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Comparison of scapular position and upper extremity muscle strength in patients with and without lateral epicondylalgia: a case-control study

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Background: The symptoms of lateral epicondylalgia (LE) can be persistent, and recurrence is frequent. Recurrence can be related to proximal segment impairment of the kinetic chain. Knowledge of any relation in the kinetic chain in LE may help treatment. We aimed to investigate scapular position and upper extremity muscle strength in patients with LE and to compare them with controls.
Methods: The study enrolled 51 patients with LE and 51 age-matched controls. We assessed scapular position asymmetry using the lateral scapular slide test and measured the strength of the upper trapezius (UT), middle trapezius (MT), lower trapezius, and serratus anterior muscles in addition to shoulder abduction, external rotation, and internal rotation and grip strength.
Results: The percentage of participants with scapular asymmetry was greater in the patients than in the controls ($P = .005$). The involved side regarding shoulder external rotation among the patients was significantly weaker than in the controls ($P = .016$, $P = .009$). The involved side of the LE patients was significantly weaker than the uninvolved side in terms of shoulder abduction, external rotation, and internal rotation ($P = .013$, $P = .048$, $P = .013$). The UT/MT ratio on the nondominant side of the controls was significantly greater than that on the involved side of the LE patients ($P = .016$).
Conclusion: Upper extremity muscle strength, grip strength, UT/MT ratio, and scapular position are affected in patients with LE. In addition to the elbow, focusing on the upper segments is essential in the management of LE.
Level of evidence: Level III; Case-Control Design; Epidemiology Study

Keywords: Grip strength; scapular dyskinesia; shoulder; strength testing; tennis elbow; upper extremity

The study protocol was approved by the Ethics Committee of the Izmir Katip Çelebi University (No. 153). Written and verbal consents were obtained from all participants.

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Lateral epicondylalgia (LE), also known as tennis elbow, is a common cause of chronic musculoskeletal pain in the elbow with a prevalence as high as 12.2% in the working population.[34] The condition is characterized by pain in the lateral epicondyle area, and its symptoms are felt during daily activities that especially involve gripping or lifting.[6] In addition, the condition leads to loss of function and productivity.[35] Conservative management is usually the first treatment option.[6] However, one study showed that in general practice, more than half of the patients reported they did not recover from the elbow pain after 1 year.[7]

Because of the persistent and recurrent symptoms despite treatments directed at the elbow,[7,12] researchers suggested that the condition could be triggered from other regions in the kinetic chain.[12,23] Smidt et al[36] have associated concomitant shoulder pain with poor prognosis of the patients with LE. Mandalidis and O'Brien[25] have shown the association between hand grip strength and shoulder muscle strength among the healthy population. Besides, Suzuki et al[37] have demonstrated altered elbow kinematics after scapular muscle fatigue in healthy men and suggested that fatigue of the scapular muscles might contribute to elbow pathologic changes through resulting compensatory motions at the elbow. Moreover, Tripp et al[39] demonstrated that fatigue protocols affected reproducibility of arm position, with the deficits being alteration in scapular, glenohumeral, and elbow position.

Specific alterations to the scapular muscle activity and kinematics were associated with scapular dyskinesia.[16] Scapular dyskinesia is defined as an alteration of the scapular position and motion patterns[17,24] and is commonly associated with shoulder diseases.[24] Research has shown that rather than global weakness, scapular muscle imbalance, which is defined as decreased activity of the middle trapezius (MT), lower trapezius (LT), and serratus anterior (SA) muscles with increased activity of the upper trapezius (UT), can be one of the factors that contribute to scapular dyskinesia and thus shoulder disease.[11,21]

Besides shoulder disease, global weakness of the scapular muscles has also been reported in patients with LE.[12] Lucado et al[23] reported altered strength ratios of the shoulder and the scapular muscles (UT/LT) among tennis players with LE compared with players without LE. However, to our knowledge, no study has yet investigated scapular muscle imbalance reporting muscle strength ratios in nonathletic patients with LE. Taspinar et al[38] have reported scapular position asymmetry in patients with pain originating from another region in the kinetic chain (cervical disk herniation). However, scapular position asymmetry has not yet been assessed in LE. In addition, there are contradictory data in the literature concerning the strength of the shoulder musculature.[1,23] Alizadehkhaiyat et al[1] reported decreased shoulder abduction (ABD), external rotation (ER), and internal rotation (IR) in patients with LE, whereas Lucado et al[23] reported no difference in terms of shoulder muscle strength between tennis players with LE and controls. Moreover, in a case report, assessment and treatment of the scapular musculature were recommended for the management of LE.[5] However, a correlation between scapular dyskinesia and upper extremity strength characteristics in the nonathletic working population with LE has not been established.

The aim of this study was to compare the scapular position and strength ratios of the upper extremity muscles among patients with unilateral LE with the uninvolved side and with age-matched controls. The following hypotheses were questioned: scapular position asymmetry and shoulder, scapular muscle, and grip weakness occur in the involved extremity of LE patients; and scapular position and shoulder, scapular muscle, and grip strength differ between subjects with and without LE.

Materials and methods

Setting and participants

This cross-sectional study recruited 51 patients with unilateral LE from the Department of Physical Medicine and Rehabilitation of Atatürk Training and Research Hospital, Izmir Katip Celebi University (Izmir, Turkey) and 51 age-matched controls from the Izmir region between August 2017 to April 2018.

Sixty-three patients previously diagnosed with LE with a duration of 1 month were re-examined for LE symptoms. Patients who had pain with palpation over the lateral epicondyle or the extensor carpi radialis brevis muscle and positive results of at least 2 LE-specific clinical tests, including resisted wrist extension (Cozen test), resisted middle finger extension (Maudsley test), and passive stretching of wrist extensors (Mills test),[30] were included in the study. Those who had no pain reproduction with palpation over the lateral epicondyle area and no history of LE were enrolled as controls.

The presence of one of the following conditions was accepted as an exclusion criterion: current musculoskeletal problems in the shoulder, cervical, or thoracic region; entrapment neuropathy or neurologic deficit of the upper extremity; history of major trauma or surgery in the elbow; deformity or movement limitation in the shoulder, elbow, or wrist; systemic inflammatory disease; and any previous treatment for LE in the last 3 months. Patients whose LE-related symptoms had emerged <1 month ago were excluded. The details of the included and excluded subjects are provided as a flowchart in Figure 1.

Procedures

First, we collected the demographic and disease-related data. We measured the pain intensity with a rating scale that ranged from 0 (no pain) to 10 (maximum pain).[9] Then, we performed the following assessments for all participants in the same order: scapular position asymmetry, shoulder and scapular strength, grip strength, and LE-specific questionnaire (only for LE patients).

We assessed scapular position asymmetry using the lateral scapular slide test (LSST), which is a reliable and objective measurement of scapular asymmetry.[17,28] Participants were instructed to look straight ahead and to fix their eyes on an object

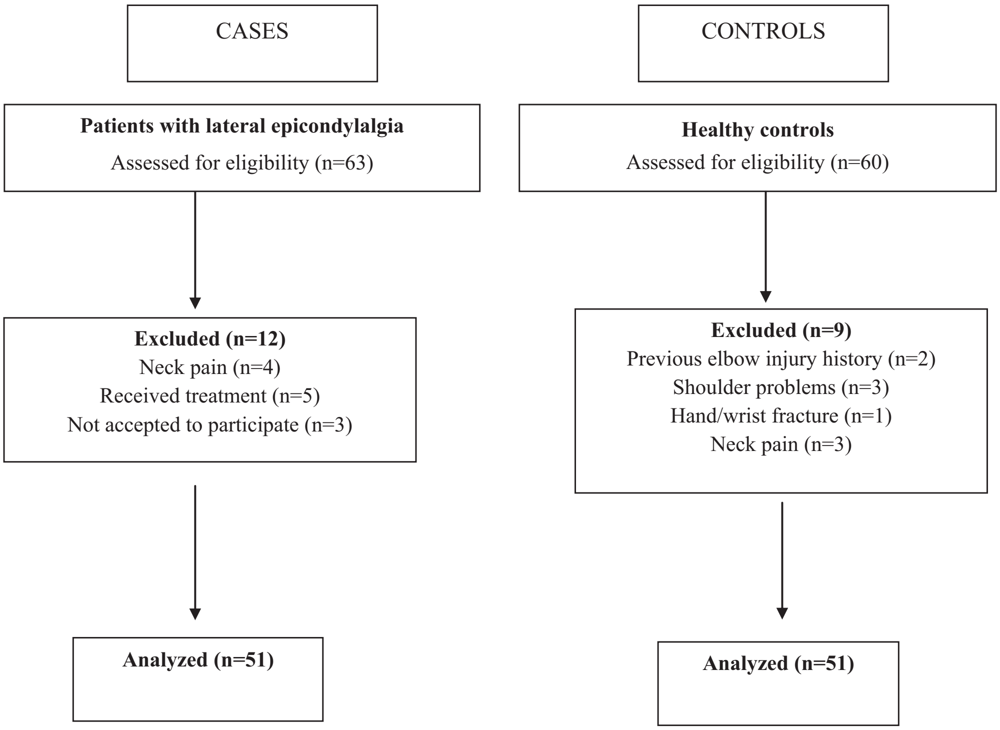

Figure 1 Details of the included and excluded patients.

in the examination area to maintain a consistent posture. The distance between the inferior angle of each scapula and the closest spinous process was measured bilaterally using a tape measure in 3 test positions. In the first position, the participants' arms were at the sides in the neutral position (LSST1; Fig. 2); in the second position, the hands were placed on the hips (lateral iliac crests) with the thumbs pointed posteriorly (LSST2; Fig. 3); and in the third position, the subjects stood with the shoulders abducted in full IR (LSST3; Fig. 4). For obtaining the scapular asymmetry values, the side-to-side differences were calculated by subtracting the scapular distance of the uninvolved side from the scapular distance of the involved side for the patients with LE and by subtracting the scapular distance of the dominant side from the scapular distance of the nondominant side for controls. The absolute value of the side-to-side difference was used for data analysis. A side-to-side difference of $\geq$1.5 cm was considered a positive result, which indicates scapular asymmetry.[17]

We performed the shoulder and scapular muscle strength measurements for both arms using a hand-held dynamometer (HHD; Lafayette Manual Muscle Testing System, model 01163; Lafayette Instrument, Lafayette, IN, USA). Participants were asked to hold the muscle-specific positions as the investigator applied resistance through the HHD using the "hold" test procedure.[27] All participants performed the muscle tests in the same order: shoulder IR, shoulder ER, shoulder ABD, UT, MT, LT, and SA tests. Three repetitions of maximal voluntary effort were taken for each muscle, with an adequate rest between the measurements to avoid muscle fatigue.[8] We calculated the mean of the 3 measurements of each strength test. Previous studies have shown acceptable reliability of HHDs in strength measurements of the shoulder and scapular muscles.[8,10,27]

In the strength measurements of the shoulder ABD, ER, and IR, the participants were seated with the feet supported on the ground.[8,10] The investigator tested the shoulder ABD with the shoulder at 90° ABD in the scapular plane and the elbow at full extension. Then, the investigator applied resistance perpendicular to just above the lateral epicondyle of the distal humerus using the HHD.[8] For the shoulder ER and IR, participants were tested with the shoulder at the side (0° ABD) in neutral rotation and the elbow at 90° of flexion (Fig. 5). The investigator placed the HHD 2 cm proximal to the ulnar styloid process and applied resistance perpendicular to the extensor aspect of the distal forearm for shoulder ER and perpendicular to the flexor aspect of the distal forearm for shoulder IR.[10]

For the strength measurement of the UT, we asked the participant to sit upright with the head in neutral position. The investigator applied downward resistance in the direction of scapular depression over the superior scapula using the HHD and asked the participant to perform scapular elevation. We measured the MT and LT strength with the participant in the prone position. For measuring strength of the MT, the investigator positioned the participant's arm in 90° ABD with the elbow flexed and applied resistance to the scapular spine (between the acromial process and medial-superior border of the scapula). The investigator then asked the participant to perform a scapular retraction by lifting the arm upward against the resistance applied by the HHD in the lateral direction. For LT strength measurement, the investigator positioned the participant's arm in 135° ABD with the elbow extended and placed the HHD over the spine of the scapula (between the acromial process and medial-superior border of the scapula). The investigator applied resistance in the superior-lateral direction, and the participant was asked to perform scapular

Figure 2 Lateral scapular slide test, position 1.

Figure 3 Lateral scapular slide test, position 2.

Figure 4 Lateral scapular slide test, position 3.

Figure 5 External rotation muscle strength measurement.

adduction and depression. Finally, for strength measurement of the SA, the investigator placed the participant in the supine position with the shoulder and elbow flexed 90° and then applied downward resistance over the olecranon along the humeral shaft and asked the participant to perform a scapular protraction.[27]

We assessed grip strength in the upright sitting position using a hydraulic handgrip dynamometer (North Coast Medical Inc., Morgan Hill, CA, USA). The participant's arm was at the side and the elbow was in 90° of flexion with the forearm and wrist in neutral position, and the examiner asked the participant to perform

Table I Demographic and physical characteristics of the participants

Characteristics	Patients with LE (N = 51)	Controls (N = 51)	*P*
Age (yr)	44.88±9.66	42.71±9.72	.259
Weight (kg)	73.39±15.38	69.22±13.55	.128
Height (m)	1.63±0.80	1.65±0.9	.415
Body mass index (kg/m^2)	27.54±5.39	25.40±4.20	.028
Sex			
Female	39 (76.5)	42 (82.4)	.463
Male	12 (23.5)	9 (17.6)	
Dominant side			
Right	50 (98)	48 (94.1)	.308
Left	1 (2)	3 (5.9)	
Complaint duration (mo)	11.98±13.68		
PRTEE, pain	27.86±13.86		
PRTEE, function	27.04±9.91		
PRTEE, total	54.88±18.18		

LE, lateral epicondylalgia; *PRTEE*, Patient-Rated Tennis Elbow Evaluation.
Categorical variables are presented as number (%). Continuous values are presented as mean±standard deviation.

maximum grip effort.[4] We took the measurement 3 times and used the mean of the 3 measurements for data analysis.

Finally, only patients with LE completed the Turkish version of the Patient-Rated Tennis Elbow Evaluation (PRTEE) questionnaire.[3] This tennis elbow–specific patient-reported questionnaire assesses perceived pain and function in the past week with 15 items. The total score is between 0 and 100. Higher scores show greater pain and functional disability. The PRTEE has been shown to be reliable and sensitive in patients with LE.[3,32]

Sample size and statistical analyses

We used the G*Power software version 3.1.9.2 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) to determine the required sample size for this study and a medium effect size (0.50) in our a priori power analyses. We selected 51 participants in each group to identify intergroup differences with a power of at least 80% at an α level of .05.

Normality was evaluated using the Kolmogorov-Smirnov test. Nonparametric tests were used in the analyses when the data did not show normal distribution. The groups were compared using the independent samples *t*-test for age and body mass index and the Mann-Whitney *U* test for body weight and height. The χ^2 test was used to compare groups for sex and dominant side. For the patients with LE, additional descriptive data were calculated for symptom duration, PRTEE, and pain intensity.

We used the Mann-Whitney *U* test to compare the groups for side-to-side differences in the LSST. In addition, we used the χ^2 test to compare the groups for scapular asymmetry percentages. Muscle strength measurements were normalized for body weight (muscle strength was divided by body weight in kilograms), and these values were used in data analysis. In comparing the involved and uninvolved sides of the patients with LE, we used the paired-samples *t*-test for the strength of grip, MT, LT, and shoulder IR and ABD and the Wilcoxon signed rank test for the UT, SA, shoulder IR, and muscle strength ratios. For intergroup comparisons, we performed the independent samples *t*-test for comparing the strength of the grip, LT, and shoulder IR and ABD between the involved side of the patients with LE and the nondominant side of the controls and for the comparison of UT/LT muscle ratios between patients with LE and controls. The Mann-Whitney *U* test was used for the comparisons of other normalized strength values and muscle ratios. *P* values $<$ .05 were considered statistically significant.

Results

The demographic and physical characteristics of the groups were similar ($P > .05$), except that the body mass index of the patients with LE was significantly greater than that of the controls (Table I). In LE patients, the mean duration of the symptoms was 12 (range, 1-60) months, and the mean PRTEE score was 54.88±18.18 (range, 11-93.5). The mean pain intensity was 2.65±2.81 at rest, 3.63±3.58 at night, 7.29±2.03 when lifting heavy objects, and 7.22±2.09 during repeated elbow motions. Of the patients with LE, 39 patients reported the involved side as their dominant side and 42 patients reported an overuse in usual or unusual activities.

There was no statistically significant difference between the groups in terms of side-to-side difference values in any test position in the LSST ($P = .368$, $P = .763$, $P = .949$; Table II). On the other hand, there was a significant difference between the groups in the percentages of the participants who had a side-to-side difference of ≥1.5 cm for test positions 1 and 2 ($P = .005$ for both) but none for test position 3 ($P = .063$; Table III).

The results of normalized muscle strength values are shown in Table IV. The involved side of the LE patients was significantly weaker than both sides of the controls in terms of shoulder ER and grip strength ($P = .016$, $P = .009$, $P <$

Table II Scapular distance and side-to-side differences of the participants in the LSST

Group	Test position 1				Test position 2				Test position 3			
	Involved	Uninvolved	Difference	*P*	Involved	Uninvolved	Difference	*P*	Involved	Uninvolved	Difference	*P*
Patients with LE	9.51±1.77	9.39±1.66	0.12±1.27	.368	9.35±1.77	9.23±1.79	0.12±1.30	.763	9.08±1.88	9.01±1.82	0.06±1.08	.949
Controls*	9.47±1.65	9.54±1.62	−0.07±0.96		9.63±1.55	9.68±1.45	−0.06±0.96		9.40±1.56	9.40±1.49	0.00±0.92	

LSST, lateral scapular slide test; *LE*, lateral epicondylalgia.
Values are presented as mean±standard deviation in centimeters.
* For controls, involved side represents the nondominant side, and uninvolved side represents the dominant side.

.001). Again, in LE patients, the involved side was weaker than the uninvolved regarding shoulder ABD, ER, and IR and grip strength ($P = .013$, $P = .048$, $P = .013$, $P < .001$). Scapular muscle ratios were not significantly different between the groups (UT/LT, $P = .084$, $P = .143$; UT/ST, $P = .698$, $P = .756$), except for the UT/MT, which was significantly greater on the nondominant side of the controls compared with the involved side of LE patients ($P = .016$; Table V).

Discussion

The most outstanding outcomes of this study were that we observed no scapular position asymmetry in LE patients. However, the rate of positive LSST results was higher in LE patients; shoulder ER, grip strength, and UT/MT ratios were lower in LE patients, and shoulder ABD, shoulder IR and ER, and grip strength were reduced on the involved side compared with the noninvolved side of the LE patients.

Scapular position asymmetry assessed in this study has been commonly associated with upper extremity dysfunction or injury. The scapula, shoulder, and arm work in harmony to generate, to absorb, and to transfer forces in the kinetic chain.[17] During upper extremity movements, energy is transferred from the proximal to more distal segments. Alterations of the scapular position may create an impaired ability to stabilize the scapula, thus increasing energy demands in the distal parts during activities of daily living. In theory, the increased force may cause an overuse injury in the elbow.[12] Our study investigated this theory in LE patients. To our knowledge, this is the first study to investigate scapular position in LE patients using the LSST. According to the LSST results, there was no significant difference between the LE patients and the controls. However, we observed that the rate of positive LSST results in LE patients was higher than in the controls. This indicates that the scapular position is associated with LE. Further studies are needed to assess this relationship in detail.

Unlike scapular positioning, numerous studies have investigated grip strength in LE patients and shown that grip strength is reduced in LE cases.[13,30,40] Similarly, we observed that the grip strength of the involved side in LE patients was weaker than that of the uninvolved side and the controls. On the other hand, weakness in grip strength may be associated with upper extremity weakness because of the close kinetic relation between the proximal and distal segments.[2,23] However, few studies have investigated the shoulder muscle strength in LE cases, and thus the data are limited. Alizadehkhaiyat et al[2] previously reported a 25%-35% decrease in shoulder strength among individuals with LE compared with the control groups. The authors asserted that a global upper extremity weakness exists in LE patients. Lucado et al[23] investigated the strength of the shoulder in IR, ER, and ABD and the strength of the UT and found no significant difference between the LE patients and the controls. However, the authors asserted that the weakness of the shoulder ER muscles would result in compensatory injury of the wrist extensors, potentially leading to LE. Mandalidis and O'Brien[25] have also reported

Table III Comparison of the groups for scapular asymmetry percentages

Groups	Test position 1		*P*	Test position 2		*P*	Test position 3		*P*
	LSST+	LSST−		LSST+	LSST−		LSST+	LSST−	
Patients with LE	18 (35.3)	33 (64.7)	.005	15 (29.4)	36 (70.6)	.005	12 (23.5)	39 (76.5)	.063
Controls	6 (11.8)	45 (88.2)		4 (7.8)	47 (92.2)		5 (9.8)	46 (90.2)	

LSST, lateral scapular slide test; *LE*, lateral epicondylalgia.
LSST+ indicates the number of participants with scapular asymmetry; LSST− indicates the number of participants without scapular asymmetry.
Values are presented as number (%).

Table IV Normalized strength values of the participants

	Patients with LE			Controls		Intergroup comparisons	
	Involved side	Uninvolved side	Intragroup comparisons	Nondominant side	Dominant side	Involved side vs. nondominant side	Involved side vs. dominant side
Upper trapezius	0.25±0.09	0.26±0.09	Z = −0.856, P = .392	0.27±0.08	0.27±0.07	Z = −1.553, P = .120	Z = −1.221, P = .222
Middle trapezius	0.19±0.06	0.19±0.06	t = −1.113, P = .271	0.18±0.05	0.18±0.05	Z = −0.843, P = .399	Z = −0.422, P = .673
Lower trapezius	0.18±0.06	0.19±0.05	t = −0.678, P = .501	0.18±0.05	0.18±0.04	t = 0.514, P = .609	Z = −0.850, P = .365
Serratus anterior	0.19±0.06	0.20±0.07	Z = −1.418, P = .156	0.20±0.06	0.20±0.06	Z = −0.997, P = .319	Z = −0.910, P = .363
Shoulder abduction	0.17±0.06	0.18±0.05	t = −2.573, P = .013	0.19±0.05	0.21±0.16	t = −1.749, P = .083	Z = −1.931, P = .053
Shoulder external rotation	0.13±0.04	0.14±0.04	Z = −1.975, P = .048	0.15±0.04	0.15±0.05	Z = −2.419, P = .016	Z = −2.597, P = .009
Shoulder internal rotation	0.14±0.04	0.15±0.04	t = −2.584, P = .013	0.15±0.05	0.15±0.04	t = −1.686, P = .095	Z = −0.877, P = .381
Grip strength	0.25±0.12	0.29±0.12	t = −4.445, P < .001	0.35±0.09	0.36±0.10	t = −5208, P < .001	t = −5224, P < .001

LE, lateral epicondylalgia; *t*, paired samples *t*-test; *Z*, Mann-Whitney *U* test.
Values are presented as mean±standard deviation in kilograms (muscle strength)/kilograms (body weight).

that lower grip strength seems partially correlated with lower shoulder isokinetic strength. In spite of shoulder muscle weakness, some studies have pointed out the fact that shoulder symptoms may occur only when more distal compensatory mechanisms do not suffice or fail.[2,20] Although our patients did not have any shoulder problems, we discovered that the involved side in LE patients was weaker than that of the controls in terms of shoulder ER, like the findings from the literature. In addition, the involved side was weaker than the uninvolved side for shoulder ABD, ER, and IR.

Previous studies have indicated that overuse injuries in the elbow may often occur with shoulder or scapular dysfunction.[14,29] In addition, some authors have mentioned the need to assess the shoulder and scapular muscle strength in patients with elbow pain.[2,18] Lahz[22] suggested that fatigue of the scapular muscles causes changes in elbow kinematics and could be a predisposing factor in elbow problems in throwing athletes. Samani et al[33] reported that pain at the UT generates an increase in the wrist extensor electromyographic signal intensity in healthy individuals, which could potentially lead to overuse injury such as LE. Suzuki et al[37] suggested that fatigued scapular muscles may contribute to elbow problems in patients with LE. Day et al[12] assessed patients with symptomatic LE and controls and found that the involved side of the group with LE had significantly lower values for MT, SA, and LT strength compared with the controls. In addition, the arms with LE had significantly lower strength of

Table V Scapular muscle strength ratios of the participants

Ratios	Patients with LE		Within-group comparisons	Controls		Between-group comparisons	
	Involved	Uninvolved		Nondominant	Dominant	Involved side vs. nondominant side	Involved side vs. dominant side
UT/MT	1.39 ± 0.37	1.38 ± 0.35	Z = −0.253, P = .800	1.56 ± 0.33	1.49 ± 0.34	Z = −2.406, **P* = .016**	Z = −1.345, P = 0179
UT/LT	1.43 ± 0.42	1.42 ± 0.37	Z = −0.131, P = .896	1.56 ± 0.36	1.53 ± 0.29	t = −1.745, P = .084	t = −1.477, P = .143
UT/SA	1.39 ± 0.33	1.38 ± 0.39	Z = −0.253, P = .800	1.42 ± 0.34	1.40 ± 0.31	Z = −0.388, P = .698	Z = −0.311, P = .756

LE, lateral epicondylalgia; *UT*, upper trapezius; *MT*, middle trapezius; *LT*, lower trapezius; *SA*, serratus anterior; *t*, paired samples *t*-test; *Z*, Mann-Whitney *U* test.
Values are presented as mean ± standard deviation.
* $P < .05$.

the LT and SA compared with the uninvolved limb. Similarly, Lucado et al[23] reported diminished LT muscle strength in a group of female tennis players with LE compared with asymptomatic female tennis players. In our study, we evaluated the strengths of the UT, MT, LT, and SA muscles and found no significant difference between LE cases and controls, except that the UT/MT ratio was lower in LE cases. Weakening of the distal mechanism, such as weakening in the grip strength, is compensated by the shoulder and proximal structures, especially in chronic cases [2,18,25] We believe that the UT is overactive to compensate for the weakened shoulder muscles. Over time, this hyperactivity may cause fatigue of the UT or inhibit its movement. This might be the reason for the decreased UT/MT ratio in our LE cases.

The assessment of the shoulder and scapular muscle strength and scapular position in LE patients is important in providing objective information on the causes of the problem. The important findings of our study were that the alterations in the scapular position of LE patients had a higher percentage compared with controls, and their muscle strengths also showed differences. We recommend that interventions be directed toward restoration of the shoulder and scapular deficits in patients with LE because, in theory, strength deficits at these segments may be compensated by other segments in the short term. Because of these compensations, the performance of the shoulder and elbow declines.[19,26] This may cause muscle weakness along the upper extremities in the kinetic chain. During functional movement, kinetic energy is shifted from the proximal to distal segments of the upper extremity. In theory, when stabilization of the upper region is impaired, demands from the tissues in the distal segments are increased in performing a functional activity.[15,31] Again, in theory, the pain at the extensor muscles may cause restriction of the arm movements and thus cause limitation of the shoulder motion and weakness of the shoulder muscles.

In our study, we observed that the proximal strengths of our LE patients were also affected in addition to their grip strengths. If we consider the upper extremity as a kinetic ring, it can be asserted that the problems in the distal and proximal segments are associated with each other. The deficits in the strength and motor movement may be masked as they are compensated by the other segments in the early term. However, this might affect the performance of the distal and proximal segments in time. The literature holds different views of this matter. Alizadehkhaiyat et al[2] reported that especially the impairment in the extensor carpi radialis activation in LE patients will lead to imbalance of the whole upper extremity in the later period. Lucado et al[23] stated that the weakness of the external rotators of the shoulder will increase the movement of the distal segments and thus may cause LE. Data from our study are not sufficient to confirm whether the distal segments impair the proximal segments or the proximal segments trigger the distal segments.

There are some limitations to our study. First, the duration of the complaints, which may affect the symptoms of the disease, was different in each patient. Therefore, only the patients with similar complaint duration were comparable. Second, we assessed the scapular position only in the sagittal plane, whereas the scapula moves in all 3 planes. Furthermore, the sensitivity of the LSST was lower. This may be the reason for our finding of no scapular position asymmetry in LE patients. However, we preferred this test as the best choice because our study groups could not tolerate the dynamic tests. Three-dimensional assessment of the scapular position and movements may help to better understand the importance of the scapula in patients with LE. Third, we evaluated static muscle strength. Muscle endurance could also be evaluated in addition to strength as muscle fatigue that would result from the loss of muscle endurance might have contributed to the problem. Further studies considering these points can be planned.

Conclusion

In addition to the elbow, focusing on the upper segments is essential in the treatment and prevention of LE. Further detailed work in this field is necessary. In addition, strength and endurance of the upper extremities, spinal curvature and core stabilization and endurance, and the relationships between the two should be investigated in future studies.

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