PJAHS
Philippine Journal of Allied Health Sciences

Study Protocol

The Short-Term Effects of Biomechanical Taping on Upper Extremity Muscles in Unilateral Lateral Epicondylalgia: A Pre-and Post-Experimental Study Protocol

Valentin Dones III[1], Christian Rimando[1], Andrea Janelle Co[1], Clarence Almazan[1], Marie Capistrano[1], Kimberly-Anne Enriquez[1], Jorell Inarda[1], Maria Quebral[1], John Aldee Rigor[1], Angelica Supangan[1]

[1]Department of Physical Therapy, College of Rehabilitation Sciences, University of Santo Tomas, Manila, Metro Manila, Philippines

Correspondence should be addressed to: Valentin Dones III[1]; vcdones@ust.edu.ph

Article Received: June 9, 2021

Article Accepted: October 5, 2021

Article Published: February 15, 2022

Abstract

Background: Lateral epicondylalgia (LE) causes ineffective handgrip due to microtrauma on the elbow's common extensor origin. Objectives: This study will determine the differences in the Extensor Digitorum Communis' (EDC) fascia slide, percentage maximum voluntary contraction (%MVC), static maximum handgrip strength (SMHGT), muscle activation onset time (MAOT) in LE and non-LE elbows, with and without Biomechanical Tape (BMT). The study will determine differences in Visual Analogue Scales (VAS) and Patient Rated Tennis Elbow Evaluation (PRTEE) scores of patients with and without BMT. **Methods**: Nineteen participants' elbows with unilateral LE with and without BMT will be evaluated using musculoskeletal ultrasound (MSK) and electromyography (EMG) on Days 1, 3, and 5. A Physiotherapist-Sonographer, a Physiotherapist-EMG user, and a Research Assistant using Jamar hydraulic dynamometer will evaluate the participants. The participants will perform Mill's test during MSK and SMHGT using the dynamometer during EMG. A Chi-squared test will evaluate the relationship between BMT and fascia slide. Two-way repeated-measures ANOVA will compare the fascia slide, %MVC, SMHGT, and MAOT between elbows with and without BMT. It will be blocked according to elbow status (i.e., LE, no LE). Dunnett post hoc test will determine the groups whose results differed significantly. Differences in PRTEE scores at Days 1 and 5 will be determined. A p-value <0.05 indicates a significant difference in scores. **Expected Results**: We expect decreased fascial slide measurements on EDC, VAS, PRTEE scores, and increased %MVC, MAOT, and SMHGT on taped elbows. Results will determine the underpinning mechanism behind the short-term effects of BMT.

Key Words: *Biomechanical Taping, Lateral Epicondylalgia, Ultrasound, Electromyography*

INTRODUCTION

Lateral Epicondylalgia (LE) is a condition caused by a progressive injury in the elbow manifesting as lateral elbow pain.[1] It occurs during gripping, requiring co-activation of forearm muscles.[2] It affects individuals between the ages of 30 and 55. LE prevalence is 1.3% in work-related physical load factors such as high handgrip forces and repetitive wrist and hand activities.[3,4] The mean number of lost workdays per year for LE is 2.3-3.9.[5]

LE may present with an impaired fascia slide reducing elbow mobility.[6] The nature of the fascia slide on the Extensor Digitorum Communis (EDC) during the Mill test is not described in the literature. Fascia slide demonstrates horizontal and vertical displacements during a joint movement.[7] The EDC and the ECRB have a common origin and are both surrounded by a tight deep fascia where the proximal bellies of the EDC are tightly attached, and this plays a role in the normal functioning of forceful hand gripping activities because repetitive and forceful handgrip activities require a level of tightness in the elbow. When the relationship between the deep fascia and the proximal bellies of the EDC is disrupted, this will cause a

decreased stiffness on the elbow. As a result, there will be an increased slide of the EDC in individuals with LE (p=0.06).[8] Decreased elbow stiffness is assumed to reduce the EDC resistance to wrist flexion during the Mill test. It also indicates the inability of the elbow to resist rapidly changing forces associated with handgrip activities.[8,9]

Repetitive forearm extensor activity may strain the regular dense connective tissue (RDCT) associated with lateral elbow pain.[10] The forearm extensor muscles are attached to the lateral epicondyle through this RDCT.[10] During a static maximum handgrip test (SMHGT), the RDCT pulls on the lateral epicondyle transferring tensile forces.[10] The authors assumed that the repetitive contraction of the forearm extensor muscles strains the RDCT and the lateral epicondyle. Electromyography (EMG), which measures upper extremity muscle activity, is still not tested during SMHGT of participants with unilateral LE.

Through EMG, muscle imbalance between agonist and antagonist muscles (flexors vs. extensors) in the shoulder, arm, and forearm were investigated in the literature as a possible cause for LE.[11,12] Percentage maximal voluntary contraction (%MVC) and muscle activation onset time (MAOT) were reported for forearm and arm muscles during tennis play. [11] Due to the involvement of shoulder, arm, and forearm muscles, upper extremity weakness exists in patients with LE.[11]

Biomechanical Taping (BMT), an inelastic tape put over the painful elbow aiming to elevate and tighten the fascia and skin, helped 23 participants with unilateral LE.[13] BMT application resulted in a significant reduction of lateral elbow pain (p<0.05) and an improvement of handgrip strength ($p \leq 0.01$).[13] BMT is assumed to minimize fascial mobility, allow more slides for the EDC muscle, and reduce elbow stiffness via fascia lift.[13] The effects of BMT on fascia slide on EDC and EMG activities in the shoulder, arm, and forearm muscles will determine the underlying physiologic mechanism of BMT in pain reduction and functional improvement.

We assume a lesser fascia slide and greater %MVC and SMHGT in the taped elbow than non-taped elbows. This study aims to determine the short-term effects of BMT, in particular the differences in the measured fascia slide on EDC, VAS and PRTEE scores, %MVC, MAOT of EDC, FDS, ECR, FCR, and MD during SMHGT in these conditions: Non-LE elbows without BMT versus LE elbows without BMT; Non-LE elbows with BMT versus LE elbows with BMT.

METHODS

Ethics Approval. This Ethics Review Committee of the College of Rehabilitation Sciences of the University of Santo Tomas (UST-CRS) approved this study.

Study Design. This study is experimental in nature that will use a time series and pretest-posttest design. The participants will be assessed and treated on Days 1, 3, and 5.

Sample Size Calculation. Using G*Power 3.1.9.2, 19 participants with unilateral LE are needed to determine the PT-Sonographer and PT-EMG user's reliability in determining the characteristics of the fascia overlying the EDC and quantifying the cross-sectional area of EDC (Phase 1). The basis of the computation includes (a) correlation of 0.60, (b) alpha-value of 0.05, (c) power of 0.80. The sample size for the Phase 2 study will be estimated using the EDC slide measurements from Phase 1. No studies are reporting the effects of BMT on EDC fascia slides during Mill's test.

Participants. Table 1 shows the eligibility criteria that will be used to screen the participants.

Recruitment. Participants with unilateral LE will be recruited using the purposive sample strategy from these places in Metro Manila, Philippines:

a. Barangay 421 of Pureza, Manila

b. Barangays 509, 499, 489, and 507 of Sampaloc, Manila

c. Mandaluyong City

d. Barangay 645 of San Miguel, Manila

e. Food outlets surrounding UST and in the University belt

Table 1. Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
a. Age 30-55 years b. Elbow pain confined on the dorsal proximal third of the forearm between the elbow crease and 5cm distal to it c. Positive to at least one of the provocation tests: Cozen, or Mill, or Maudsley Test	a. Malignancy, b. Pregnant women, c. Bilateral elbow pain, d. Systemic diseases known to cause general body malaise, e. Fracture of the involved extremity and neck, f. Elbow osteoarthritis, g. Recent blunt force trauma, h. Motor vehicular accident, i. Surgery and treatment in the last six months.

The researchers will recruit participants by disseminating information on social media, sending leaflets and brochures. An experienced and licensed physiotherapist will conduct a screening process of the potential participants using an initial screening checklist. The researchers, then, will orient eligible participants on the aims and mechanics of the study. Participants who agree will sign informed consent papers. A licensed physiotherapist will evaluate those who meet the criteria using an evaluation form for LE.

Assessors. The three MSK assessors are the PT-Sonographer and two physiotherapists to read the MSK video images using the WMP and Tracker. The Case Report Form 1a will account for the findings of the MSK assessors. The PT-Sonographer has 19 years of physiotherapy practice with three years of diagnostic ultrasound experience. He has trained in MSK, general, and vascular imaging techniques. The two physiotherapists have over seven years of manual physiotherapy experience in treating musculoskeletal pain. One of the two physiotherapists has training on MSK use.

A PT-EMG user with three years of EMG experience will determine the %MVC and MAOT of upper extremity muscles.

The Research Assistant, a registered physiotherapist with over three years of manual physiotherapy experience, will use the Jamar hydraulic dynamometer in quantifying the participant's SMHGT.

Intervention. Biomechanical Tape will be applied on elbows with and without LE following the standard BMT application technique. The researcher will place a base BMT strip without tension over the elbow. With the participant's wrist held in extension, the researchers will place two strips of BMT to the participant's elbow. The researcher will anchor the first strip of BMT on the lateral aspect of the base of the BMT fascia tape, creating a skin-fascia lift on the proximal aspect of the elbow.[13] The researcher will anchor the second strip of BMT on the medial aspect of the base BMT fascia tape. A similar BMT approach will be used on the proximal forearm with the participant's wrist in a neutral then flexed position. While the wrist is fully flexed, the researcher will apply a cover-up BMT strip over the proximal forearm.

The participant's elbows will then undergo evaluation using MSK and EMG. The directions and degree of fascial excursion of EDC with and without BMT will be determined through MSK. EMG will measure the activity of the forearm extensor muscles and detect any possible muscle imbalance between the agonist and antagonists. The muscles that would be measured for EMG activity are the extensor carpi radialis (ECR), flexor carpi radialis (FCR), EDC, flexor digitorum superficialis (FDS) on the forearm, and middle deltoid (MD) on the arm.

Instruments

Equipment. The 5–13 MHz linear broadband transducer of the HS1 Konica Minolta MSK will capture the EDC fascia sliding in the presence and absence of BMT in elbows with and without the LE.

The Delsys 16 channel wireless sEMG system with EMGWorks® Software is a surface EMG machine that will measure the %MVC and MAOT of ECR, EDC, FDS, FCR, and MD during SMHGT.

Biomechanical Tape, an inelastic tape, is used on the elbows of participants. BMTs are hypoallergenic, skin-like tapes with high adhesive strength 5 cm high and 10 yards long.

The mechanical test jig is a wrist jointed contraption that will position and hold the tested elbow in extension, forearm pronation, and wrist neutral using Velcro straps.

Software. Windows Media Player (WMP) is a video player and an image viewing application by Microsoft for personal computers with a Microsoft Windows operating system.[16]

Tracker 5.0 © 2018 is a free video analysis and modeling tool developed by Douglas Brown and Wolfgang Christian on the Open Source Physics Java Framework.[16] The Tracker shows the fascia slide direction and quantifies the fascia slide of the right upper trapezius in millimeters (mm). It uses normalized cross-correlation to follow frame-to-frame in the video, a rectangular area known as a template.[16]

Outcome Measures. The VAS is a 10cm long horizontal line. The extremes of this define the minimum and maximum intensity of perceived pain. A score of zero is described as 'no pain' while ten is described as 'worst possible pain.' The VAS is sensitive to measuring the perceived pain and is also reliable (measurements between groups).[17,18,19]

The participant's SMHGT strength is determined using the handheld Jamar hydraulic dynamometer, which is highly recommended in measuring grip strength.[20] ICC values of 0.85-0.98 for an expert's intra-tester and inter-tester reliability using the handheld dynamometer are clinically acceptable.[21]

The PRTEE is 15 questions that quantify the average level of pain and function in patients with LE (maximum score: 100, minimum score: 0). PRTEE presents high reliability (r= 0.89) and sensitivity (sensitivity=0.96) in evaluating LE patients.[22,23]

The Motion Tracking Analysis Program is software that measures body structures' linear displacement in pixels. This program provides coordinate values per frame while tracking after identifying the structure's location. Also, the program tracks an area that is rectangular and, using cross-correlation, uses the subsequent frames as a reference point. The intra-tester and inter-tester reliability were moderate to good, with an ICC score of 0.67-1.00 in analyzing MSK videos.[8]

Procedures. The researchers will evaluate both elbows with unilateral LE with and without BMT, using MSK and EMG on Days 1, 3, and 5. This study will determine the effects of BMT on participants with unilateral LE on test days. The researcher- in-charge will prepare the test site and collect the data using the MSK, EMG, and Jamar hydraulic dynamometer. The Research Assistant will record participants' responses using the Case Report Forms. The three MSK assessors will use a Case Report Form in determining the direction and quantifying the fascia slide on EDC using platforms WMP and Tracker. The PT-EMG user will record the results of their EMG analysis both on the Case Report Form.

Day 1. This is the MSK procedure. Initially, the participant will answer the PRTEE and VAS. Afterward, the PT-Sonographer will scan the right elbow while the participant does Mill's test. The Research Assistant will ask for the participant's VAS during Mill's test. The procedure is repeated with the right elbow taped. Then the PT-Sonographer will scan the left elbow using the same MSK procedure.

This is the EMG procedure. The PT-Sonographer will use the MSK to determine the participant's forearm muscles' largest cross-sectional area, which will guide the placement of EMG markers on the EDC, ECR, FDS, FCR, and MD. The PT-EMG user will perform crosstalk minimization with non-tested muscles. The participant will perform the right SMHGT, rate the pain, and rest. This evaluation is performed first without BMT and subsequently with BMT. The same EMG procedure is done on the left side.

After the MSK and EMG procedures, the participants will perform the gentle passive stretch on these muscles: (a) MD; (b) triceps; (c) biceps; (d) forearm wrist flexors; (e) forearm wrist extensors, in both elbows for five times,

each held 30 seconds. A pamphlet containing instructions and illustrations of the flexibility exercises alleviating lateral elbow pain will be given to each participant.

Days 2 and 4. The participants will tape their LE elbows for three hours using BMT.

Day 3. The MSK and EMG procedures from Day 1 are repeated on Day 3, except for PRTEE.

Day 5. This is the MSK procedure. Initially, the participants will answer the VAS. The PT-Sonographer will scan the right and left elbows without BMT at first, then with BMT. The participant reports their VAS during Mill's test.

This is the EMG procedure. The PT-Sonographer will determine the upper extremities' larges cross-sectional area for crosstalk minimization. The participant will report the VAS before and during the SMHGT. The participant will grip the Jamar hydraulic dynamometer without BMT then with BMT. The participant will answer the VAS during SMHGT. The same EMG procedure is repeated on the left upper extremity.

After the MSK and EMG procedures, the Research Assistant will perform the gentle passive stretch on the participant's wrist flexors and wrist extensors in both elbows five times, each held for 30 seconds.

Data analysis

Phase 1. The ICC will determine the reliability of the PT-Sonographer and EMG operator in analyzing the fascia slide on EDC and electromyographic activities of the bilateral upper extremities. The guidelines by Landis will be used to interpret the ICC of the examiner.[24]

The researchers will consider a minimum score of >=0.40 Kappa and ICC to establish the intra-rater reliability of the examiner.[25]

Phase 2. The Chi-squared test will test the relationship between BMT and the direction of the fascia slide on each test day. A *p*-value of <0.05 indicates a significant relationship between BMT and the direction of the fascia slide.

The two-way repeated-measures ANOVA will determine differences in fascia slide, %MVC and MAOT between elbows with and without LE based on BMT application and blocked according to elbow status. Dunnett's test will determine the groups whose results differed significantly. A *p*-value of <0.05 indicates a significant difference.

Repeated-measures ANOVA will determine differences in SMHGT between LE (taped) and non-LE elbows (not taped) between three test days. Dunnett's test will determine the groups whose results differed significantly. A *p*-value= <0.05 indicates a significant difference in scores between groups.

Repeated-measures ANOVA will compare the VAS and PRTEE scores between elbows with and without LE in three test days. Dunnett's test will then determine the groups whose results differed significantly.

The study will use STATA for statistical treatments, a statistical software that allows data management and presentation developed by StataCorp.

EXPECTED RESULTS

We expect decreased fascial slide on EDC, VAS, and PRTEE scores, increased %MVC and MAOT, and SMHGT in participants with taped LE elbows. The study will benefit patients and physical therapists in the academic and clinical settings as it provides evidence on the short-term effects of BMT on pain reduction and functional improvement in patients with LE. This study can lead to further investigations on BMT use in managing pain in other musculoskeletal conditions.

Individual author's contributions

VD; Conceptualized the study's overarching idea, wrote the research proposal, supervised the performance of the entire research study, supervised the co-authors in the write-up and revisions, contributed the conception and design of the study, participated in the drafting, revising and finalization processes of the paper to be published; CR; Conceptualized the EMG part of the study, supervised the implementation of the entire research study, supervised the co-authors in the write-up and revisions, participated in the finalization of the paper to be published; AC; Served as the liaison between the author and the

co-authors, assigned and distributed equal assignments and work distribution to the co-authors, reviewed resources for the related literature of the study for instrumentation and analytic purposes, created and planned the study's methodological framework, and coordinated and administered the indentures such as informed consent forms and needed paperwork for the project, contributed the conception and design of the study, made contributions in drafting and revising the study, participated in the finalization of the paper to be published; CA, MC, KE, JI, MQ, JR, AS; reviewed resources for the study's related literature for instrumentation and analytic purposes, managed and administered indentures such as informed consent forms and needed proposal documents, developed, designed the study's methodological framework, initiated the conceptualization of visualization, and data presentation through illustrations and tables, contributed the conception and design of the study, made contributions in drafting and revising the study, participated in the finalization of the paper to be published.

Disclosure statement

This study did not receive funding from any public or private institution inside or outside the University of Santo Tomas.

Conflicts of interest

The authors of this study declare that the principal author is a member of the editorial board of the Philippine Journal of Allied Health Sciences. VCD is the creator of Biomechanical Tape. His company PainFree Management and Consulting, Inc. markets the product to help management the pain of individuals with musculoskeletal conditions.

Glossary of Abbreviations

The following spell out the meanings of the significant standard and nonstandard acronyms and initials found in the study:

BMT: Biomechanical Taping

ECR: Extensor Carpi Radialis

EDC: Extensor Digitorum Communis

EMG: Electromyography

FCR: Flexor Carpi Radialis

FDS: Flexor Digitorum Superficialis

LE: Lateral Epicondylalgia

MAOT: Muscle Activation Onset Time

MD: Middle Deltoid

MSK: Musculoskeletal Ultrasound

PRTEE: Patient Rated Tennis Elbow Evaluation

SMHGT: Static Maximum Handgrip Strength

VAS: Visual Analogue Scale

WMP: Windows Media Player

%MVC: Percentage Maximum Voluntary Contraction

Supplementary Material

Supplementary Material A. Assessment Tool.

References

1. Walz DM, Newman JS, Konin GP, Ross G. Epicondylitis: pathogenesis, imaging, and treatment. Radiographics. 2010 Jan;30(1):167–84. DOI: 10.1148/rg.301095078
2. Shiri R, Viikari-Juntura E. Lateral and medial epicondylitis: role of occupational factors. Best Practice and Research Clinical Rheumatology. 2011 Feb;25(1):43–57. DOI: 10.1016/j.berh.2011.01.013
3. Shiri R, Viikari-Juntura E, Varonen H, Heliövaara M. Prevalence and determinants of lateral and medial epicondylitis: a population study. American Journal of Epidemiology. 2006 Dec 1;164(11):1065–74. DOI: 10.1093/aje/kwj325
4. Walker-Bone K, Palmer KT, Reading I, Coggon D, Cooper C. Prevalence and impact of musculoskeletal disorders of the upper limb in the general population. Arthritis Care & Research. 2004 Aug 15;51(4):642–51. DOI: 10.1002/art.20535
5. Darmawan J, Valkenburg HA, Muirden KD, Wigley RD. The prevalence of soft-tissue rheumatism. Rheumatology International. 1995 Sep 1;15(3):121–4. DOI: 10.1007/BF00302129
6. Bianchi S, Martinoli C. Ultrasound of the Musculoskeletal System. Springer Science & Business Media. 2007 Dec 3.
7. Guimberteau JC, Sentucq-Rigall J, Panconi B, Boileau R, Mouton P, Bakhach J. Introduction à la connaissance du

glissement des structures sous-cutanées humaines. Annales de Chirurgie Plastique Esthétique. 2005 Feb 1;50(1):19–34. DOI: 10.1016/j.anplas.2004.10.012

8. Dones VC III, Suarez CG, Rimando CD, Yap M, Seril, Lopez JF, Dizon LB, Carbajal JO, Francisco CD, Macaranas JD, Paris JH. The Use of Motion Tracking Analysis Program in Detecting Linear Muscular Displacement of the Extensor Digitorum Communis in Patients with Lateral Epicondylalgia: A Cross-Sectional Study. Austin Journal of Musculoskeletal Disorders. 2015 June 23; 2(2):1021.

9. Chourasia AO, Buhr KA, Rabago DP, Kijowski R, Sesto ME. The Effect of Lateral Epicondylosis on Upper Limb Mechanical Parameters. Clinical Biomechanics (Bristol, Avon). 2012 Feb;27(2):124–30. DOI: 10.1016/j.clinbiomech.2011.08.014

10. Van der Wal J. The architecture of the connective tissue in the musculoskeletal system- an often overlooked functional parameter as to proprioception in the locomotor apparatus. International Journal of Therapeutic Massage & Bodywork. 2009 Dec 7;2(4):9–23. DOI: 10.3822/ijtmb.v2i4.62

11. Alizadehkhaiyat O, Frostick SP. Electromyographic assessment of forearm muscle function in tennis players with and without Lateral Epicondylitis. Journal of Electromyography and Kinesiology. 2015 Dec;25(6):876–86. DOI: 10.1016/j.jelekin.2015.10.013

12. Day JM, Bush H., Nitz A.J, Uhl T.L. Scapular Muscle Performance in Individuals With Lateral Epicondylalgia. Journal of Orthopaedic & Sports Physical Therapy. 2015 May 1;45(5):414–24. DOI: 10.2519/jospt.2015.5290

13. Dones VC, Serra MAB, Kamus GOT, Esteban AC, Mercado AMS, Rivera RGA, Vergara AC, Francisco III RJ, De Ocampo LM, De Jesus PJ. The effectiveness of Biomechanical Taping Technique on a visual analogue scale, static maximum handgrip strength, and Patient Rated Tennis Elbow Evaluation of patients with lateral epicondylalgia: A cross-over study. Journal of Bodywork and Movement Therapies. 2019 Apr;23(2):405–16.

14. Christou EA. Patellar taping increases vastus medialis oblique activity in the presence of patellofemoral pain. Journal of Electromyography and Kinesiology. 2004 Aug;14(4):495–504. DOI: 10.1016/j.jelekin.2003.10.007

15. Sawkins K, Refshauge K, Kilbreath S, Raymond J. The placebo effect of ankle taping in ankle instability. Medicine and Science in Sports Exercise. 2007 May;39(5):781–7. DOI: 10.1249/MSS.0b013e3180337371

16. Cota-Robles E, Held JP. A comparison of windows driver model latency performance on windows NT and Windows 98. Operating Systems Design and Implementation '99. 1999 Feb 22;159-172

17. Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. Journal of Clinical Nursing. 2005 Aug;14(7):798–804. DOI: 10.1111/j.1365-2702.2005.01121.x

18. Jamison RN, Gracely RH, Raymond SA, Levine JG, Marino B, Herrmann TJ, et al. Comparative study of electronic vs. paper VAS ratings: a randomized, crossover trial using healthy volunteers. Pain. 2002 Sep;99(1–2):341–7. DOI: 10.1016/s0304-3959(02)00178-1

19. Price DD, McGrath PA, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain. 1983 Sep 1;17(1):45–56. DOI: 10.1016/0304-3959(83)90126-4

20. Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. Age and Ageing. 2011 Jul;40(4):423–9. DOI: 10.1093/ageing/afr05110.1093/ageing/afr051

21. Peolsson A, Hedlund R, Oberg B. Intra- and inter-tester reliability and reference values for hand strength. Journal of Rehabilitation Medicine. 2001 Jan;33(1):36–41. DOI: 10.1080/165019701300006524

22. Newcomer KL, Martinez-Silvestrini JA, Schaefer MP, Gay RE, Arendt KW. Sensitivity of the Patient-rated Forearm Evaluation Questionnaire in lateral epicondylitis. Journal of Hand Therapy. 2005 Dec;18(4):400–6. DOI: 10.1197/j.jht.2005.07.001

23. Overend TJ, Wuori-Fearn JL, Kramer JF, MacDermid JC. Reliability of a patient-rated forearm evaluation questionnaire for patients with lateral epicondylitis. Journal of Hand Therapy. 1999 Jan 1;12(1):31–7. DOI: 10.1016/S0894-1130(99)80031-3

24. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977 Mar;33(1):159–74.

25. Stochkendahl MJ, Christensen HW, Hartvigsen J, Vach W, Haas M, Hestbaek L, Adams A, Bronfort G. Manual examination of the spine: a systematic critical literature review of reproducibility. Journal of Manipulative Physiological Therapeutics. 2006 Aug;29(6):475–85, 485.e1-10. DOI: 10.1016/j.jmpt.2006.06.011