PJAHS
Philippine Journal of Allied Health Sciences

Original Article

Association of Lateral Epicondylalgia and Shoulder Rotatory Motion: A Cross-sectional Case Control Study

Lyle Patrick Tangcuangco[a,b], Valentin Dones[a,b,c]

[a]Graduate School, University of Santo Tomas, Manila, Philippines; [b]Center for Health Research and Movement Sciences - College of Rehabilitation Sciences, University of Santo Tomas, Manila, Philippines; [c]College of Rehabilitation Sciences, University of Santo Tomas, Manila, Philippines

Correspondence should be addressed to: Lyle Patrick Tangcuangco [a,c]; ldtangcuangco@ust.edu.ph

Article Received: 25 March 2019

Article Accepted: 8 July 2019

Article Published: 19 July 2019 (Online)

Abstract

Background: Lateral epicondylalgia (LE) is a cumulative strain injury affecting the common extensor origin of the elbow, manifesting as lateral elbow pain. Tightness of the fascia connecting the lateral elbow area with the shoulder area was assumed as potential source of LE. Limitation in shoulder rotatory motions may be associated with painful LE elbows. **Aim:** To determine the difference on shoulder rotatory motions between sides of symptomatic and asymptomatic elbows. **Methods:** Eligible participants had at least one elbow that tested positive for Cozen, Mill, or Maudsley's test. Using a universal goniometer, a blinded assessor measured the participants' active and followed by passive shoulder internal and external rotation. The primary investigator tested the external rotation followed by internal rotation of the right upper extremity, then subsequently the left upper extremity of healthy participants both passively and actively. **Results:** The assessor showed excellent intra-tester reliability in measuring active and passive shoulder rotatory motions of 20 asymptomatic right upper extremities (ICC=0.98). Twenty-seven (27) participants (3 males, 24 females) with a mean (95%CI) age of 54 (49-58) years old were enrolled in the study. The mean visual analogue scale of the patients was 6.53 (5.91-7.13), with mean (95%CI) duration of 96 (50-142) weeks. Based on hand dominance and side of LE, significant difference was found in active and passive shoulder internal rotation ($p>0.05$). **Conclusion:** Shoulder active and passive internal rotations were significantly associated with hand dominance in patients with LE. Tightness of the fascia and muscle in the shoulder and painful LE elbow may underpin the decreased shoulder rotatory motions.

***Keywords*:** lateral epicondylalgia, tennis elbow, shoulder, fascia

Introduction

Lateral epicondylalgia (LE) is a musculoskeletal injury characterized by lateral elbow pain and painful grip affecting daily functions.[1] LE is most prevalent in jobs or activities requiring repetitive manual tasks commonly seen in tennis players, cooks, washers, painters, plumbers, butchers and carpenters[2]. LE is commonly found between 45-54 years old with prevalence of 1-3% with no apparent gender bias[1; 3; 4].

Lateral epicondylalgia (LE) is clinically diagnosed by reproducing patient's lateral elbow pain using the Cozen, Mill or Maudsley's test[5].Cozen, Mill and Maudsley tests have sensitivities of 91%, 76%, and 66% respectively[6].

The forearm wrist extensor muscles and the lateral intermuscular septum were reported to be associated with lateral elbow pain in LE elbows[7;8;9;10]. The lateral intermuscular septum is connected to the forearm wrist extensor muscles through the lateral epicondyle[9;10;11;12]. The lateral intermuscular septum is proximally connected to the triceps brachii, middle deltoid and posterior deltoid[6;12;13].

The forearm wrist extensor-lateral intermuscular septum-shoulder muscles fascia link could have underpinned the reported association between shoulder and elbow movements in LE patients by Abott (2001). The limitation in the shoulder range of motion of 23 participants with LE elbow was due to due to increased muscle activity in the shoulder[14]. The assumed shoulder and elbow limitation in the range of motion remains to be under-investigated in the current literature.

This study aimed to associate shoulder rotatory motion with presence or absence of LE. We aimed to find association between hand dominance, age, gender, activities, and chronicity of LE symptoms with shoulder rotatory motions.

Materials and Methods

Ethics Approval

This study obtained ethics approval from the Ethics Review Committee of the College of Rehabilitation Sciences of the University of Santo Tomas (UST-CRS), Manila, Philippines (Ethics Protocol Number SE-2014-033-R1).

Study Design

This was an observational cross-sectional case-control study. Active and passive shoulder rotatory motions of participants with unilateral LE and healthy participants without LE were measured. Non-LE elbows were the non-painful elbows of participants with unilateral LE. Non-symptomatic elbows were the bilateral asymptomatic elbows of healthy participants.

Recruitment Protocol and Sample Size

From January 2015 to March 2015, potential participants were recruited from the following places:

1. University of Santo Tomas-College of Rehabilitation Sciences affiliated centers,
2. health centers surrounding the vicinity of University of Santo Tomas
3. Tennis/golf clubs in Metro Manila identified through yellow pages.

The participants were evaluated by a licensed physiotherapist other than the Assessor at the Physiotherapy Skills Laboratory of UST-CRS using an initial screening checklist (Supplement A_File). Participants' responses to replication tests (i.e. Cozen, Mill and Maudsley tests) were noted. The control participants were matched with case participants based on gender, age, and occupation. Based on sample size calculation, a 1:1 case: control matching was performed.

Criteria of Eligible Participants

Participants were LE were selected based on the following inclusion criteria:

- Characteristic lateral elbow pain replicated by any one or combination of the Cozen, Mill or Maudsley test;
- Engaged in forceful and repetitive upper extremity activities such as laundry washing, carpentry, car mechanics, tennis playing, and golfing;

Participants with orthopedic conditions in the elbow that may mimic LE (i.e. fractures in the elbow, arthritic conditions, medial epicondylalgia, nerve impingement at the elbow, elbow pain from cervical radiculopathy, paresthesia occurring along the elbow region) were excluded from the study.

The non-symptomatic elbows of healthy participants were tested negative to all Cozen, Mill and Maudsley tests. The healthy participants had no lateral elbow pain in the past six months prior to inclusion in the study and were involved in repetitive and forceful handgrip activities (i.e. laundry, sewing, typing).

Status of Elbows Used in the Study

Elbows, whose sides of shoulder range of movement were measured, were referred to in the study as:

1. LE elbows i.e. symptomatic elbows of participants with unilateral LE
2. Non-LE elbows i.e., asymptomatic elbows of participants with unilateral LE
3. Non-symptomatic elbows i.e., elbows of healthy participants

Setting

The study was conducted at Lingap Karunungan, Rehabilitation and Empowerment of Adults and Children with Handicap (REACH) Foundation, Mandaluyong City serving 44 barangays in Mandaluyong City. REACH is a non-profit organization providing physical therapy, occupational therapy, speech therapy, and special education classes.

Equipment Used

A mechanical contraption was used in this study (Fig. 1). The mechanical contraption held the head and neck in a neutral position, and shoulder at 90 degrees of abduction of a supine-lying patient. The mechanical contraption prevented unnecessary neck (lateral and rotatory) and shoulder (elevation) motions.

Figure 1.

A universal goniometer was used to measure the active and passive shoulder internal rotation and external rotation. The universal goniometer has moderate to good reliability, with Intraclass Correlation Coefficients of ≥ 0.94[15].

Assessor

The Assessor had 10 years of clinical practice in musculoskeletal physiotherapy. Using the standard universal goniometer, the Assessor was blinded to the side of LE during measurements of shoulder rotatory motions.

Study Protocol

Participants lay supine on mechanical contraption (Fig. 1). The primary investigator tested the external rotation followed by internal rotation of the right upper extremity, then subsequently the left upper extremity of healthy participants both actively first followed by passive movement.

Outcome Measures

Measurements on shoulder active and passive external and internal rotatory motions were used to determine differences in shoulder rotatory motions between LE and non-LE elbows of participants with unilateral LE. Shoulder rotatory motions were compared between shoulders of case and control participants.

The following section described in detail the components of Phases 1 and 2.

Steps used in measuring shoulder rotatory movements. A series of three trial measurements were performed by the primary investigator. The second and third trials were performed after the 20 non-symptomatic upper extremities had been measured, to minimize recall bias of the primary investigator. The junior investigator noted the readings of the primary investigator.

Statistical analysis used. MedCalc Version 15.2.2 software (MedCalc Software, Ostend, Belgium) was used for data analysis. The intra-class correlation coefficient (ICC) of the same raters and absolute agreement was used to determine the intra-tester reliability of the primary investigator in measuring the shoulder rotatory motions of healthy participants. Absolute agreement considered systematic differences involved in the process of quantifying shoulder rotatory movement of included participants. The ICC was interpreted as follows:

- 0-0.2: poor agreement
- 0.3-0.4: fair agreement
- 0.5-0.6: moderate agreement
- 0.7-0.8: strong agreement
- >0.8: almost perfect agreement

The Standard Error of Measurement (SE_M) was used to estimate the error of the primary investigator in reading the shoulder rotatory movement measurements using the formula:

SE_M = SD* [square root of (1-ICC)]

Key: SD, Standard deviation; ICC, Intraclass Correlation Coefficient

An a-priori level of significance was set at α=0.05 to indicate a significant difference between groups. Associations between shoulder rotatory motions, side of LE, hand dominance, gender, activities, and visual analog scores were tested.

The paired-samples t-test was used to compare:

- mean of the shoulder rotatory motions between LE and non-LE elbows of participants based on side of LE and hand dominance; and
- mean of shoulder rotatory movements between non-symptomatic elbows of healthy participants.

All predictor variables (i.e. age, gender, activities, hand dominance, presence of LE) found significantly associated to shoulder rotatory movements were analyzed using multiple regression. Multiple regression was the method used to examine the relationship between shoulder rotatory movements as the dependent variable and their significantly associated predictors as independent variables. The backward method was used to minimize suppressor effects which occur when a predictor had a significant effect only when another variable was constant. Backward method minimized the risk of making a Type II error (i.e. missing a predictor that does, in fact, predict the outcome). A predictor variable with a p-value of less than 0.05 was entered into the model. A predictor variable with *p*-value more than 0.10 was removed from the model. The coefficient of determination R^2 was used to explain the proportion of the variation in the dependent variable by the regression model. In the regression equation, the beta coefficient (standard error) quantified the change in shoulder range of movement for every point change in the predictor variable. The *p*-value was the probability that one had found the current result if the coefficient were equal to 0 (null hypothesis). Additionally, a two-way analysis of variance was used to determine interaction effects between significantly associated predictor variables.

Results

Reliability and Standard Error of Measurement

The primary investigator demonstrated almost perfect agreement in both active and passive shoulder external (0.98) and internal (0.99) rotatory motion measurements. Supplement B shows the intra-tester reliability of primary investigator in measuring shoulder rotatory movements of both shoulder of 10 healthy participants.

The primary investigator had less SE_M for passive shoulder internal rotation (SE_M=0.40 degree) and active shoulder internal rotation (SE_M=0.70 degree). The SE_M for shoulder passive and active external rotation was 1.41 and 1.69 degrees, respectively.

Baseline Demographics

Thirty-six (36) participants with lateral elbow pain were initially screened. Of the 36 participants, nine (9) participants were excluded secondary to the following:

- Negative to all provocation tests: 6
- Past history of elbow fracture: 1
- Signfiicant shoulder pain: 2

Twenty-seven eligible participants with unilateral LE (male: female=3:24) had mean (95% CI) age of 54 (49-58) years. The mean (95% CI) visual analog scale pain score of the participants was 6.53 (5.91-7.13) with a mean (95%CI) pain duration of 96 (50-142) weeks. 24 participants were right hand dominant and 3 participants were left hand dominant. Meanwhile, 13 participants had LE elbows on the dominant hand side. Laundry work (67%) was the most common activity engaged by participants with unilateral LE followed by typing (22%), vending (7%) and sewing (4%).

Twenty-seven healthy participants without LE (male: female=3:24) had a mean (95% CI) age of 53 (49-57). Considering that the controls were matched with the cases, no significant differences on gender, hand dominance and activities were found between unilateral LE participants and healthy participants.

Shoulder Rotatory Range of Motion

Side of Lateral Epicondylalgia (LE). Based on side of LE, no significant differences in active and passive shoulder rotatory motions were found between shoulders of LE elbows and non-LE elbows (*p*>0.05). Table 1 reports the mean (SD) of active and passive shoulder external and internal rotation based on the presence or absence of LE.

Table 1. Shoulder range of movement based on the presence or absence of LE (*n*=27)

Shoulder movement	LE Mean (*SD*) in degrees	Non-LE Mean (*SD*) in degrees	Difference Mean (*SD*) in degrees	*p*-value
Active ER	79 (12)	78 (8)	-1.21	0.50
Active IR	60 (7)	58 (8)	-1.65	0.33
Passive ER	86 (10)	86 (8)	-0.77	0.56
Passive IR	66 (4)	66 (6)	-0.20	0.89

Key: ER, external rotation; IR, internal rotation; LE, lateral epicondylalgia; SD, standard deviation

Hand Dominance of the Case and Control Participants. Based on hand dominance, only right active and passive shoulder rotatory motions were included in the analysis considering the sufficient number of participants who were right hand dominant (*n*=24). Active and passive shoulder internal rotation were significantly smaller on the side of dominant elbow compared to non-dominant elbow ($p<0.05$). Table 2 reports the mean (SD) of active and passive shoulder external and internal rotation based on hand dominance.

Based on findings on right hand dominant participants (*n*=24), no significant differences in active and passive shoulder rotatory motions between dominant and non-dominant hands were noted ($p>0.05$). Table 2 reports the mean (SD) of active and passive shoulder external and internal rotation in right hand dominant participants.

Table 2. Shoulder range of movement in right hand dominant participants (*n*=24)

CASE PARTICPANTS				
Shoulder movement	**Dominant Mean (SD) in degrees**	**Non-dominant Mean (SD) in degrees**	**Difference Mean (SD) in degrees**	***p*-value**
Active ER	78 (11)	79 (10)	1.61	0.41
Active IR	56 (7)	61 (7)	4.78	0.003*
Passive ER	86 (10)	87 (9)	0.33	0.82
Passive IR	65 (6)	68 (5)	3.17	0.03*
CONTROL PARTICIPANTS				
Shoulder movement	**Dominant Mean (SD) in degrees**	**Non-dominant Mean (SD) in degrees**	**Difference Mean (SD) in degrees**	***p*-value**
Active ER	81 (5)	82 (6)	1.11	0.15
Active IR	62 (5)	63 (5)	1.25	0.09
Passive ER	87 (3)	87 (3)	-0.03	0.96
Passive IR	68 (3)	68 (3)	0.58	0.39

*significant finding

Hand dominance and presence of LE. Of the 24 right hand dominant participants, 12 participants had LE on the right-hand dominant side. Active and passive shoulder internal rotation were significantly smaller in the right hand dominant side with LE compared to the left hand non-dominant side with non-LE elbow ($p<0.05$). Table 3 reports the mean (SD) of active and passive shoulder external and internal rotation based on hand dominance and presence of LE.

Table 3. Shoulder range of movement in right hand dominant with LE elbows (*n*=12)

Shoulder movement	Dominant Mean (SD) in degrees	Non-dominant Mean (SD) in degrees	Difference Mean (SD) in degrees	*p*-value
Active ER	79 (14)	80 (10)	1.06	0.70
Active IR	59 (6)	63 (6)	4.17	**0.04***
Passive ER	88 (13)	87 (11)	0.17	0.93
Passive IR	66 (5)	69 (5)	3.56	**0.04***

*significant finding
Key: ER, external rotation; IR, internal rotation; LE, lateral epicondylalgia; SD, standard deviation

No significant associations were found between shoulder rotatory motions, gender activities and visual analogue scale scores ($p>0.05$).

Case and Control Participants: Multiple regression. Considering that shoulder active and passive internal rotation range of movements were significantly lesser compared to shoulder external rotation based on hand dominance and presence of LE in shoulder of case participants, the following classifications were entered in the multiple regression analysis using both shoulder range of movements from case (*n*=54 shoulders) and control (*n*=48 shoulders) participants:

- Dependent variables: Shoulder passive and active internal rotation range of movement
- Predictor variables: Hand dominance and presence of LE

Both predictor variables explained variations in shoulder active internal rotation (R^2=16%) and passive internal rotation (R^2=11%) of case and control participants. Table 4 shows the results of the regression equation.

Table 4. Regression equation for shoulder internal rotation (n=102)

Dependent variable	Independent variables	Beta coefficient (SE)	*p*-value
Active IR	Hand dominance	-2.95 (1.23)	0.01*
	LE	2.55 (0.74)	0.02*
Passive IR	Hand dominance	-2.13 (0.83)	0.01*
	LE	1.14 (0.50)	0.02*

*significant finding
Key: IR, internal rotation; LE, lateral epicondylalgia; N, number of shoulders; SE, standard error

Significant interaction effects between hand dominance and status of elbows (LE, non-LE, non-symptomatic) on shoulder active (p=0.001) and passive (p=0.003) internal rotation were found. Supplement C reports on the interaction effects between hand dominance and status of elbows.

Discussion

This study investigated the association between shoulder rotatory motions, LE status, hand dominance, gender, activities, and visual analog scale score of participants with unilateral LE. We found that: a. Shoulder internal rotation was significantly smaller at dominant hand side compared to the non-dominant hand side ($p<0.05$); b. Shoulder internal rotation was significantly smaller in right dominant hand with LE compared to left non-dominant hand with non-LE elbow ($p<0.05$); c. Status of elbow and hand dominance accounted for variations in shoulder active internal rotation (R^2=16%) and passive internal rotation (R^2=11%); and d. No associations between shoulder rotatory motions, gender, activities and visual analog scale were found ($p>0.05$). In healthy participants and regardless of hand dominance, no significant differences in active and passive shoulder range of motions were found ($p>0.05$).

The contrasting association of hand dominance and shoulder rotatory motions between participants with LE and healthy participants were underpinned by the interaction effects between hand dominance and LE (*p*<0.05). We hypothesized that the restriction on the use of the dominant painful extremity could have altered the flexibility of the upper extremity muscles. This alteration on the flexibility of upper extremity muscles in the dominant painful side may likely explain the decreased active shoulder internal rotation (by 2.95 degrees) and passive shoulder internal rotation (by 2.13 degrees).

Hand dominance and status of elbow significantly affects shoulder internal rotation (p<0.01). The decrease in shoulder ranges of motion may be secondary to tightness in the upper extremity muscles, suggested to be associated with LE[16]. In LE, decreased tightness suggests a lower capacity of the elbow to oppose rapidly changing forces of handgrip activities[16]. Although, we recommend having a bigger and more diverse population to have a better representation of the effect of hand dominance and LE on shoulder internal rotation. Considering that the SEM of the primary investigator is less in shoulder internal rotation (SEM=0.4-0.7), the measurements taken for shoulder internal rotation truly reflected the changes brought by hand dominance and LE in the shoulder.

The interplay between the elbow and shoulder may be explained by the musculofascial system in the lateral elbow area. In the current literature, authors had reported the connection of the forearm extensor muscles with the upper arm muscles[9;12;13;17;18]. The lateral intermuscular septum connects the forearm extensor muscles with the middle deltoid, on its posterior aspect[17]. We assume that a shortened lateral intermuscular septum promotes shoulder external rotation. This was reflected in our study by the decreased shoulder internal rotation on the dominant hand side and status of the elbow (*p*<0.05). Considering that the lateral intermuscular septum is a deep fascia that transmits tensile forces[18], it may potentially transmit stress forces from the elbow (lateral epicondyle) to the shoulder (deltoid).

The participants with LE in this study truly represented those individuals diagnosed with LE. The painful elbows were tested positive to either one of the Cozen, Mill or Maudsley test. The participants were engaged in repetitive and forceful activities that were commonly suggested to be the cause of LE. The mean (95% CI) age of 54 (50-59) years of participants with LE reflected the common age range for individuals with LE as reported in the literature.

Only one left elbow with LE was reported in this study. This reflected the scarcity of left elbows with LE as reported in the current literature[14]. The strength of the reported association of LE and dominant hand side should only be claimed for the right had dominant side participants.

Implications to Practice

We are aware that the influence of hand dominance and LE on shoulder internal rotation constituted only 11-16% of the variation found in shoulder range of movement in this study. However small, we recommend the inclusion of shoulder active and passive internal rotation in the evaluation of upper extremities of participants with LE. This evaluation underpins the importance of the deep fascia specifically the lateral intermuscular septum in transmitting stresses from elbow to shoulder. The treatment directed towards the lateral intermuscular septum may mitigate the lateral elbow pain and restriction in shoulder movement of participants with LE. This, however, should be investigated both in clinics and research.

Implications to Research

A prospective randomized controlled study investigating the effects of physiotherapy treatment directed to LE elbows, on shoulder range of movement is recommended. This will strengthen the association between LE, hand dominance and shoulder internal rotation reported in this study.

Acknowledgments

The authors would like to thank the following people, Lou Erika Rubion, Geronimo Orlino Kamus III, Angelito Esteban, Jr. Alyanna Miko Mercado, Rani Gayle Rivera, Aimee Cara Vergara, Rufino Francisco III, Lea Mai De Ocampo, and Patrick John De Jesus.

Contribution, Disclosure, and Conflict of Interest Statement

The two authors contributed equally to conceptualization, implementation, data collection and analysis and writing of the research manuscript. They have no conflict of interest.

Supplementary Files

Supplement A. Initial Screening Checklist.

Supplement B. Intra-tester reliability of primary investigator in measuring shoulder rotatory movements of both shoulder of 10 healthy participants.

Supplement C. Interaction effects between hand dominance and status of elbows

References

1. Herd, C. & Meserve, B., (2007). A Systematic Review of the Effectiveness of Manipulative Therapy in Treating Lateral Epicondylalgia. The Journal of Manual & Manipulative Therapy. 16, 225-237.
2. American Academy of Orthopedic Surgeon. (2009). Tennis Elbow (Lateral Epicondylitis). Retrieved September 2014, from http://orthoinfo.aaos.org/topic.cfm?topic=a00068
3. Chard, M.D. & Hazlema, B.L. (1989). Tennis elbow--a reappraisal. Br J Rhematol, 28, 187-90.
4. Nordander C, Ohlsson K, Akesson I, Arvidsson I, Balogh I, Hansson G A, et al (2009). Risk of musculoskeletal disorders among females and males in repetitive/constrained work. Ergonomics. 52(10): 1226-39.
5. Saroja, G., Aseer, A.L. & Venkata, S. (2014). Diagnostic Accuracy of Provocative Tests in Lateral Epicondylitis. Int J Physiother Res, 2(6), 815-823.
6. Dones, V.CIII., Grimmer-Somers, K., Milanese, S. & Kumar, S., (2014). The Sensitivity of the Provocation Tests in Replicating Pain on the Lateral Elbow Area of Participants with Lateral Epicondylalgia. http://arrow.unisa.edu.au:8081/1959.8/161722
7. Albrecht, S., Cordis, R., Kleihues, H., Noack, W. (1997). Pathoanatomic findings in radiohumeral epicondylopathy. A combined anatomic and electromyographic study. Arch Orthop Trauma Surg, 116, 157–163
8. Bunata RE, Brown DS, Capelo R (2007). Anatomic factors related to the cause of tennis elbow. J Bone Joint Surg Am. Available from: http://dx.doi.org/10.2106/JBJS.F.00727.
9. Van Der Wal, J. (2009). The architecture of the connective tissue in the musculoskeletal system: an often overlooked functional parameter as to proprioception in the locomotor apparatus. Int J Ther Massage Bodywork, 2, 9-23.
10. Wilhelm, A. (1996). Tennis elbow: treatment of resistant cases by denervation. British Journal of Hand Surgery, 21, 523-533.
11. Fairbank, S.M. & Corlett, R.J. (2002). The role of the extensor digitorum communis muscle in lateral epicondylitis. American Journal of Hand Surgery, 27, 405–409
12. Paoletti, S. (2006). The Fasciae - Anatomy, Dysfunction, & Treatment, 1st edition. United Kingdom: Eastland Press
13. Stecco, L. & Stecco, C. (2009). 1st edition. Mf sequence of lateromotion. Fascial manipulation: Practical Part. Padua, Italy: Piccin, 119-45
14. Abbott, J.H. (2001). Mobilization with movement applied to the elbow affects shoulder range of movement in subjects with lateral epicondylalgia. Man Ther, 6(3), 170-7
15. Kolber, M. & Hanney, W. (2012). The reliability and concurrent validity of shoulder mobility measurements using a digital inclinometer and goniometer: a technical report. International Journal of Sports Physical Therapy 7(3), 306-313
16. Chourasia, A., Buhr, K., Rabago, D., Kijowski, R. & Sesto, M. (2012) The Effect of Lateral Epicondylosis on Upper Limb Mechanical Parameters. Clin Biomech, 2, 124-130.
17. Dones, V.CIII., Milanese, S., Worth, D. & Grimmer-Somers, K. (2013). The anatomy of the forearm extensor muscles and the fascia in the lateral aspect of the elbow joint complex. Anatom Physiol, 3, 117
18. Myers, T. (2009). Anatomy Trains, 2nd edition. Churchill Livingstone Elsevier.