, infection, or local injection treatment (steroid, glucose, or platelet-rich plasma); (iii) any elbow with previous trauma (fracture or dislocation), operation, or malignancy; (iv) any elbow with osteoarthritis, rheumatic arthritis, or gouty arthritis; (v) neuromuscular disorders with elbow pain or dysfunction or fibromyalgia syndrome; and (vi) unwillingness to sign informed consent or join the study. All participants provided written informed consent before enrollment.

Physical and functional evaluation

Basic data such as age, sex, affected side, and symptom duration were collected. This study used the Disabilities of the Arm, Shoulder, and Hand (DASH), Patient-Rated Tennis Elbow Evaluation (PRTEE), and European Quality of Life Five-Dimensions 3 Level Version (EQ5D-3 L) questionnaires for functional evaluation. Physical examinations were conducted by a physiotherapist who was blinded to the history of the participants. Pain provocation tests for LET included palpation of the lateral elbow epicondyle and Cozen's, Maudsley's,[9] and chair tests (lifting a chair with the forearm in a neutral position and elbow extended).[19] Handgrip strength measurements were performed using a calibrated Jamar Plus + dynamometer (Sammons Preston, Rolyon, Bolingbrook, IL, USA) at handle position level II. Participants were seated with their shoulder adducted and neutrally rotated, elbow flexed at 90°, and forearm and wrist in a neutral position. Three attempts were made, and the maximum grip strength was recorded. The affected and unaffected arms in the LET group and the matched arms of the control group were evaluated using the same protocol mentioned above.

Ultrasonography

For the ultrasonographic examination, the participants were positioned with the affected elbow bent at 90° and their forearm pronated on an armrest. An SL15-4 linear transducer (lateral resolution <0.4 mm) was used with the Aixplorer ultrasound system (SuperSonic Imagine, Aixplorer®, Aixen-Provence, France). The gain was adjusted to 44%–46% in the preset musculoskeletal mode to stabilize the image quality. A physician with >5 years of experience in ultrasound examination, blinded to the medical history of the participants, conducted the ultrasonography. A gripper stabilized the transducer on the lateral epicondyle, ensuring minimal contact with the skin surface and preventing measurement bias related to soft-tissue compression.

The transducer was then adjusted perpendicular to the skin surface and parallel to the forearm axis, allowing a standard longitudinal image of the CET to be obtained [Figure 1a and b]. B-mode images were then recorded to evaluate morphological features, such as CET thickness (plateau measurement),[20] partial tear, focal hypoechoic change, microcalcification (defined as a hyperechoic area >1 mm, with tiny acoustic shadow), and cortical erosion at the lateral epicondyle. Doppler ultrasonography was used to evaluate the CET's vascularity. The color-flow imaging mode was employed to overlay the B-mode image in a rectangular ROI that included the CET, and the presence or absence of vascularity was documented.

Shear wave elastography was used to measure the biomechanical properties of the tendon in standard mode, and the range of the color scale was set from 0 to 800 kPa. A round ROI with a 3-mm diameter was selected at the tendon site for the plateau measurement. The transducer was held in place for 10 s during the elasticity measurement, and the mean Young's modulus of the tendon was recorded [Figure 2a and b].

Statistical analysis

Numerical variables are expressed as means and standard deviations. Comparisons between the LET group (including affected and unaffected elbows) and the control group were performed using the Mann–Whitney *U*-test. Categorical variables are expressed as counts and percentages. Fisher's exact test was used to analyze differences between the affected and unaffected elbows of the LET group and the elbows of the control group. All analyses were performed using SPSS 22.0 for Windows (SPSS Inc., Chicago, IL, USA), with the significance level set at $P < 0.05$.

Results

Patient characteristics and functional status

The demographic and functional evaluation data of participants in the LET and control groups are shown in Table 1. The LET group had 30 participants (males: 13 and females: 17; mean age: 51.2 years), and 93% had dominant right hands. The control group also had 30 participants, with a similar

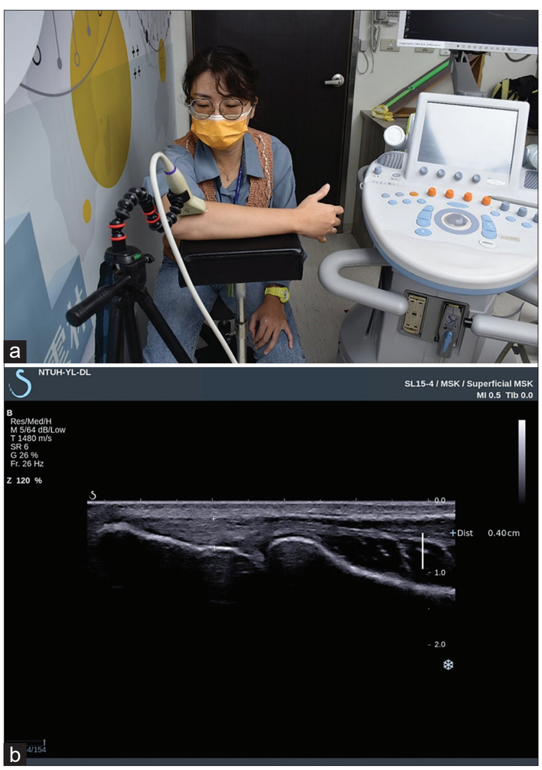

Figure 1: Participant position during ultrasonography. The transducer was stabilized using a gripper to be perpendicular with minimal skin contact and parallel to the forearm axis (a), which allowed the common extensor tendon to be longitudinally imaged (b)

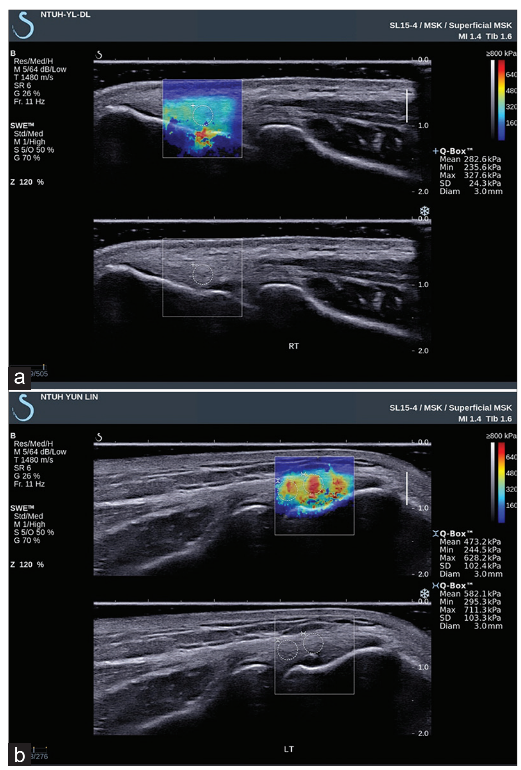

Figure 2: Shear wave elastography of the elbow common extensor tendon. Young's modulus measurement with a 3-mm round region of interest at the plateau thickness measurement site in elbows from the control (a) and lateral elbow tendinopathy (b) groups

distribution of males and females (mean age: 51.2 years); they all had dominant right hands. The symptom duration in the LET group was 13.9 ± 8.0 months. The LET group had a significantly higher proportion of manual workers (100%) than the control group (13%; $P < 0.001$). The LET group also had significantly higher DASH, PRTEE, and lower EQ5D-3 L scores (29.1 ± 15.4, 35.8 ± 17.7, and 67.4 ± 18.9, respectively) than the control group (4.9 ± 5.9, 3.5 ± 5.5, and 85.7 ± 19.1, respectively; $P < 0.001$).

Physical examination

Table 2 provides the results of physical examinations conducted on the unaffected, affected, and control elbows. The positive tenderness rate and Cozen's and Maudsley's test results varied among the unaffected, affected, and control elbows. Comparisons between the unaffected and control elbows did not reveal significant differences. Contrastingly, significant differences were observed between the affected and control elbows ($P < 0.001$). For the chair test, 33%, 53%, and 3% of the unaffected, affected, and control elbows, respectively, tested positive. The prevalence of positive chair test results was higher for unaffected and affected elbows than for control elbows ($P < 0.01$ and $P < 0.001$, respectively). Finally, no significant difference in hand grip strength was observed between the unaffected and control elbows and the affected and control elbows.

Table 1: Demographic data and functional evaluation of the lateral elbow tendonitis and control groups

	LET group	Control group	P
Age (years)	51.2±7.5	51.2±7.4	1.000†
Sex (male/female)	13 (43)/17 (57)	13 (43)/17 (57)	1.000†
Dominant hand (right/left)	28 (93)/2 (7)	30 (100)/0	0.4915†
Affected elbow (right/left)	18 (60)/12 (40)	N/A	
Duration of symptoms	13.9±8.0	N/A	
Manual work	30 (100)	4 (13)	<0.001*,†
DASH score	29.1±15.4	4.9±5.9	<0.001*,‡
PRTEE score	35.8±17.7	3.5±5.5	<0.001*,‡
EQ5D-3L	67.4±18.9	85.7±19.1	<0.001*,‡

*Statistically significant, †Fisher's exact test, ‡Mann–Whitney *U*-test. Data are presented as mean±SD or count with percentages in parentheses. LET: Lateral elbow tendonitis, N/A: Not available, DASH Score: Disabilities of the Arm, Shoulder, and Hand Score, PRTEE score: Patient-Rated Tennis Elbow Evaluation Score, EQ5D-3L: European Quality of Life 5 Dimensions 3 Level Version, SD: Standard deviation

Ultrasonography

The ultrasonographic findings for the affected, unaffected, and control elbows are shown in Table 3. Significant differences in the prevalence of focal hypoechoic change and microcalcification were observed between the unaffected and control elbows ($P < 0.05$ and $P < 0.05$, respectively). Differences in the prevalence of focal hypoechoic change, microcalcification, erosive cortex, and neovascularity were observed between the affected and control elbows ($P < 0.001$, $P < 0.01$, $P < 0.05$, and $P < 0.001$, respectively). In addition, the CET thickness of the unaffected and affected elbows was greater than that of the controls ($P < 0.05$ and $P < 0.001$, respectively). Finally, CET Young's modulus of the affected elbows was significantly higher than that of the control elbows ($P < 0.05$).

Discussion

The present study validated the following hypotheses: (i) unaffected elbows in manual workers with unilateral LET have a higher prevalence of positive chair test results and morphological changes in elbow ultrasonography than those of the controls and (ii) affected elbows of workers with unilateral LET showed significant differences on physical examination and ultrasonography, as well as in the mechanical properties of the CET, compared to those of the controls. Studies have shown

Table 2: Comparison of physical examination results between the unaffected, affected, and control elbows

Parameters	Elbow	n	Counts (%)	Comparisons	P†
Tenderness on lateral elbow	Unaffected	30	8 (27)	Unaffected versus control	0.0797
	Affected	30	27 (90)	Affected versus control	<0.001*
	Control	30	2 (7)		
Cozen test (+)	Unaffected	30	4 (13)	Unaffected versus control	0.1124
	Affected	30	23 (77)	Affected versus control	<0.001*
	Control	30	0		
Maudsley's test (+)	Unaffected	30	3 (10)	Unaffected versus control	0.2373
	Affected	30	19 (63)	Affected versus control	<0.001*
	Control	30	0		
Chair test (+)	Unaffected	30	10 (33)	Unaffected versus control	0.0056*
	Affected	30	16 (53)	Affected versus control	<0.001*
	Control	30	1 (3)		
Parameters	**Elbow**	***n***	**Mean±SD**	**Comparisons**	**P‡**
Hand grip strength (kg)	Unaffected	30	32.7±12.3	Unaffected versus control	0.536
	Affected	30	28.0±13.6	Affected versus control	0.262
	Control	30	30.9±10.0		

*Statistically significant, †*P*-values derived using Fisher's exact test, ‡*P*-values derived using the Mann–Whitney *U*-test. CET: Common extensor tendon, SD: Standard deviation

Table 3: Ultrasonographic findings of the unaffected, affected, and control elbows with comparisons

Parameters	Elbow	*n*	Counts (%)	Comparisons	*P*†
Partial tear	Unaffected	30	2 (7)	Unaffected versus control	0.4915
	Affected	30	4 (13)	Affected versus control	0.1124
	Control	30	0		
Focal hypoechoic change	Unaffected	30	17 (57)	Unaffected versus control	0.0028*
	Affected	30	26 (87)	Affected versus control	<0.001*
	Control	30	5 (17)		
Microcalcification	Unaffected	30	13 (43)	Unaffected versus control	0.047*
	Affected	30	20 (67)	Affected versus control	0.0002*
	Control	30	5 (17)		
Erosive cortex	Unaffected	30	5 (17)	Unaffected versus control	0.7065
	Affected	30	11 (37)	Affected versus control	0.0303*
	Control	30	3 (10)		
Neovascularity	Unaffected	30	5 (17)	Unaffected versus control	0.1945
	Affected	30	14 (47)	Affected versus control	0.00021*
	Control	30	1 (3)		
Parameters	**Elbow**	***n***	**Mean±SD**	**Comparisons**	***P*‡**
CET thickness (mm)	Unaffected	30	4.88±0.83	Unaffected versus control	0.015*
	Affected	30	5.31±0.71	Affected versus control	<0.001*
	Control	30	4.34±0.50		
CET Young's modulus (kPa)	Unaffected	30	369.6±162.8	Unaffected versus control	0.058
	Affected	30	445.6±174.5	Affected versus control	0.001*
	Control	30	269.6±135.8		

*Statistically significant, †*P*-values derived using Fisher's exact test, ‡*P*-values derived using Mann–Whitney *U*-test. CET: Common extensor tendon, SD: Standard deviation

that the chair test and ultrasonography can be screening tools to monitor the risk of LET in unaffected elbows of manual workers.

This study discovered that manual workers with unilateral LET have a higher prevalence of positive chair test results for their unaffected elbows compared to those of the control group. Furthermore, the ultrasonography results for the unaffected elbows of manual workers showed a higher prevalence of focal hypoechoic changes and microcalcification compared to the controls. Based on these findings, further risk assessment and surveillance protocols for unaffected elbows in manual workers with LET should be considered. The differences between the LET-unaffected elbows and controls in this study may suggest the presence of an asymptomatic preclinical stage of LET. These abnormal ultrasonographic findings indicate a degenerative progression, reducing their ability to bear weight and subsequently leading to additional dysfunction.[21] Based on the concept that positive physical examination results and abnormal ultrasonographic findings could be used for predicting tendinopathy in asymptomatic athletes,[22,23] the current findings suggest that the asymptomatic elbows of manual workers should be considered at risk of LET instead of healthy elbows. Thus, the authors propose a protocol for risk assessment [Figure 3] to identify screening for preclinical LET and consummate present occupational health management. Asymptomatic manual workers developing LET can expect decreased tolerance for work or loss of the ability to work, particularly if both elbows are affected. Hence, the chair test and ultrasound examination can be used as screening for the preclinical LET stage to prevent advancement to the clinical stage.

The present study compared the ultrasonographic findings of manual workers with LET and those of control groups. It showed that focal hypoechoic change, microcalcification, erosive cortex, and neovascularity were more prevalent in the affected elbows than in the controls. These findings correspond to the ultrasonographic features for LET diagnosis, including focal hypoechoic change (sensitivity: 35%–100%, specificity: 38%–100%), microcalcification (sensitivity: 5%–42%, specificity: 83%–100%), and erosive cortex (sensitivity: 18%–63%, specificity: 63%–100%).[24] Notably, microcalcification was detected in up to 67% of manual workers with chronic LET in the present study, which has never been reported. Microcalcification has been proposed as a possible indicator of the LET degenerative stage. Furthermore, poor prognostic factors for conservative treatment[25] have also been reported in patients with refractory LET who underwent surgery;[26] this may be why manual workers experience poor outcomes. This finding of a high prevalence of microcalcification is consistent with the medical history of participants in this study (i.e. symptoms persisting for > 4 months). It may be responsible for the adverse outcomes experienced by manual workers. Future studies are recommended to investigate the effects of early shockwave therapy on the LET to reduce the incidence of calcification.

The prevalence of positive power Doppler and CET thickness in the affected elbows was, respectively, higher and greater than those in the controls. Power Doppler, a strong diagnostic indicator for LET, is related to neovascularity in degenerative tendinopathy.[27] CET thickness in the affected elbows was previously found to be significantly greater than that in the

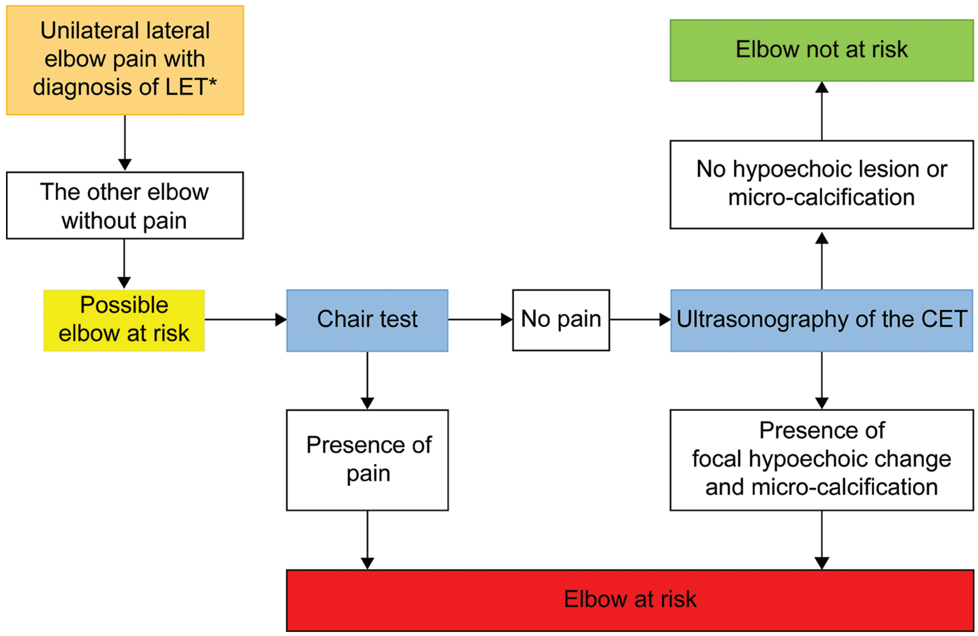

Figure 3: Risk assessment of the asymptomatic elbow in a manual worker with unilateral lateral elbow tendinopathy. *Diagnosis based on SALTSA criteria. LET: Lateral elbow tendinopathy, CET: Common extensor tendon

control elbows;[28] this is thought to be due to an increased extracellular matrix (containing largely collagen and proteoglycans) generated in the tendinopathy process.[21,26] The mean CET thickness for the affected elbows was 5.31 mm, surpassing the proposed cutoff threshold of 5.15 mm for LET diagnosis.[28] This indicates that occupational type may determine the baseline CET thickness; therefore, diagnostic cutoff values should be adjusted accordingly.

Young's modulus of the CET among the manual workers with unilateral LET was greater than that in healthy controls. Manual workers in this study may have experienced chronic degenerative tendinopathy dominated by microcalcifications; therefore, their CETs were stiffer, and Young's modulus of their CETs was higher than those of the control group. In contrast, previous studies have reported lower shear wave velocity and Young's modulus of the CET in patients with LET.[13,14] These differences may be due to the different populations and stages in the continuum models investigated.[7] These previous studies might have included participants with reactive tendinopathy, characterized by tendon swelling and softening, leading to a lower Young's modulus of the CET. The present study's findings indicate that LET stages may also determine the Young's modulus of the CET.

Differences in CET characteristics were observed between the LET-unaffected and LET-affected elbows of the manual workers and elbows from the control groups. Tendinopathy theories have been proposed to explain the pathogenic mechanism of LET.[29] The most widely accepted theory is the mechanistic theory, which proposes that tendon degeneration occurs due to excessive mechanical stimulation and impaired healing after injury. In comparison, the friction theory proposes that shearing stress develops between the extensor carpi radialis brevis tendon and the capitellum during elbow motion, and this is supported by a cadaveric study.[30] These theories imply that manual workers who perform forceful or repetitive movements in their jobs are likelier to develop LET.

The present study found that participants in the LET group were more likely to progress to the degenerative stage, experiencing pain and dysfunction in the affected elbow. In contrast, their unaffected elbows did not exhibit pain or dysfunction. However, regardless of whether the elbow was affected or unaffected, manual workers demonstrated pathologic characteristics such as increased tendon thickness and a higher prevalence of microcalcification compared to healthy controls.

This study's strength lies in its relatively strict inclusion criteria for patients with chronic lateral elbow pain, which is theoretically associated with tendinopathy. We also attempted to analyze tendinopathy from multiple perspectives, including questionnaires, clinical examinations, and various ultrasound techniques. However, this study had some limitations, including (i) a small sample size; (ii) the possibility of operator-dependent bias during ultrasonographic examinations; (iii) a lack of reliable measurement analysis; (iv) lack of tissue-proof evidence of tendinopathy; (v) lack of certain evaluations related to WRMSD, such as the Work Ability Index, or assessment of physical exposure, such as the strain index and key indicator methods; and (vi) the history of the unaffected elbow could not be fully comprehended; therefore, a controversy arose regarding the difference between the unaffected elbow and the control. This could indicate a subclinical stage without symptoms or a recovery stage from disability.

To the best of our knowledge, this is the first study focusing on the physical examinations and ultrasonographic findings of manual workers with unilateral LET.

Future research should focus on the relationship between physical exposure and biomechanical properties of the CET. Furthermore, multidisciplinary research is needed to determine the practicality of utilizing ultrasonography in the workplace. It is also required to verify the decision-making process proposed in the present study for identifying the elbow at risk as part of preassignment medical examinations or annual health surveillance for manual workers. The authors believe that only appropriate risk stratification can aid reasonable provisions regarding fitness for work and work limitations/restrictions and improve occupational health management.

Conclusion

This study demonstrates the ultrasound characteristics of LET in manual workers and the potential use of ultrasounds for occupational health management. Further multidisciplinary research is needed to determine the practicality of performing ultrasounds in the workplace.

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Conflicts of interest

There are no conflicts of interest.

References

1. Haahr JP, Andersen JH. Prognostic factors in lateral epicondylitis: A randomized trial with one-year follow-up in 266 new cases treated with minimal occupational intervention or the usual approach in general practice. Rheumatology (Oxford) 2003;42:1216-25.
2. Govaerts R, Tassignon B, Ghillebert J, Serrien B, De Bock S, Ampe T, *et al*. Prevalence and incidence of work-related musculoskeletal disorders in secondary industries of 21st century Europe: A systematic review and meta-analysis. BMC Musculoskelet Disord 2021;22:751.
3. Sanders TL, Maradit Kremers H, Bryan AJ, Ransom JE, Smith J, Morrey BF. The epidemiology and health care burden of tennis elbow: A population-based study. Am J Sports Med 2015;43:1066-1071.
4. Herquelot E, Bodin J, Roquelaure Y, Ha C, Leclerc A, Goldberg M, *et al.* Work-related risk factors for lateral epicondylitis and other cause of elbow pain in the working population. Am J Ind Med 2013;56:400-9.
5. van Rijn RM, Huisstede BM, Koes BW, Burdorf A. Associations between work-related factors and specific disorders at the elbow: A systematic literature review. Rheumatology (Oxford) 2009;48:528-36.
6. Garg A, Kapellusch JM, Hegmann KT, Thiese MS, Merryweather AS, Wang YC, *et al.* The strain index and TLV for HAL: Risk of lateral epicondylitis in a prospective cohort. Am J Ind Med 2014;57:286-302.
7. Cook JL, Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med 2009;43:409-16.
8. Fu SC, Rolf C, Cheuk YC, Lui PP, Chan KM. Deciphering the pathogenesis of tendinopathy: A three-stages process. Sports Med Arthrosc Rehabil Ther Technol 2010;2:30.
9. Smith MV, Lamplot JD, Wright RW, Brophy RH. Comprehensive review of the elbow physical examination. J Am Acad Orthop Surg 2018;26:678-87.
10. Sconfienza LM, Albano D, Allen G, Bazzocchi A, Bignotti B, Chianca V, *et al.* Clinical indications for musculoskeletal ultrasound updated in 2017 by European Society of Musculoskeletal Radiology (ESSR) consensus. Eur Radiol 2018;28:5338-51.
11. Levin D, Nazarian LN, Miller TT, O'Kane PL, Feld RI, Parker L, *et al*. Lateral epicondylitis of the elbow: US findings. Radiology 2005;237:230-4.
12. Obradov M, Anderson PG. Ultra sonographic findings for chronic lateral epicondylitis. JBR BTR 2012;95:66-70.
13. Dirrichs T, Quack V, Gatz M, Tingart M, Kuhl CK, Schrading S. Shear wave elastography (SWE) for the evaluation of patients with tendinopathies. Acad Radiol 2016;23:1204-13.
14. Zhu B, You Y, Xiang X, Wang L, Qiu L. Assessment of common extensor tendon elasticity in patients with lateral epicondylitis using shear wave elastography. Quant Imaging Med Surg 2020;10:211-9.
15. Cools AM, Cambier D, Witvrouw EE. Screening the athlete's shoulder for impingement symptoms: A clinical reasoning algorithm for early detection of shoulder pathology. Br J Sports Med 2008;42:628-35.
16. Singh AP, Chandak S, Agarwal A, Malhotra A, Jain A, Khan AA. Utility of high-resolution sonography for evaluation of knee joint pathologies as a screening tool. J Diagn Med Sonogr 2021;37:556-7.
17. World Medical Association. World Medical Association declaration of Helsinki: Ethical principles for medical research involving human subjects. JAMA 2013;310:2191-4.
18. Sluiter JK, Rest KM, Frings-Dresen MH. Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scand J Work Environ Health 2001;27 Suppl 1:1-102.
19. Wang CJ, Chen HS. Shock wave therapy for patients with lateral epicondylitis of the elbow: A one- to two-year follow-up study. Am J Sports Med 2002;30:422-5.
20. Krogh TP, Fredberg U, Ammitzbøl C, Ellingsen T. Ultrasonographic characteristics of the common extensor tendon of the elbow in asymptomatic individuals: Thickness, color Doppler activity, and bony spurs. Orthop J Sports Med 2017;5:2325967117704186.
21. Cook JL, Rio E, Purdam CR, Docking SI. Revisiting the continuum model of tendon pathology: What is its merit in clinical practice and research? Br J Sports Med 2016;50:1187-91.
22. Fazekas ML, Sugimoto D, Cianci A, Minor JL, Corrado GD, d'Hemecourt PA. Ultrasound examination and patellar tendinopathy scores in asymptomatic college jumpers. Phys Sportsmed 2018;46:477-84.
23. Kudron C, Carlson MJ, Meron A, Sridhar B, Brakke Holman R. Using ultrasound measurement of the Achilles tendon in asymptomatic runners to assist in predicting tendinopathy. J Ultrasound Med 2020;39:491-6.
24. Karanasios S, Korakakis V, Moutzouri M, Drakonaki E, Koci K, Pantazopoulou V, *et al.* Diagnostic accuracy of examination tests for lateral elbow tendinopathy (LET) – A systematic review. J Hand Ther 2022;35:541-51.
25. Chou WY, Wang CJ, Wu KT, Yang YJ, Ko JY, Siu KK. Prognostic factors for the outcome of extracorporeal shockwave therapy for calcific tendinitis of the shoulder. Bone Joint J 2017;99-B: 1643-50.
26. Kraushaar BS, Nirschl RP. Tendinosis of the elbow (tennis elbow). Clinical features and findings of histological, immunohistochemical, and electron microscopy studies. J Bone Joint Surg Am 1999;81:259-78.
27. du Toit C, Stieler M, Saunders R, Bisset L, Vicenzino B. Diagnostic accuracy of power Doppler ultrasound in patients with chronic tennis elbow. Br J Sports Med 2008;42:872-6.
28. Toprak U, Başkan B, Üstüner E, Öten E, Altin L, Karademir MA, *et al*. Common extensor tendon thickness measurements at the radiocapitellar region in diagnosis of lateral elbow tendinopathy. Diagn Interv Radiol 2012;18:566-70.
29. Millar NL, Silbernagel KG, Thorborg K, Kirwan PD, Galatz LM, Abrams GD, *et al*. Tendinopathy. Nat Rev Dis Primers 2021;7:1.
30. Bunata RE, Brown DS, Capelo R. Anatomic factors related to the cause of tennis elbow. J Bone Joint Surg Am 2007;89:1955-63.