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Short Term Treatment Effectiveness And Long Term Prognosis In Patients With Lateral Epicondylosis/Tennis Elbow

Pritika Gogia
The University of Western Ontario

Supervisor
Joy C Macdermid
The University of Western Ontario

Graduate Program in Health and Rehabilitation Sciences
A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

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(Thesis format: Integrated Article)

by

Pritika Gogia

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The School of Graduate and Postdoctoral Studies
London, Ontario, Canada

Abstract

This thesis investigated the short term and long term outcomes of patients who underwent treatment for lateral epicondylosis (LE). The first manuscript compared the immediate effects of counterforce brace versus kinesiotaping on pain free grip during a repetitive upper extremity reaching task in thirty patients (n=30) with LE. The study found kinesiotape to be superior over bracing as it not only improved immediate pain free grip strength by 17.5% but also maintained this during activity as compared to brace which had a smaller improvement of 9.3%. The second manuscript determined the extent of work disability/limitations experienced by patients (n=32) following lateral arthroscopic release and how it is influenced by demographic, occupational and worker's compensation status. Patients in this cohort reported substantial work limitations when compared to other chronic conditions. Force and repetition of work tasks were identified as the most significant predictors of work disability.

Keywords

Tennis elbow, prognosis, work disability, work limitations, orthosis, kinesiotape, counterforce brace, worker's compensation

Co-Authorship Statement

Chapter 1: Pritika Gogia - sole author

Chapter 2: Pritika Gogia- concept and development of research protocol, data collection and analysis, interpretation of data, drafting manuscript; Joy Macdermid- concept and development of research protocol, provided testing equipment, interpretation of data, reviewed manuscript; Ruby Grewal- concept of research protocol, patient referral for participation, interpretation of data and reviewed manuscript; Graham JW King- concept of research protocol, patient referral for participation, reviewed manuscript

Chapter 3: Pritika Gogia- concept and development of research protocol, data collection and analysis, interpretation of data, drafting manuscript; Joy Macdermid- concept and development of research protocol, interpretation of data, reviewed manuscript; Ruby Grewal- concept of research protocol, data collection and interpretation and reviewed manuscript; Graham JW King- concept of research protocol, data collection and interpretation, reviewed manuscript

Chapter 4: Pritika Gogia –Sole author

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Chapter 1

1 Background

Lateral Epicondylosis (LE) or "Tennis elbow" is a soft tissue lesion of the musculo-tendinous origin of the wrist extensor muscles that results in lateral elbow pain. It has been referred by other common names such as epicondylagia, lateral elbow pain, periostitis and, lateral epicondylitis in the past literature. Its primary clinical features includes discomfort over the lateral elbow, pain and tenderness at or slightly distal to the lateral epicondyle and tenderness of proximal muscle mass. [1] A clinical diagnosis is often confirmed by appropriate history and pain reproduced by resisted extension of wrist and middle finger.[2] While the term epicondylitis or tendinitis are commonly used to describe this condition, histopathological studies have shown that tennis elbow is not an inflammatory condition as implied by 'itis', rather it is a degenerative process characterized by fibroblast proliferation, vascular dysplasia and disorganized collagen, collectively termed as angiofibroblastic hyperplasia. [3,4] Cyriax (1936) first noted that the primary site of injury in LE is the origin of extensor carpi radialis brevis and that one third of patients also have involvement of extensor digitorum communis. [5] The microtearing of the extensor tendon origin along with the subsequent failed healing response alters the normal musculotendinous biomechanics leading to the onset of lateral elbow pain. [6] LE is aggravated by wrist and hand movements and can severely restrict job performance, activities of daily living and leisure pursuits.

1.1 Epidemiology

Lateral Epicondylosis is one of the most frequently reported work related musculoskeletal disorders. [8,9] Recent studies have shown that there are certain occupations such as auto-assembly, food processing and construction where employees are more likely to experience this condition (4-30%) [10] than the general population (1-3%). [11] For such manual professions, strong evidence exists for a relationship between a combination of risk factors (repetitive upper extremity motion, forceful work and extreme postures) and LE. [10] Research also supports evidence for individual risk factors such as repetition [12], force [13], aging [14], gender and occurrence of LE. Repetitive work at the elbow can be described as work that involves cyclical flexion and extension of the elbow, pronation and supination of the forearm and flexion and extension of the wrist that generates loads to the elbow and forearm region. [10] Burt et al. (1990) found a significant association between repetition as an exposure and elbow/forearm symptoms in those newspaper employees who reported typing 80-100% of their working day compared to those typing 0-20%. [12] As reported in the literature, another significant occupational factor for the development of LE is force. Forceful work involves strenuous work using the forearm extensors or flexors, which generates load to the elbow/forearm region. [10] A prospective study by Kurppa et al. categorized the workers job in meat processing industry into two categories: strenuous who were involved in cutting approximately 1200 kg of veal or 3000 kg of pork per day and non-strenuous which involved mainly office work. [13] They found that those involved in strenuous work were 6.7 times more likely to have LE than those workers performing non-strenuous work.

It should be noted that the term ‘tennis elbow’ may be misnomer because tennis players represent only 5-10% of clinical cases, the practice of racquet sports however does increase the risk of developing LE (Odd’s Ratio= 2.8, 95% Confidence Interval 1.64-4.82) [15] and 40 to 50% of players may develop this condition. [16] Other etiologic and risk factors include overuse of the forearm muscles, faulty biomechanics, poor circulation, training errors, strength deficits or muscle imbalances and psychosocial problems. [17,18] Though insufficient evidence exists to find an association between gender and LE [19] in the general population, a study by Magra et al. found that females have higher incidence of developing elbow conditions in sports. [20] It has also been reported that older people, employed in manual jobs are more likely to have less resolution of symptoms than younger adults.[14]

1.2 Anatomy of Lateral Elbow

The elbow joint complex is made up of three bones- the radius, ulna and humerus which articulate to form three joints- radiohumeral, ulnohumeral and proximal radioulnar joint. The lateral side of elbow is composed of both bony and ligamentous structures (lateral collateral ligament) that stabilize the joint and also serve as an origin for the musculotendinous attachments of the distal forearm. Five extensor muscles- the extensor carpi radialis longus and brevis, extensor digitorum communis, extensor digiti minimi and extensor carpi ulnaris together referred as common extensor group originate from lateral epicondyle of humerus. This area is of chief concern in LE. Another muscle originating from lateral epicondyle is the supinator muscle. The function of these muscles is to create an extension motion at the wrist and fingers, rotation of the forearm, and to assist in extension of the elbow. [21]

1.3 Pathomechanics

Clinical studies have shown that pain production around the elbow takes place as a result of two mechanisms: dynamic stabilization around the wrist [22] and repetitive loading of the extensor tendons that generates a force transmitted via the muscles to their origin on the lateral epicondyle. [23] Kushner and Reid (1986) stated that ‘’it is the repetitive strong synergistic and fixator action of the wrist extensors during gripping that seems to give rise to this syndrome’’. [24] With the help of electromyographic (EMG) studies and biomechanical models, Snijders et al [22] demonstrated that various activities involving grasping and pinching actions (e.g., backhand stroke while playing tennis, screw- driving or wringing laundry) also required additional wrist extensor activity. This over-exertion of the wrist extensor assembly caused by the extreme repetitive movements or high impact loading of wrist joint contributes to the origin of lateral epicondyalgia. Additionally, studies on forearm muscle fatigue during gripping in healthy individuals have reported that larger fatigue effects existed in the extensor group as compared to flexor group during gripping action. [25] This observation was also suggested by the authors to be contributing to the patho-physiology of tennis elbow.

This extensor contribution to injury was further supported by greater EMG activity of wrist extensor muscles and ECRB in particular during ground strokes in healthy tennis players. [26] Two studies involving high speed photography and EMG analysis of elbow function in healthy high level tennis players also showed significant activity of wrist extensors. [26,27] Kelly et al. (1994) with the help of EMG studies compared the tennis players who had symptoms of LE to asymptomatic players and found that symptomatic tennis players demonstrated increased wrist extensor activity as compared to asymptomatic players. [28] The authors considered their finding to correlate to etiology of over-activity leading to wrist extensor injury. [28]

These repetitive contractions have been shown to produce a chronic overload of the bone-tendon junction, which in turn lead to changes at this junction. Following this repeated micro-trauma at the tendon site, healing takes place by granulation tissue formation and adhesion. This granulation tissue contains a large number of free nerve endings which accounts for the increased tenderness on palpation. [5,29,30]

1.4 Clinical Presentation of LE

Lateral epicondylosis is characterized by the insidious onset of lateral elbow pain radiating to the forearm, reproduced by wrist extension with pronation or supination, aggravated by gripping [5] and often coinciding with recent changes in work or sports activities. Tenderness over the common extensor origin just anterior and distal to the lateral humeral epicondyle is another classic sign of LE. Many patients also complain of weaker or painful grasp [31] due to weakness of forearm muscles as a result of long standing pain. Patients often complain a unique discomfort with activities such as shaking hands, opening jars, turning door knobs, lifting a grocery bag with an extended elbow or raising a coffee mug. [32] Usually the patient demonstrates full range of motion at the elbow and wrist. Special testing includes resisted extension of the wrist (radial deviation) and middle digit of hand with the elbow in extension by the examiner. This causes stress to the extensor carpi radialis and extensor digitorum comminus respectively. A positive sign will be pain or discomfort in the region of lateral epicondyle. [2] Imaging is not required for diagnosis of LE.

In few cases, symptoms associated with LE can persist, becoming chronic and resistant to treatment [30] which negatively affects the person's ability to participate in meaningful occupations or recreational activities. In such patients, the other important concern is work disability especially among young and middle aged individuals. [33] Work disability, as defined by Debra et al., is the partial or total inability of a working individual to perform his job roles considered normative or expected of that person, as a result of a chronic health condition and/or its treatment. [34] Work disability can be associated with a variety of employment problems including excess absenteeism (lost work time), presenteeism (diminished job performance and at-work productivity loss), and early departure from the labour market. [35,36] According to a national health survey, musculoskeletal disorders are one of the most leading causes of work disability in United States of America. [37]

Work disability has been well documented in common chronic conditions such as osteoarthritis [36], rheumatoid arthritis [68] but has not been addressed extensively for LE. Grewal et al. [38] reported work limitations as a secondary outcome measure using work limitation-26 questionnaire in patients who underwent surgery for lateral elbow pain and suggested that further work needs to be done to identify the factors associated with it.

1.5 Treatment for LE

A survey of clinical practice patterns indicates that a large number of non-operative interventions are used by therapists to relieve symptoms and facilitate the client's safe return to work.[39] Based on this survey, some of the interventions that therapists reported most effective were education on rest and activity modification, home exercise program, LE orthoses, stretching, strengthening and ergonomic interventions. Kinesiotaping was also reported as an additional treatment modality by hand therapists with more common usage in chronic cases (31%) than acute (25%).

A brief overview of the evidence on treatment for LE is presented in this chapter with a focus on what is indicated by systematic reviews across interventions and a more detailed focus on the nature and evidence with respect to interventions of interest for this study (orthotics/taping). In this thesis splinting is considered to fit within the intervention now termed as "orthoses/orthotics" as required by some journals/payers.

A systematic review on conservative treatment methods used for LE reported that treatment modalities such as acupuncture, exercise therapy, manipulations/mobilizations, ultrasound, phonophoresis and ionization with dicolfenac have beneficial effect in pain reduction and improvement of function loss in LE. [1] However, the authors also reported that evidence is still incomplete due to methodological limitations and treatment plans should be constructed based on clinical practicalities and experience.[1] Another review also found weak evidence to inform and support the efficacy of common occupational therapy interventions for the treatment of work related elbow injuries such as epicondylitis.[40] However, they suggested that further research needs to be done in terms of designing and implementing functional outcome studies to measure the effectiveness of treatment interventions for work related injuries.

Orthoses are a potential adjunct to conservative management. These are defined as orthopaedic appliances that are used to align, support, prevent or correct the deformities of a body part or to improve the function of mobile parts of body. [41] American Society of Hand therapists acknowledge that the terms orthoses, brace and splints can be and have been used interchangeably in the literature. [42]

Counterforce bracing is one of the most commonly used orthoses in clinical practice for LE. The concept of bracing was first introduced by Ilfied and Field in 1965, but later Nirschl introduced the concept of bracing as a diffusing counterforce. [29] It is being used by thousands of patients' everyday with the purpose of injury prevention, facilitation of return to work and other routine activities. [43] It is applied with its proximal edge 2.5 cm distal to the lateral epicondyle over the wrist extensor muscle mass. [44] The brace has been proposed to have immediate effects on pain intensity and pain free grip via two mechanisms. By partially changing the point of force application, the brace helps to broaden the area of stress around the inflamed site. [45] This widens the origin and dissipates the direct pressure of muscle contraction off the tendon attachment site on the lateral epicondyle. Also, the gentle compression by the brace partially limits muscle expansion at the time of intrinsic muscle contraction or limits the exaggerated tendon movement. [43] This reduces the force transmission across the tendon unit which further promotes healing and alleviates pain.

EMG studies have attempted to prove the counterforce concept by demonstrating the decrease in the muscle activity of wrist extensors with the brace use. The result of these studies varied from no effect to a significant effect. [43,46] Burton and Edwards [46] collected surface EMG on two healthy subjects and compared the effect of five different braces on the proximal wrist extensor muscle activity. They found no significant differences in the EMG activity in the muscles proximal to the strap. Due to the small sample size (n=2), the results should be interpreted with caution. On the contrary, Groppel and Nirschl [43] demonstrated lower muscular activity in extensor carpi radialis and extensor carpi ulnaris muscles of healthy tennis players with counterforce brace use for both serve and one-handed back hand. Research shows that these two muscles are most implicated structures responsible for LE. [43]

There has been some support in the past literature on the immediate effects of counterforce brace on patient's symptoms, however the results vary. A recent study (n=15) investigated the immediate post application effect of counterforce bracing in patients with LE and reported statistically significant improvement in grip strength (p=.02) and wrist extension muscle force (p=.001) with the brace use. [47] However, due to small sample size and poor methodological quality, the results cannot be extended to clinical practice. In a comparative study, counterforce bracing was not found to be superior over wrist splint for patients with LE, although it was suggested that counterforce bracing could be favored more by the patients as it is more practical to use and cosmetically acceptable. Moreover, hand activities can be done more comfortably while wearing a counterforce brace than a wrist splint. [48]

However, some studies do not support the brace use in clinical population. [44,49] Wuori et al. compared two forearm braces with a placebo brace and a no brace condition in subjects with tennis elbow. Pain-free grip strength and pain level was measured in each test condition immediately after brace application. They found no difference in any of the test conditions and they concluded that forearm bracing does not provide short-term pain relief or improve strength in patients with LE. [49] Anderson and Rutt [44] found a decrease in wrist extensor muscle strength with the counterforce brace suggesting that brace compresses the musculotendinous structures with a resulting restriction of muscle contraction, impeding the tendon movement and force production capacity.

Results of brace effectiveness in tennis players are also not clear. Forbes and Hopper (1990) examined 19 tennis players with complaints of elbow pain. [50] No significant improvement was found in the maximal grip strength in both symptomatic and asymptomatic arms with the use of an ACE counterforce brace. However, because results of those who had lateral elbow pain were not statistically separated and discussed, the findings of this study should be interpreted with caution. In a recent Cochrane review (2009) by Struijs et al. on the efficacy of orthotic devices for lateral epicondylosis, no conclusion could be drawn due to the poor quality and inconsistent results of the available studies.[51] They recommended that better designed, high quality randomized controlled trial's with sufficient power are warranted. [51]

Kinesiotaping (KT) is another frequently used intervention by therapists to manage patients with various musculoskeletal conditions. KT is an elastic therapeutic taping method invented by Kenzo Kase in 1970's in Japan. It is latex free, skin friendly and uses heat activated adhesive to adhere to the skin. [52] It has the same thickness as the epidermis and can be stretched to 120 to 140% of its original length. Before KT is applied, the skin and the muscles are stretched and held until the tape is applied with 15-25% stretch. [53] After tape has been applied and the underlying muscles return to their relaxed position, convolutions are formed in the skin. It is believed that these convolutions increase the interstitial space allowing for greater flow of venous and lymphatic fluids, and also directly reducing pressure off the subcutaneous nociceptors thus alleviating pain. [53] Another mechanism by which KT is proposed to help alleviate pain is by increasing the afferent feedback by the stimulation of sensory pathways in the nervous system. [54] This causes blocking of the pain signals due to gate control theory.

A number of studies have been done in the past to investigate the efficacy of KT in managing patient’s symptoms for a number of musculoskeletal disorders. In a recent study by Gonzalez- Iglesias et al, patients (n=41) with acute whiplash associated disorder (WAD) were randomized into two groups with one group (n=21) receiving KT over the cervical spine with tension and the other group (n=20) receiving sham KT. [55] The level of pain was recorded using numeric pain rating scale (NPRS) and cervical range of motion (ROM) was measured using cervical ROM device. They found that KT group reported a statistically significant reduction ($p<0.001$) in pain and an improvement in cervical ROM ($p<0.001$) both immediately post application and 24 hours after as compared to the sham group. But they also reported that these differences were small and of minimal clinical significance, so could not provide a conclusive evidence for its clinical use. These results were similar to another study by Thelen et al which reported immediate improvement in pain-free shoulder ROM in patients with shoulder impingement in the KT group but no improvement in pain and function in both KT and sham treatment group. [56] Although the results of these studies were statistically significant indicating therapeutic benefit, the clinical significance of the intervention was not established.

Previous researchers have shown that KT can also help increase or maintain the muscle strength. It is believed to improve muscle strength by producing a concentric pull on the fascia which further stimulates muscle contraction. [57] A recent study by Hsu et al demonstrated a statistically significant increase in lower trapezius muscle strength ($p= .05$) in the KT group as opposed to placebo tape group in baseball players with shoulder impingement syndrome. [58] Lee et al also assessed the effect of KT on grip strength in 40 healthy adults. [59] Both males and females reported higher grip strength upon application of KT on the flexor muscles of the dominant hand as compared to a no-tape condition. However, whether these results can be extended to symptomatic individuals is not clear. In another study on normal collegiate tennis players, KT helped maintain the strength of forearm extensors from pre-test to post-test as compared to no tape condition. [60]

On the contrary, few studies do not support these results. Chang et al. reported no significant difference in the maximal grip strength between no tape, placebo and KT condition when KT was applied on wrist flexor muscles of the dominant hand of 21 healthy males.[61] Another study investigated the effect of kinesiotape on electrical activity of vastus medialis muscle in healthy individuals (n=9) using transdermal electrodes. [62] The effect was measured before the placement of tape and after 24 hours of application. The tape was then removed and EMG was recorded 48 hours following the removal. No immediate change in the peak torque was found following the application, but they reported a significant increase in the bioelectrical activity (peak torque) of vastus medialis muscle both 24 hours after the application and 48 hours following the removal. The authors presumed that the stimulation of mechanoreceptors and generation of reflex action by the tape recruited more motor units during muscle contraction leading to increased muscle tone. [62] Studies investigating the electrical activity of the muscles following the application of kinesiotape in the symptomatic individuals are still lacking.

Recently, a meta-analysis was conducted on the efficacy of KT on musculoskeletal outcomes. Ten trials were included and a number of outcome measures were analyzed including pain, strength, range of movement, proprioception and muscle activity. [63] Despite, some statistically significant results in the existing studies, the authors were not able to provide any conclusive evidence on the KT's potency to alleviate pain or improve muscle activity. The review suggested that higher quality research is needed to provide definitive answers on the efficacy of KT. There is also a dearth of studies in the scientific literature directly reporting the effect of kinesiotaping on patients with tennis elbow/lateral epicondylosis.

LE is considered an overuse injury and symptoms are associated with activity, therefore it is important to investigate how treatment interventions work under conditions of repetitive and prolonged muscle activity. A study (1999)[64] investigated the effects of brace before and after 9 minutes 45 seconds of fatiguing wrist extension exercises with and without use of forearm band on asymptomatic individuals. They found that wearing the band increased the level of muscular fatigue in the subjects. They also commented that many subjects complained of more muscle burn and pain when wearing the forearm band than without it. However, the degree to which these results can be extended to symptomatic individuals was not discussed. Therefore, future studies with less strenuous activity in the experimental protocol on patients with LE are needed to provide a better understanding of their immediate results in a more clinically relevant context.

When all the non-surgical means of treatment fails, surgery is the last resort. [65] It involves making a small cut in the arm and trimming away the damaged tissue from the ECRB tendon (ECRB debridement). Another process involves sectioning the ECRB tendon (ECRB release) [65] which may be done percutaneously, arthroscopically or openly. A Cochrane review by Buchbinder et al. based on the surgical trials for LE concluded that operative treatment may benefit patients with LE, but due to lack of high quality studies, it remains an unproven treatment modality at this time. [65]

1.6 Prognosis

Research has shown that a certain number of factors are prognostic for poorer outcomes in LE population. For example, a study by Werner et al involving auto-assembly workers showed that factors such as older age and higher repetition of hands and non-neutral wrist posture were responsible for persistence of their elbow symptoms. [14] Another study by Waugh et al reported that worse outcomes have been reported for female gender and those with associated nerve problems following 8 weeks of physical therapy for LE. [7] Research also shows that those who report higher pain and disability at presentation, receive public assistance, have longer duration of symptoms or belong to female gender and younger age group are more likely to show poorer recovery following open lateral extensor release for their tennis elbow. [66]

Lateral epicondylosis is one of the most common work-related upper extremity disorders. [8] Despite its prevalence and impact, little is known about its prognosis as far as return to work is concerned. Previous research has shown that musculoskeletal (MSK) disorders in general affect the ability to perform normal work and hinders gradual return to work in those who go off-work because of their persistent symptoms. [35] This work disability and its associated costs can pose serious problems for not just the individual but for the whole society as well. Direct consequences include loss of wages, medical costs, disability settlement and pensions and indirect costs include loss of work productivity, tax revenues and administrative costs. [67]

A literature search showed that a significant amount of research in the area of work disability has been done on other common chronic musculoskeletal conditions such as osteoarthritis [36] , rheumatoid arthritis [68] but studies directly addressing this concern in LE population are still lacking. A systematic review on the predictors of chronic disability in injured workers suggested that further research needs to be done to address factors which predict whether an injured worker is at risk for prolonged disability. [67] They further recommended that the effect of other non-work related factors such as compensation should be evaluated in assessing return to work and recovery from injury.

Based on the results of previous studies, it is very clear that high quality, structured research is warranted to determine the extent of work disability in patients with LE and associated risk factors. If workers at high risk of work disability are identified before surgery, interventions to prevent post-op disability could be targeted towards those most likely to require special treatment. Also, the identification of modifiable early risk factors could help focus treatments to address those factors.

1.7 Outcome Measures

Therapists rely on number of impairment measures to evaluate outcomes in patients with LE. According to a recent survey on the outcome measures used by hand therapists in clinical practice, the most common ones are traditional grip strength (elbow flexed), numeric pain rating scale, pain free grip strength and self-reported questionnaires. [39]

a) *Pain*- Pain is one of the primary clinical features in patients with LE. To measure or evaluate the levels of pain, clinicians use a variety of tools in their practice such as visual analog scale (VAS), numeric pain rating scale and visual rating scale. [69] The numeric pain rating scale (NPRS) is a 11 point scale in which patient rate their level of pain from (0) no pain to 10 (worst imaginable pain), this scale has been shown to have concurrent and predictive validity. [70] The visual analog scale is presented as a 10-cm line with two ends marked as 'no pain' and 'worst imaginable pain'. The patient is asked to mark a 100 mm line to indicate the level of pain. The score is measured from zero anchor to the marked level. The Verbal Rating Scale (VRS) is an ordinal scale which uses adjectives to denote the level of pain- no pain; mild pain; moderate pain; and severe or intense pain. A review conducted by Williamson et al. [69] concluded that VRS is the least sensitive but is easiest to use; and the VAS has highest failure rate and is practically the most difficult scale to use when comparing the VAS, numeric pain rating scale and verbal rating scale. [69] In a recent study on the validity of four pain rating scales, it was reported that the NPRS is more responsive and sensitive to change than other scales such as the visual analog scale, the verbal rating scale and the faces pain scale revised (FPS-R). [71]

b) *Grip strength*- Grip strength is commonly measured to quantify the progression of LE. There are several variations in the measurement of grip strength. Patients with

LE show weaker grip strength with the elbow in an extended position than with the elbow flexed. [72,73] This is because grip strength testing in the elbow extended position will reproduce the pain at lower strength levels thus allowing easier discrimination between affected and healthy elbow. Another important variation for the researchers and clinicians in the grip strength measurement is maximum grip strength and the pain free grip strength. Though maximum grip strength has shown good inter-observer reproducibility (0.97) [74] pain free grip strength is preferred more by the researchers, as it has better correlation with pain scales [75] and is more sensitive to change than maximal grip strength. [76]

c) *Pressure Pain Threshold*- Pressure pain threshold is the minimum pressure (force) which produces pain or discomfort. [77] It is measured with an algometer, a device with a force gauge and rubber disc of $1cm^2$ surface. The tip of the algometer is placed at the point to be examined, at an angle perpendicular to the surface of the skin. The pressure is applied at the rate of 5N/sec and patient is instructed to say "stop" or indicate when the sensation changes from comfortable pressure to discomfort. [78] PPT has been measured in the past for both diagnosis as well as evaluation of treatment effects. [77] In case of healthy individuals no differences in PPT has been shown in the homologous body regions suggesting that normal side can be used as a reference in unilateral painful conditions. [77] But in LE, lower levels of PPT have been shown over the affected lateral and medial elbow as compared to the healthy sites. [79]

d) A number of *self-report questionnaires* have been used in the past for the measurement of patient's perceived pain and other disabilities. The PRTEE (Patient Rated Tennis Elbow Evaluation) is a self- administered questionnaire that has demonstrated sufficient psychometric properties. [80] It does not require training to perform and can be completed in less than 5 minutes. It measures the level of pain and functional disability by asking the respondents to mark the level of pain and difficulty on a scale of 0 to 10 where 0 means no pain/difficulty and 10 means maximum level of pain/difficulty. Scores are averaged to generate total score from 0 to 100 where higher score means higher pain and functional disability. It has been shown to be a reliable (ICC=0.96), valid (concurrent) and a responsive tool. [81] In 2007, a study compared PRTEE to other outcome measures such as DASH (Disabilities of the arm, shoulder and hand), the Roles and Maudsley score, UEFS (Upper Extremity Functional Scale) and numeric pain rating scale, and found that PRTEE was most responsive to change after treatment than other measures for patients with lateral elbow tendinopathy. [82] MEPI (Mayo Elbow performance index) is another commonly used patient rated questionnaire which has four scales for- pain, elbow motion, stability and function. [83] DASH is a validated 30 item self-reported questionnaire with excellent reliability (0.93) designed to measure physical function and symptoms in patient with variety of upper limb conditions. [84] Its functional domains include physical, social and psychological subscales.

e) *Work limitations*- Previous studies have assessed work disability or work limitations using indicators such as employment status or number of worker absences, but these indicators do not address on-the-job disability or difficulty performing a certain task at job. The Work Limitation Questionnaire was developed to measure on-the-job disability. [34] It has several versions- the original version (WLQ) developed by Dr. Lerner et al. [34] which has 25 items and the other commonly utilized version- 26 item version (WLQ-26). [85] The WLQ-26 differs in three concepts from WLQ- its uses 4 week recall period than two week recall period, it uses single response set for all questions with “half of the time” as middle category instead of “some of the time” plus it contains some additional items. The WLQ-26 is a brief (26 item), easy to use, self-administered questionnaire which asks working individuals to rate the amount of time they had difficulty performing certain tasks at their job during the past four weeks [85]. The

WLQ-26 has four scales for assessing limitations performing specific job demands. The physical demands scale (k=8) covers the ability to perform job tasks that involve bodily strength, movement, endurance, coordination and flexibility. The time management scale (k=6) addresses difficulty handling a job's time and scheduling demands. Mental demands (k=8) addresses cognitively demanding tasks and interpersonal (k=4) demands covers on-the-job social interactions. The responses to each item are 0 (none of the time), 1(some of the time), 2 (half of the time), 3 (most of the time), 4 (all of the time) and 5 (does not apply to my job). Scale responses are scored from 0 to 4 and 5 is treated as missing. Total scores and individual scale scores are calculated mathematically from 0 (no limitations) to 100 (most limitations).

1.8 Summary of Limitations in Current Knowledge

Despite their widespread use, multiple systematic reviews, meta-analysis and clinical trials have been unable to provide conclusive evidence on the benefits of counterforce bracing and kinesiotaping in management of LE. There is lack of studies in particular comparing different treatment interventions for patients with LE. Existing literature shows there is need of further clinical trials with appropriate scientific power and methodology to determine these effects in LE population.

LE has been shown to have profound impact on work and activity level but despite these effects epidemiological studies have failed to address the degree of at-work disability experienced by LE population and factors responsible for it. To date, there has been no study reporting this concern in LE population.

1.9 Purpose of this Thesis

Overall objective: To determine initial effects of bracing versus kinesiotaping on pain with activity in patients with LE; and the long-term burden of work limitations after surgical management- including how this is influenced by demographic and work factors. The specific research questions are

1. What is the effect of counterforce bracing versus kinesiotaping on pain free grip strength, pressure pain threshold and pain intensity following a 5-minute repetitive task in patients with LE?

2. What are the residual work limitations after return to work in patients who underwent arthroscopic release for LE and does this differ across subgroups based on compensation status, age groups, genders and work demands?

1.10 Thesis Overview

This thesis is composed of two manuscripts. The second chapter (first manuscript) addresses question 1 and the third chapter (second manuscript) addresses question 2. Chapter 4 discusses the conclusions, limitations and applications of the thesis.

1.11 References

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Immediate Effectiveness of Counterforce Bracing versus Kinesiotaping during Activity: A Randomized Crossover Trial in patients with Lateral Epicondylosis

A version of this chapter has been submitted for publication

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2.1 Introduction

Lateral Epicondylosis (LE) commonly referred as Tennis Elbow (TE) is one of the most common causes of elbow and forearm pain encountered in clinical practice [1] and affects 1 to 3% of the general population. [2] It begins as inflammation with microscopic and macroscopic tears at the common tendon origin of wrist extensor muscles [3] and results in degeneration with histologic changes of angiofibroblastic hyperplasia. [4] Although many tennis players experience this condition, it is usually associated with work activities or other sports that involve repetitive forearm pronation, supination, wrist motion or gripping activities. [5, 6] Certain occupations are at higher risk of developing LE than others. For example within the province of Ontario in 1997, the injury rates were highest among occupations of textiles, furs and leather goods, machine operations and transportation.[7] The onset of LE is usually gradual and typical clinical features include pain and tenderness at or around lateral epicondyle, weak grasp and difficulty performing basic activities such as lifting a briefcase by the handle, opening jars or wringing clothes. [8]

Lateral Epicondylosis is often diagnosed clinically based on the location and nature of the symptoms and use of selected clinical diagnostic tests. These tests include the reproduction of pain with palpation around lateral epicondyle or resisted wrist and middle finger extension.[9] Pain free grip strength (PFGS) and pressure pain threshold (PPT) are outcome measures that are responsive to detect changes in LE. [10, 11] Although, maximum grip strength has been shown to have good inter-observer reliability (Intraclass coefficient ICC: 0.97) [12], PFGS is preferable in LE since the amount of grip that can be comfortably performed indicate tissue irritability as demonstrated by its correlation with pain scales. [10] Furthermore, PFGS has been shown to have high intra-observer reliability (ICC range: 0.95-0.97) [12] and is more responsive than maximum grip strength to detect changes following treatment. [10,11] The reliability of PPT has also been reported to be excellent (ICC range: 0.91-0.96). [12]

A survey of clinical practice patterns has shown that numerous interventions are used by therapists to relieve symptoms and facilitate safe return to work. [13] The most commonly used are rest and activity modification, home exercise program, stretching and strengthening and use of LE orthosis. A recent systematic review on the efficacy of physiotherapeutic interventions for the management of LE concluded that there is insufficient evidence to support most of the interventions due to contradictory results, insufficient power, methodological weaknesses and a low number of studies per intervention. [14] A systematic review that specifically focused on orthosis use in LE concluded that there is weak evidence to support the use of an orthosis, but insufficient evidence to select between different options. [15] Both reviews suggested that better designed, well conducted randomized controlled trials are needed.

Sports therapy management of LE typically involves manipulation and exercise [16] or use of adhesive tape and orthotic devices.[17] In Dutch primary care, orthoses are prescribed to 21% of patients presenting with LE.[18] Despite their limited scientific evidence,[17] orthoses were ranked as third most effective intervention for acute LE in a recent practice survey of Hand Therapists. [13] Out of all the different orthoses available for LE, counterforce brace is one of the most common. It is known by several names in the literature such as forearm strap, circumferential band, counterforce brace and forearm support band.[1] It is worn circumferentially over the wrist extensor muscle belly 2.5 cm below the lateral epicondyle [19] and has been shown to improve the immediate function by dissipating the force off the areas of inflammation thereby reducing the stress around injured lateral epicondyle.[20, 21] It is also believed to restrict full muscle expansion and diminish the force of muscle contraction [22] as shown by decrease in EMG activity of wrist extensor muscles while wearing a counterforce brace. [20]

Kinesiotaping (KT) is also becoming a frequently used modality in clinical practice for the prevention and treatment of musculoskeletal conditions. [23] It was used by 25% of hand therapists to manage acute LE as reported by a recent practice survey.[13] KT is an elastic therapeutic tape invented by Dr. Kenzo Kase in Japan in the 1970s. [24] It has same thickness as skin and can be stretched to 120-140% of its original length longitudinally and following application it recoils back to its original length. [24] With its wave-like grain design and elasticity, when applied over the skin, it provides a pulling force to the skin by lifting the fascia and soft tissues beneath the area where it is applied. [25] KT has been shown to be beneficial in various musculoskeletal conditions such as shoulder impingement syndrome [26], acute whiplash injury [27] and anterior cruciate ligament repair.[28] Despite its widespread use, the scientific evidence to support its effect in LE population is sparse.

Studies to date that have addressed the short-term effectiveness of orthosis typically look at a cross-over design where each brace is worn in an unloaded condition and measures of grip, pain free grip, and pain are recorded. [19, 29-31] Lateral Epicondylosis is an injury that is associated with activity involving use of the wrist extensors, therefore a comparison of effectiveness of these two treatment interventions with exposure to repetitive upper extremity activity would provide more clinically relevant information. Therefore the purpose of this study was to compare the effects of counterforce bracing versus kinesiotaping on pain free grip strength, pressure pain threshold and pain levels immediately upon application and following a repetitive upper extremity physical activity in patients with lateral epicondylosis.

2.2 Methods

A cross over randomized clinical trial was used. Thirty patients (n=30) (21 men and 9 women), aged between 19 and 69 years (mean age, 46 ± 14 years), with a clinical diagnosis of LE were recruited between Jan -June 2013. Patients were referred from local sports, physiotherapy and hand therapy clinics; and were recruited through posters (**Appendix A-2**) at the university tennis club. All patients underwent an initial screening assessment by the primary examiner (P.G) to confirm the diagnosis, determine eligibility and obtain informed consent. Once these were completed, they were familiarized with testing procedures, equipment and the testing sequence. A clinical diagnostic criterion is the accepted gold standard as the correlation of imaging with the symptoms is variable in lateral epicondylosis.[32, 33] In order to participate, the patients had to meet the following inclusion/ exclusion criteria-

Inclusion Criteria-

1) Age (18-70 years)
2) Ability to provide written informed consent to participate
3) Were at least three weeks from onset of symptoms
4) Complaints of discomfort or pain at the lateral elbow region for a minimum of three weeks and tenderness with palpation of the lateral epicondyle
5) Provocation of lateral elbow pain with at least one of the following tests - resisted middle finger extension, resisted wrist extension or passive stretch of wrist extensors

Exclusion Criteria-

1) History of surgery on affected elbow
2) History of cortisone injections on the affected elbow in the past 4 weeks
3) Any physical or mental limitations that precluded performance of the study testing
4) Allergy to adhesive tapes

Study Setting and Ethics Approval

The testing was conducted at the Clinical Research Lab (room no. DB 226) of the Hand and Upper Limb Centre at St. Joseph Health Care, London, Ontario. This study was approved by Western University's Review Board for Health Sciences Research Involving Human Patients (HSREB # 103099) (**Appendix A-8**).

Sample Size determination

An online sample size calculator for difference of means comparing two independent samples was used to calculate sample size (http://www.stat.ubc.ca/~rollin/stats/ssize/n2.html). For a two tailed test, the value of alpha was set at 0.5 and desired power was 0.80. The sample size calculation was based on grip force measure adopted from a similar study [34] which showed a clinically relevant difference of 34N. Based on these measures, the approximate sample size needed for this crossed over trial study to demonstrate sufficient power was 30. Since the sample size requirement for independent is larger than for repeated measures for the same subject, this sample size was more than adequate to provide adequate power in this study.

Random Allocation Procedures-

Allocation was performed after consent was obtained and after control testing by having subjects select an assignment from a pool of concealed opaque assignment slips (8 per assignment- Brace & KT).

2.3 Outcome measures

Pain free grip strength was the primary outcome measure utilized in this study. It was measured using J-tech Medical's Tracker Freedom® Wireless Grip device (version 5) with the patient seated on high chair, their elbow beside their body in full extension with shoulder and radio-ulnar joints in neutral rotation and wrist in neural flexion. The elbow extended position has been described as most efficient position for the elbow for measuring grip strength in patients with LE.[35] Maximum grip strength of the uninvolved side was also measured in the same position at baseline. Handle position of the dynamometer was selected by the patients based on their comfort level and what they could squeeze most effectively. The unit of measurement was kilograms (kgs). Pressure pain threshold (PPT) and pain levels were secondary outcome measures. PPT was measured using Tracker Freedom® Wireless algometry device. It consisted of a force gauge attached to a round 1cm^2 rubber tip which is screwed on to the rod. The pressure exerted on the rod was transmitted to the body and recorded by a computer. For this test, the patient was seated with their shoulder in neutral rotation and their elbow extended beside their body. Then the most palpably tender site around the lateral epicondyle that reproduced the patient's pain and its corresponding point on the unaffected side were identified gently and marked to ensure that same site was used for repeated measures. The tip of algometer was applied perpendicular to the skin over the marked points, with pressure increasing at rate of 5N/sec (50kPa/sec).[36] The patients were instructed to say 'stop' or press the hand switch (held in untested hand) the instant sensation changed from comfortable pressure to slightly unpleasant pain[36] and device was removed from the skin. The unit of measurement was Newton/cm^2. Intra-observer reliability of PPT has been shown to be excellent (ICC range 0.91-0.96) in LE population. [12] Both the devices were wireless and connected to the Tracker Manual software with the help of USB receiver connection. They were calibrated by the examiner before beginning the first test for each patient.

The numeric pain rating scale was used to rate the level of pain experienced at the affected elbow site immediately before and following the activity. The patients were shown a card depicting the scale from 0 to 10 where 0 meant experiencing no pain at all and 10 meant maximum level of pain. A recent study has shown NPRS to be more responsive and sensitive to change than the visual analog scale (VAS), the verbal rating scale (VRS) and the faces pain scale revised (FPS-R).[37] At the conclusion of the test, patients were asked which of the treatments they preferred. Responses were recorded by the examiner.

Other Study Measures

The Patient Rated Tennis Elbow Evaluation (PRTEE) [38] (**Appendix A-3**) was used at the baseline to assess the pain (5 items) and function level (10 items) of the patient over the past week from the day of testing. The PRTEE has been shown to be a valid and reliable tool (ICC: 0.96) to measure pain and function in both acute and chronic LE cases.[39, 40] Patients also reported other coexisting conditions by completing the Self-Administered Comorbidity questionnaire (**Appendix A-4**). [41] It has been shown to demonstrate good test-retest reliability (ICC: 0.94). [41] Patients completed Rapid Assessment of Physical Activity (RAPA) questionnaire (**Appendix A-5)** to report their current level of physical activity.[42] The RAPA is a nine-item questionnaire with the response options of yes or no to questions covering the range of levels of physical activity from sedentary to regular physical activity as well as strength and flexibility. [42]

Physical Activity Exposure

To provide standardization to the physical activity exposure, a reaching task from a published functional endurance test [43] was selected that involved grip/manipulation of hand and elbow. This involved Test-1 (waist up) subtest of the Fit-HANSA (The Functional Impairment Test-Head, and Neck/Shoulder/Arm) protocol.[43] On the JobSim system (J tech Medical Salt Lake City USA), two shelves were placed. The first shelf was placed at the patient's waist level and the second shelf was placed 25cm above it. The three 1-kg containers were placed 10cm apart on the lower shelf, in line with the screws on the upper shelf. The patients stood in front of the system with their feet apart flat on the ground. With the affected arm, patient lifted three 1 kg containers one at a time between the lower shelf (set at the patient's waist level) and the shelf placed 25cms above for 5 minutes at a speed of 60 beats per minute, controlled by metronome (beat 1- grab, beat 2- lift and place). Time was monitored using a stopwatch. The patients were told to continue until 5 minutes have elapsed or stop if unable to continue the task due to pain or discomfort in the elbow. [43]

2.4 Treatments

There was a control condition (no brace or KT) and two treatment conditions (brace and KT) evaluated in this study. The outcome measures were tested before and after activity using the treatment condition assigned.

The counterforce brace (**FIGURE 2.1a**) was approximately 5cm wide with velcro attachment for adjustable girth. It had gel pack for extra support on extensor muscle mass. With the elbow extended, brace was applied 2.5cm below the lateral epicondyle. A feeling of comfortable compression, as reported by the patients was used to adjust the brace.

Pre-cut Kinesiotape (**FIGURE 2.1b**) was used only on the affected side as per the manufacturer instructions. The examiner received training on its application technique by a certified kinesiotaping instructor. With the elbow extended, wrist fully flexed and fingers pointed down [24], KT was applied with slight stretch (15-25%) and paper off tension to the lateral arm beginning just above the bony portion of lateral epicondyle. Once the top strand was anchored, KT was applied along the lateral side of elbow such that hole in the tape was over the marked point. Two strands of tape followed the lateral forearm and ended at around beginning of the distal one third of forearm. Once the support was applied, KT was gently rubbed to activate the glue.

2.5 Procedure

The testing process was one hour long and was performed on a single occasion by the primary author (P.G). The letter of information (**Appendix A-1)** was explained and written informed consent was obtained. Patients provided demographic and occupational data and also reported their worker's compensation status. Patients were then instructed on completing PRTEE and were asked to base their responses on the week prior to the testing session. They also completed the self-administered comorbidity questionnaire and RAPA to report their current physical activity status.

The patients were provided instructions on what was involved in the treatments and test procedures; and were told not to look at the computer screen nor expect verbal encouragement while the test was going on. Testing began with control condition (no intervention). The concept of maximum grip strength and pain free grip strength was explained to the patients prior to testing. Testing began with the unaffected side followed by the affected side. They were instructed to slowly increase the grip force by squeezing the handle, stopping when discomfort or pain was first felt in the affected elbow and maximum effort was reached on the unaffected side keeping the limb in a standardized position. For PPT measurement, an algometer along with a hand switch was introduced and explained to patients. The device was applied on the marked point on the unaffected side first followed by affected and patients fired the trigger when pain was first felt, which was the score recorded by the software. For both PFGS and PPT measurements, there was a rest period of ten seconds between each repetition. Two repetitions for each measurement were taken and averaged. Patients then rated their current level of pain according to NPRS.

Patients were then introduced to the JobSim system, the FIT-HANSA subtest, the beat speed and instructions on stopping if they were unable to continue due to elbow pain or fatigue. They performed 5 minutes of physical activity (waist up) of the FIT-HANSA test following the beat of the metronome. Immediately upon completion of five minutes of activity, their pain level was re-recorded and they completed the second measurement of PFGS and PPT on the affected side.

The same procedure for the measurement of PFGS, PPT and NPRS on affected side was repeated pre and post-activity with brace and KT based on the random assignment that determined treatment order (**FIGURE 2.2**). The brace was applied over the wrist extensor belly such that the marked point for PPT measurement was above the proximal edge of the brace. This was done so that measurement could be taken at the same site throughout the repeated measures. During the KT application, PPT was measured over the marked point within the hole of the KT. In total with 15 minutes of physical activity (5 x 3 times), 12 measures each for PFGS and PPT (3 conditions x 2 times (pre & post) x 2 repetitions) and 6 measures of pain level were recorded (3 conditions x 2 times (pre & post)). At the conclusion of the testing session, the patients were questioned on their treatment preference.

2.6 Analysis

All the measurements from the repeated trials of pain free grip strength and pressure pain threshold taken pre and post-activity were averaged and used in subsequent analyses. Data was analyzed using SPSS, version 21 software. Descriptive statistics were used to explore data distribution and identify outliers. Normality was examined (skewness and kurtosis) before proceeding to parametric statistics. Two way Analysis of variance (ANOVA) for repeated measures on SPSS (version 21.0; SPSS Inc., Chicago, IL, USA) was used to compare the outcome measures (PFGS, PPT and NPRS) with respect to interventions and activity. Post-hoc analysis was performed using Bonferroni correction to determine between group differences. Significant interactions were further examined using paired sample t-test. Difference in patient preferences was determined by McNemar testing. Statistical significance was set at $p<0.05$.

2.7 Results

Forty three (n=43) patients were screened, but only thirty (n=30) participated in the study (**FIGURE 2.2**). All the participants received the interventions as per their randomization order. There were no missing values on affected side, but there were two missing values of maximum grip strength and pressure pain threshold (PPT) on the unaffected side due to co-existing contralateral upper limb pathology. These missing values were imputed to the same percentage of affected as the remaining 28 patients. There were no patients lost to follow up. Baseline demographics and clinical characteristics are listed in **TABLE 2.1.**

According to RAPA, 19 people reported that they do moderate physical activities at least three times a week and 11 were underactive. Twelve people out of 30 reported that they do strengthening activities at least once a week and only 17 people stated that they do yoga and stretching at least once a week or more. Nineteen patients had coexisting conditions of which the most common ones were OA, back pain and depression (**TABLE 2.1**). Patients in this study presented with moderate pain and functional disability on PRTEE (**TABLE 2.1**). The % deficit in PFGS and PPT on the affected side was substantial compared to the unaffected side (**TABLE 2.2).**

A repeated measures ANOVA revealed significant main effect of treatment for PFGS ($F (2, 58) = 10.249$, $p<0.01$) and pain ($F (2, 58) = 3.6$, $p<0.05$).There was also a significant main effect of activity for the pain ($F (1, 29) = 39.2$, $p<0.01$). Furthermore, ANOVA with Greenhouse-Geisser correction showed significant interaction of treatment with activity for PFGS ($F (2, 58) = 4.1$, $p<0.05$) and pain ($F (1.6, 58) = 13.9$, $p<0.01$) (**TABLE 2.3**). The interaction plots are in **FIGURE 2.3 (a, b, c).**

Post hoc pairwise comparison of treatment effects showed positive improvement in PFGS with KT by 4.3kgs and with brace by 2.3kgs as compared to control (**TABLE 2.3**). The maximum percentage of improvement in PFGS with KT was 17.5% compared to brace which only improved by 9.3%. PPT also improved by 2.7 N/cm^2 and 1.2 N/cm^2 with KT and brace respectively as compared to control, but these differences were not statistically significant ($p>0.05$). Post hoc analysis of treatment for pain levels revealed that patients reported maximum pain with brace as compared to control and KT ($p<0.05$) (**TABLE**

2.3). Activity had a significant effect on pain levels showing greater pain post-activity by 1.3 points on NPRS scale ($p<0.01$).

Given significant interactions, differences were further examined with paired sample t-test. These demonstrated a significant drop in PFGS by 8.6% (2.2 kgs) with brace following activity ($t(29) = 3.8$, $p<0.01$) (**TABLE 2.3**). Similarly pain levels significantly increased with activity across all treatment conditions with least increase with KT ($p<0.05$). At the conclusion of testing session, 60% patients reported their preference for tape over brace (Odd's ratio= 1.5, 95% CI= 0.7 to 3.4, p=0.4).

TABLE 2.1 Demographic and clinical characteristics at baseline (n= 30)

Age	45 ± 14 years (range: 19-69)
Patients with right hand dominant	27, (90%)
Patients with dominant side affected	19, (63%)
Source of onset of LE	Sports-12 Work-12 Activities of Daily living-4 Trauma-2
Duration of symptoms	24.8 ± 27.6 months (range, 1-120)
Nature of symptoms Continuous Intermittent	 13 (43%) 17 (57%)
Patients with a past history of brace use	19, (63%)
Patients with a past history of KT use	0, (0%)
First assignment after randomization brace/KT	17 (57%)/ 13(43%)
Patients who could not complete 15 minutes of activity	5, (17%)
Worker's Compensation	2
Patients with comorbidities	19 (63%)
PRTEE Pain/50 Function/50 Total/100	 21.8 ± 9.8 17.1 ± 13.4 39 ± 22 (5-81.5)

Mean ± standard deviation, PRTEE= Patient Rated Tennis Elbow Evaluation Scores

TABLE 2. 2 Difference between the affected and unaffected side measured at baseline

Outcome measure	Affected side	Unaffected Side	% of unaffected Side
Grip strength (mean ± s.d)	24.3 ± 15.3 kgs	36 ± 13.1 kgs	67.5%
Pressure Pain Threshold	25.7 ± 9.4 N/cm^2	39.2 ± 13.1 N/cm^2	65.5 %

% of affected to unaffected= $\frac{\text{Affected side}}{\text{Unaffected side}}$, s.d= standard deviation

TABLE 2. 3 Mean (s.d) of pain free grip strength (PFGS), pressure pain threshold (PPT), pain levels for three treatment conditions- control- no brace and KT, brace and kinesiotape (KT) at two measurement times (pre and post 5 minutes of activity)

Measures	CONTROL	BRACE	KT	Brace-Control	KT-control	KT-Brace
PFGS, kg -Pre-Activity	24.3 ± 15.3	28 ± 15.1‡	28.7±15.8			
-Post-Activity	24.7 ± 14.7	25.7±14.8‡	28.9 ± 15			
Mean Difference (95% CI)	-0.4 -2.1 to-1.5	2.3 1 to 3.3	-0.2 -1.6 to -1.3	2.3* .01 to 4.6	4.3* 1.4 to 7.2	2.05* 0.1 to 4.1
PPT, N/cm^2 -Pre-Activity	25.7 ± 9.4	27.2 ± 10.8	27.4 ± 11.8			
-Post-Activity	25.1 ±11.1	26.5 ± 11.6	28.8 ± 12.5			
Mean Difference (95% CI)	0.6 -2 to 3.2	-0.7 -2.5 to 3.8	-1.4 -4.2 to 1.6	1.5 -4.5to 1.5	2.7 -0.7to 6.1	1.2 -1 to 3.5

Pain (NPRS) -Pre-Activity	$2.4 \pm 2^{‡}$	$3.1 \pm 2.3^{‡}$	$3 \pm 2.4^{‡}$			
-Post-Activity	$4.2 \pm 2.4^{‡}$	$4.6 \pm 2.5^{‡}$	$3.6 \pm 2.7^{‡}$			
Mean Difference (95%CI)	-1.8 -2.3 to -1.3	-1.5 -2.1 to -0.8	-0.6 -0.2 to -1	0.5^{*} -1 to -0.1	0.2 -0.6to0.7	-0.5 -1 to 0.4

* = between interventions differences are significant (p<0.05), ‡= within intervention differences are significant (p<0.05), mean difference with Confidence Intervals (CI) = pre-activity minus post-activity, s.d = standard deviation, kg= kilogram, N= Newtons, NPRS= numeric pain rating scale

FIGURE 2.1-a- Counterforce brace

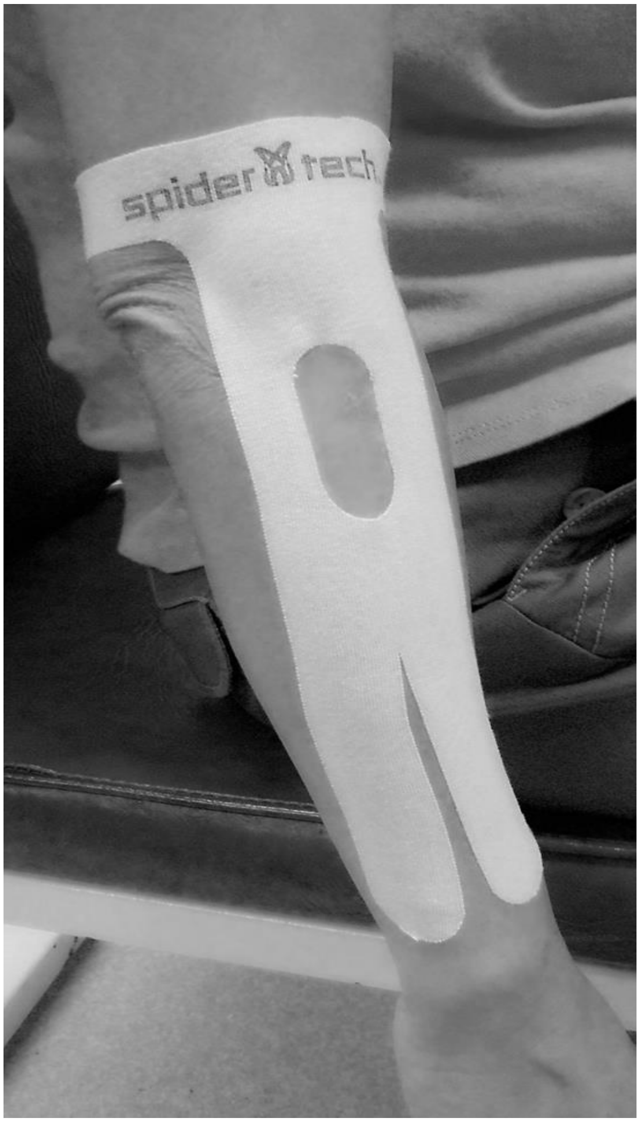


FIGURE 2.1-b- Kinesiotape

FIGURE 2.2 Flow of participants through the study

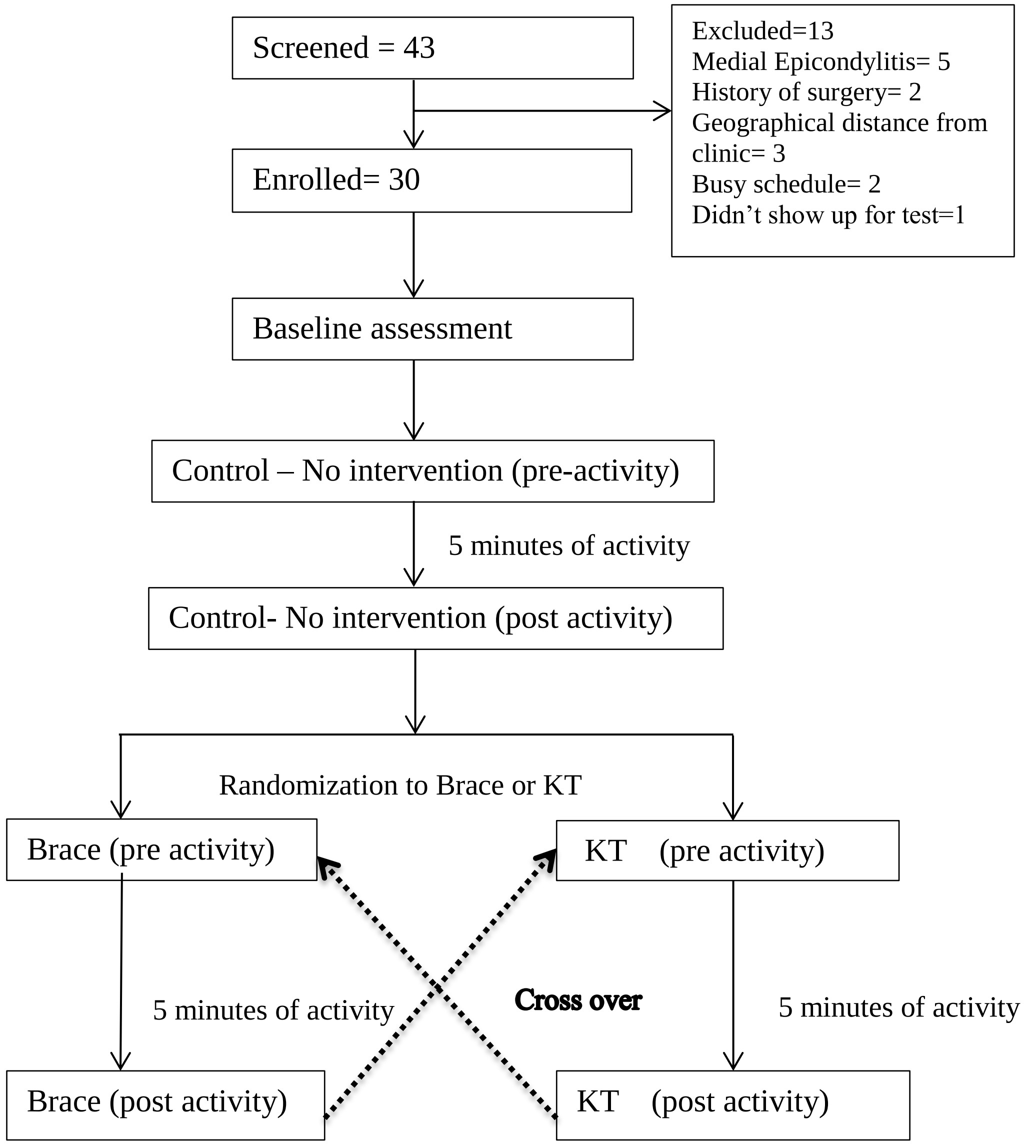


FIGURE 2.3a Effect of interaction of activity and treatment conditions on pain free grip strength (kgs) of affected side

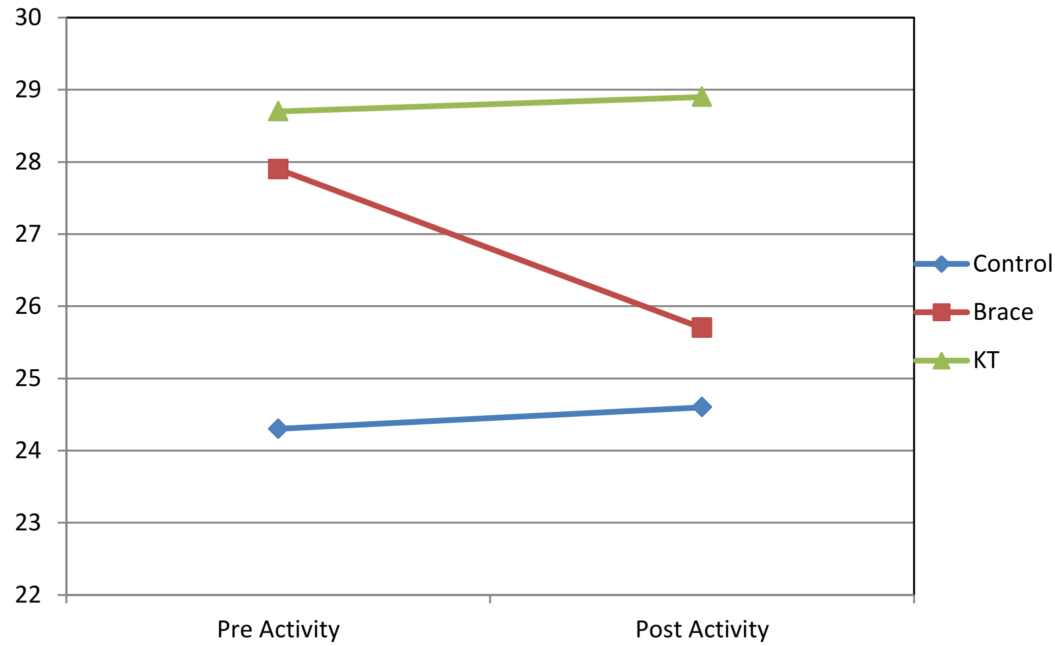


FIGURE 2.3b Effect of interaction of activity and treatment conditions on pressure pain threshold (Newton/cm^2) of affected side

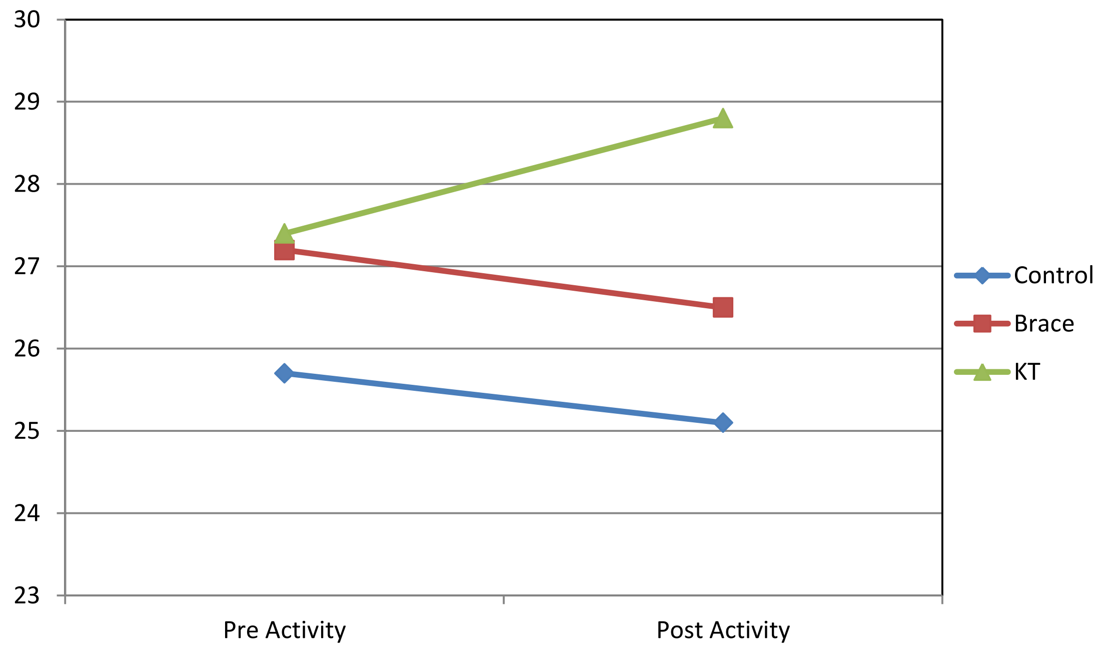
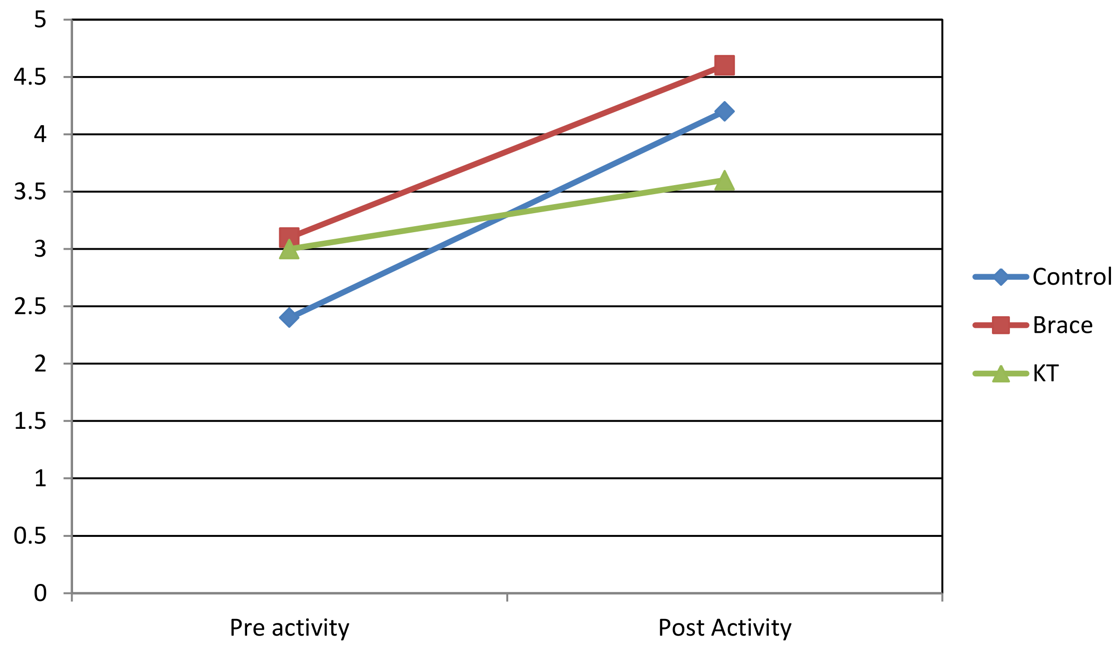


FIGURE 2.3c Effect of interaction of activity and treatment conditions on pain (on numeric pain rating) experienced on the affected side



2.8 Discussion

This study demonstrated that the application of kinesiotape in patients with lateral epicondylosis improves pain free grip strength immediately upon application and maintains this level of grip strength after a repetitive upper extremity physical activity. Counterforce brace also improved pain free grip strength upon immediate application; however, the effect was not maintained after activity.

KT is believed to improve pain and strength of overused muscles by stimulation of sensory pathways in the nervous system which increases afferent feedback [44] and suppresses the nociceptive input due to pain gate control theory.[45] Another plausible explanation is that KT application lifts the skin and directly reduces pressure off nociceptors.[46] This lift also generates a concentric pull on fascia and stimulates muscle contraction.[47]

The finding that strength was maintained after activity with KT is in agreement with a recent study which reported that when KT was applied to extensor muscles of healthy tennis players there was less strength loss following fatiguing activities as compared to control condition.[48] The tactile input provided by the KT has been reported to interact with motor cortex by altering excitability of central nervous system.[49, 50] The positive result in strength seen in this study suggests that tactile input generated by KT was strong enough to modulate extensor muscle strength. Patients in this study had substantial impairments in PFGS (67.5%) and PPT (65.5%), when compared to the unaffected side (**Table 2-2**), and moderately high scores on the Patient Rated Tennis Elbow Evaluation (PRTEE) which indicates that we studied a moderate to severe form of lateral epicondylosis. This study suggests that KT does have a beneficial effect on muscle performance during sustained activity and has the potential for application in sports, work activities and rehabilitation programs.

These findings contrast to those of Chang et al. who reported no statistically significant improvement in maximum grip strength when measured under three conditions (no tape, Placebo tape and KT).[51] The possible reasons for the conflicting results could be due to different area of KT application where in Chang et al study, KT was applied to flexors muscles of dominant hand of healthy participants. Also, they evaluated maximal grip strength, which is less sensitive to change and represents a different construct. It can be anticipated that contractile potential of the muscle would not be impacted in short-term application where no loading was present. In comparison, we evaluated pain free grip with KT as our primary outcome as we felt this was clinically relevant to functional capability and also included a standardized activity exposure. For these reasons our findings may be more clinically relevant.

KT has been shown to be effective for tendinopathy in other upper extremity disorders. Kaya et al. compared physiotherapy with KT for the treatment of shoulder impingement syndrome and suggested that it can be used as alternative treatment option particularly when immediate effects are desired.[52] Another study on baseball pitchers with medial epicondylitis reported immediate improvement in pressure pain threshold with both placebo tape and KT when applied over the flexors of affected hand.[53] The reduced tension in the muscles and myofascia as a result of KT application was thought to reduce mechanoreceptors stimulation and subsequently relieve pain. Because the effects of placebo tape and KT were similar, a conclusive clinical recommendation was not derived from that study. [53] In this study, application of KT improved PPT by 2.7 N/cm^2 as compared to control, however, the results did not reach statistically significant levels which may reflect that the activity mitigated benefits of KTor that the smaller effect size was insufficiently powered. The clinically important difference for PPT in patients with LE has been estimated at 4.5 N/cm^2 following a cervical thrust manipulation. [54]

The immediate improvement in grip strength with brace application has been supported by other studies. [55,56] A recent study demonstrated that elbow strap and elbow sleeve resulted in improved PFGS in patients with LE when tested immediately upon application.[55] Stonecipher and Caitlin [31] suggested that wearing the band could have stimulated muscle contraction by sensory stimulation of skin and pressure on muscle belly.[31] Wadsworth et al theorized that the pressure of armband disperses the stresses off the affected muscle during contractions, allowing the patient to squeeze more effectively within pain free range. [30] However the results from this study showed that, patients experienced the most pain with brace while performing the activity and also PFGS reduced as compared to KT and control. We suggest that wearing the brace during 5 minutes of repetitive activity may have caused muscle fatigue that contributed to a decrease in the grip force or early pain on squeezing; or this could be a direct mechanical effect particularly if the brace was tight. A similar study[1] also demonstrated increased wrist extensor fatigue in healthy adults after a bout of fatiguing wrist exercises with a forearm support band on. They also reported that participants experienced more pain and muscle burn while wearing the band than not wearing it. The plausible explanation provided was that the brace caused muscle and venous constriction and thereby reduced the rate of metabolites clearance (H^+ ions) from the muscle which would contribute to increased fatigue and pain. The findings from this study involving patients with LE are consistent with those reported in people without LE and call into question the short-term benefit of bracing. Whether bracing through these or other mechanisms alters activity patterns that are associated with tendon irritation, or healing processes in the longer-term is not clear.

Attempt was not made to fatigue patients in this study, but instead a standardized 5 minute repetitive reaching task was used. This task resulted in a small increase in numeric pain rating across all treatment exposures and 25/30 patients were able to complete it suggesting that it was sufficiently irritating to mildly aggravate symptoms. The 1 point difference, while below the common 2 points used to indicate a clinically important difference, [57] is clinically relevant in that if this small increase in pain is demonstrated over 5 minutes of activity then the burden with full time repetitive work or sustained sporting activity could be substantial. However, despite these short term changes in pain, there was no flaring up of symptoms in patients after the testing session suggesting that this standardized physical activity was an appropriate exposure to test short-term responses to activity. Since other studies have not included a physical activity exposure, but tested bracing at rest [29, 55], they may not have been as contextually relevant or had the opportunity to see differences in interventions that occur in response to activity.

The outcome that eighteen patients (60%) preferred KT over bracing during activity is consistent with the direction of benefit in strength and pressure pain threshold with KT in comparison to the brace. KT offers additional advantages that may have affected patient preference as it is lighter in weight, does not restrict joint motion and does not provide circumferential pressure around the wrist extensor belly. The reasons for patient preference were not determined. In the absence of clear benefit of one treatment approach over another, patient preference plays a larger role in treatment selection. Since 40% of patients preferred the brace, therapists may need to consider variations in patient preference and provide patients with evidence-informed patient centered choices when selecting an orthosis/taping treatment option since this may affect compliance. A substantial number of participants had prior bracing experience; therefore, some of the patients who preferred bracing, for example, may have been influenced by prior long-term success with bracing. The pre-cut KT was selected because this gave a consistent and uniform application enhancing the internal validity of the study. However, in clinical practice tape rolls may be more economical to buy and should provide similar benefit as long as the same application principles are used. The counterforce brace with an extra gel pack was chosen because it provides direct versus diffuse force over the extensor muscle mass. [58]

Despite some positive findings, this study also had limitations. The control (no brace or KT) was tested prior to randomization which may have instigated some order effects to these results. This baseline assessment was needed to determine each patient's status before exposure to treatment conditions. Order effects were mitigated after control testing by the randomized allocation. Although this study was the first to include a physical activity exposure, the nature of the task and whether it was an optimal exposure construct is uncertain. This study only investigated immediate treatment effects and did not determine whether long-term usage was effective. The verbal NPR was re-administered in a short time frame and thus patients would be aware of their previous response which could increase subjectivity. The potential bias is mitigated by the fact that our primary outcome (PFGS) and other secondary outcome (PPT) were blinded measurements since neither therapist nor patient saw scores during testing and these were recorded by a computer. Finally, the interventions were not blinded to either the patient or therapist. Patient preferences were studied but sufficient data on previous experiences to determine the impact of pre-existing preferences was not collected. Five patients could not complete fifteen minutes of the standardized activity due to recurrence of their pain, which meant that their physical activity exposure satisfied the criterion of being an irritant, but was not consistent across trials.

2.9 Conclusion

When applied to a population presenting with clinical diagnosis of lateral epicondylosis, superior results can be expected with KT over bracing particularly when there are short-term activity demands. The long term effectiveness of either treatment requires further study. As well, future clinical trials should be performed to investigate the effects of KT and bracing in combination with other scientifically proven interventions such as ultrasound or exercises for patients with LE.

Findings

The present study found that Kinesiotape provides immediate improvement in pain free grip strength that is maintained following repeated reaching task while bracing provided less benefit and was not able to maintain relief after activity.

Implications

The results of this study can be generalized to a population of individuals with LE with symptoms of at least three weeks duration, and whose strength deficits and pain measures are examined using similar tools. The decision to prescribe brace or kinesiotape should be based on the activity demands of the patient and their preference.

Caution

Given that short-term treatment differences are moderate, the long-terms effects remain unknown. Although patient preference was 60/40 in favor of kinesotaping, different patient's preferences and experiences must be considered when prescribing an orthosis for a patient.

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Chapter 2

Predictors of Work Disability in Patients with Lateral Epicondylosis following Arthroscopic ECRB Release

A version of this chapter has been submitted for publication.

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3.1 Introduction

Lateral epicondylosis (LE) also referred as tennis elbow, lateral epicondylitis, or lateral epicondylagia is one of the most common work related upper limb musculoskeletal disorder (WRULD).[1] It affects the tendinous origin of the wrist extensor muscles leading to pain at the lateral elbow and diminished grip strength.[2] Cyriax first reported that the primary site of injury is the origin of extensor carpi radialis brevis and one-third of patients may also have an involvement of extensor digitorum communis.[3] LE affects male and female equally [4], and has a higher incidence in manual occupations (4-30%) [5] as compared to the general population (1-3%). [6] Histopathological studies on patients with persistent symptoms have shown degenerative processes at the injury site characterized by fibroblast proliferation, vascular dysplasia and disorganized collagen, collectively termed as ‘angiofibroblastic hyperplasia’. [7]

Upper extremity disorders account for a substantial proportion of injured worker claims in developed countries; and of these, LE is one of the most prevalent diagnoses. [1,8,9] Due to chronic recalcitrant symptoms and high occupational demands, few patients with LE often experience work disability, which is related to both direct costs (compensation and medical costs) and indirect costs including productivity and quality loss, worker's replacement, training and absenteeism. [10] Based on a household survey conducted in the UK in 1995, it was estimated 5.4 million working days were lost annually due to time off work as a result of work related neck and upper limb musculoskeletal disorders. [11] In Britain, the Health and Safety Executive (HSE) estimated that work-related upper limb disorders incur approximate cost of £1.25 billion per year. [12] In United States of America, the total compensable cost for upper extremity work related musculoskeletal disorders was estimated to be $563 million in 1993. [13]

A number of treatment interventions have been proposed to manage lateral epicondylosis.[14] Surgery is recommended for refractory cases who do not respond to conservative management.[15] Arthroscopic debridement and release of the degenerated extensor tendon at the lateral humeral attachment is a predictable and generally successful method of treatment for LE [16, 17], however many patients experience residual symptoms after surgery.[16-18] A recent study concluded that higher reported pain and disability at presentation, longer duration of symptoms, female gender and young age were associated with significantly poorer outcomes following open lateral extensor release. [19] Furthermore, patients on public assistance have also been shown to exhibit poorer outcomes following arthroscopic release. [20] In fact, previous reports suggest that patients on worker's compensation more often change their jobs due to persistent symptoms following the surgery for lateral elbow pain. [21]

Given the uncertain prognosis following treatment of LE, prognostic studies that can support more accurate estimate of function and work outcomes are needed. A few studies have addressed the prognosis for functional outcomes such as pain and upper extremity function [17, 19, 20] but studies directly addressing work outcomes are still lacking. To develop disability prevention strategies, it is important to understand the characteristics of patients who become work disabled and to identify the causal relationship between two.

Therefore the purposes of this study were to:

1. Describe the extent of work disability/work limitations in patients with chronic, recalcitrant symptoms who have recovered from arthroscopic release.
2. Compare the work limitations in this population to those reported in other chronic conditions.
3. Identify whether work demands, injury compensation and demographic factors were associated with work disability.
4. Determine how impairment in grip and self-reported function relate to self-reported work limitations.

3.2 Methods

This case-series was approved by the Institutional Ethics Review Board of Western University (**Appendix A-8).** All patients provided written consent before enrollment into study prior to surgery.

Participants

The case records of 48 consecutive patients who underwent arthroscopic release from 2000 to 2005 by subspecialty upper limb surgeons at St. Joseph Health Care London, ON were reviewed. Indications for surgery included failure to show improvement with conservative treatment (physiotherapy, occupational therapy, bracing and cortisone injections) and persistence of symptoms for a minimum of one year. Thirty-six patients returned for assessment following the surgery (36 out of 48). Out of twelve patients who could not be reached for follow up- one had stroke, two could not be located, 7 were unable to attend follow-up appointment and two refused to follow up due to geographical distance from the clinic. Four patients (out of 36) returned for assessment, but did not complete the self-report forms (Work limitation questionnaire-26) leaving 32 patients in the current cohort.

Intervention

Operative treatment consisted of arthroscopic debridement and release of the extensor carpi radialis brevis (ECRB) tendon under general anaesthesia. All the surgeries were performed at same centre and all the patients received similar postoperative care. Patients were encouraged to return to their normal activities as symptoms allowed. Heavy or repetitive work was not permitted for 6 weeks post-operatively. The detailed surgical procedure and the functional outcomes for these patients have been described elsewhere.[16]

Study measures

Patients were assessed on a single occasion after the surgery and they provided the following demographic information: age, gender, duration of symptoms prior to surgery, duration of follow up and if their injury involved Worker's Safety Insurance Board/worker's compensation (WSIB/WC). Patients also reported their employment status and their current occupation after surgery. They also reported if they returned back to their previous job or changed the job, and also if they needed any permanent modifications of their job upon return.

The primary outcome of interest was 26 item version of Work Limitation Questionnaire (WLQ-26). [22] The WLQ-26 is a self-administered questionnaire (**Appendix A-6**) that was designed for assessing workplace demands for individuals (respondents) who are currently employed. WLQ-26 describes four distinct dimensions of on-the-job disability (physical, mental, time and inter-personal demands). [23] It asks the respondent to rate the amount of time they have difficulty handling certain parts of the job during the past four weeks on the scale of 0-5. The responses to each item are 0 (none of the time), 1 (some of the time), 2 (half of the time), 3 (most of the time), 4 (all of the time) and 5 was counted as missing. The subscale and total scores are averaged to generate a total limitation score from 0 (no limitations) to 100 (limited all the time on all items). [23] Scoring instructions were provided by the developer of this questionnaire upon request **(Appendix A-7**). Psychometric studies have shown its excellent reliability and validity in various patient populations such as Osteoarthritis [24] and Rheumatoid Arthritis. [25] Patients also completed the Patient Rated Tennis Elbow Evaluation questionnaire (PRTEE) [26], which has numeric rating scales for pain (five items) and function (ten items) [27] and the Mayo Elbow Performance Index (MEPI) which has subscales for pain, range of motion, stability and function. [28] The grip strength of the operated hand was measured on a NK dynamometer. [29]

3.3 Analysis

Data was entered into Statistical software (SPSS version 19.0; Chicago, IL) and a random subset of cases was double checked for accuracy. Descriptive statistics including normality of data (skewness and kurtosis) were examined with SPSS before proceeding with parametric statistics. Patient ages were divided into two subgroups to reflect younger and older working populations i.e. 25-45 or 46-65. In absence of descriptors of job, the authors classified the reported occupations into measures of force and repetition as high or low. For example, the job of an auto-assembly worker was coded as high force and high repetition and that of keyboarding as low force and high repetition.

Independent student t-test was used to detect differences in work limitations across subgroups based on demographic and work variables. Effect size was calculated using t values, with effect size $r > 0.50$ considered large, 0.30-0.50 medium and below 0.30 as small. Multiple regression was used to identify the relationship between total work limitation score- 26 (WL-26) (dependent variable) and number of predictor variable- demographic (age, gender) and occupational (force and repetition). A second multiple regression model was also conducted to identify impairment and disability variables such as MEPI, PRTEE and grip strength of operated arm (independent variables) that predicted work limitations score (WL-26) (dependent variable). Statistical significance was defined at $p<0.05$.

3.4 Results

This study included 14 females and 18 males with a median age of 44 years (range 29-61 years). The dominant arm was affected in 72% of these patients. The mean duration of symptoms prior to surgery was 26 ± 20.7 months (range 6 months-10years) and the average duration of post-operative follow up was 29 months (range 21-49 months). **TABLE 3.1** summarises patient outcomes following the surgery.

The patients in this cohort had greater difficulty meeting work's physical demands (29) in comparison to some chronic diseases such as osteoarthritis (OA) (22.7) [24] and diabetes (15.6) [30] and had similar difficulty as post-traumatic stress disorder (28.3) [31] or rheumatoid arthritis (RA) (27.5) [25] (**TABLE 3.2**). They were relatively less limited with regards to their time and mental demands. Output demands across different conditions could not be compared with our study because different versions of the same questionnaire were used in the different studies.

On average, 56% patients (18/32) who were heavy laborers experienced greater work limitations meeting all the work demands than those who did light work (14) ($t_{(28)} = 3.7$, $p<0.05$, r= 0.60) (**TABLE 3.3**). Similarly, 69% of those workers who performed high repetitive work exhibited greater work difficulties as compared to 31% of those with less repetition demands ($t_{(28)} = 5.6$, $p<0.05$, effect size r=0.73). Those who were in the younger age group or were males had relatively higher limitations scores compared to the older group or females, but the differences were not significant ($p>0.05$) (**TABLE 3.3**). Further the regression analysis in **TABLE 3.4** showed that only the work factors were significantly contributing to total WL-26 score compared to demographics.

Of thirty two patients in this cohort, eighteen (56%) were involved in Worker's Compensation (WC) claims. Sixteen of these 18 patients were able to return to their previous work with eleven patients (61%) requiring some permanent restrictions at their job. Two patients with WC changed their job owing to their persistent elbow symptoms. Out of 14 patients who were not receiving compensation, one changed job as a result of elbow pain and the remaining 13 patients were able to return to their previous jobs with only one requiring activity restrictions. Result of student t-test (**TABLE 3.5**) shows that WC patients had poorer outcomes (higher PRTEE scores, low MEPI) following the surgery as compared to non-WC patients ($p<0.0001$). As well, the WC group exhibited a greater degree of limitations meeting each of the job demands (physical, time, mental and interpersonal) ($p<0.001$). WC patients were more frequently employed in jobs that required higher force and repetition (72%, 77%) demands than non-manual jobs (low force, repetition (28%, 23%) ($p<0.001$) (**TABLE 3.5**). No difference was found between the groups with respect to age, duration of symptoms and follow up ($p>0.05$).

The self-reported outcome measure PRTEE was found to be a stronger contributor to the regression model than grip strength (**TABLE 3.6**). Due to strong correlation of MEPI and PRTEE (correlation coefficient= -0.9 $p<0.01$) in the correlation matrix, and the fact that it was less predictive of WL-26 it was excluded from the regression model.

TABLE 3.1 Patient's outcomes (mean ± standard deviation, Range)

Total PRTEE score (out of 100)	26.2 ± 24.1 (0-63.50)
MEPI score (out of 100)	78.79 ± 16.7 (48.3-100)
Maximum grip Strength of operated side (in kgs)	38 ± 14.5 (8.7-68) kgs
Total WL-26 score (out of 100)	**27.7 ± 28.3 (0-86)**

PRTEE= Patient rated Tennis Elbow Evaluation, MEPI= Mayo Elbow Performance Index, WL-26= Work limitations-26 questionnaire scores

TABLE 3.2 Work Limitations scores in LE and in comparison to other disorders.

<table>
<tr><th>Mean ± S.D</th><th>Tennis Elbow (this study)</th><th>Healthy controls</th><th>OA</th><th>Diabetes</th><th>Post-Traumatic Stress Disorder</th><th>RA</th></tr>
<tr><td>Physical Demands</td><td>29 ± 26.5</td><td>8.5 ± 21.2</td><td>22.7±24.7</td><td>15.6 ± 23</td><td>28.3 ± 19.2</td><td>27.5±25.1</td></tr>
<tr><td>Time Demands</td><td>23.3 ± 26.3</td><td>10.6±28.7</td><td>28.5±32.5</td><td>12.5 ± 18</td><td>62.1 ± 24.4</td><td>28.6±26.8</td></tr>
<tr><td>Mental Demands</td><td>30.1 ± 32.3</td><td rowspan="2">11.4±24.6</td><td rowspan="2">19.9±28.4</td><td rowspan="2">9.6 ± 16</td><td rowspan="2">49.5 ± 19.6</td><td rowspan="2">15.7 ± 19</td></tr>
<tr><td>Interpersonal Demands</td><td>26.5 ± 32</td></tr>
<tr><td>Output Demands</td><td>--------</td><td>8.8 ± 23.9</td><td>21.2±27.6</td><td>9.1 ± 17.1</td><td>57.8 ± 25</td><td>19.4±23.8</td></tr>
</table>

Comparison of limitations performing each work demand as calculated in our study to healthy controls [24], OA- Osteroarthiritis[24], Diabetes [30], Post Traumatic Stress Disorder [31] and RA- Rheumatoid Arthitis[25]. All the demands are scaled on a 1 to 100 point scale with higher score indicating more work limitations. S.d= standard deviation

TABLE 3.3 Student t-test showing effects of demographic and occupational factors on WL-26 score

Variable	No.	Physical Demands	Time Demands	Mental Demands	Interpersonal Demands	Total WL-26 score
Force						
High	18	**40.4 ±26.5***	**32.7 ± 28.5***	**46.5 ± 32***	**41.5 ± 33.8***	**41 ± 29***
Low	14	14.4 ± 18.4	11.1 ± 17.2	9.1 ± 17.6	7.14 ± 14.7	11 ± 16.7
Repetition						
High	22	**39.6 ±24.7***	**34 ± 25.4***	**42.3 ± 31.6***	**36.5 ± 33***	**39 ± 27 ***
Low	10	6 ± 12	0.0 ± 0.0	3.4 ± 11	4.4 ± 13.8	3.2 ± 8.4
Age group						
25-45	20	29.1 ± 25.1	26.4 ± 29.4	31.6 ± 33.7	27.1 ± 34.7	29.1 ± 29.7
46-65	12	29 ± 30	18.1 ± 24.1	27.8 ± 31.1	25.5 ± 28.1	25.5 ± 27)
Gender						
Males	18	30.2 ± 28.3	25.5 ± 29	33.6 ± 34.5	30.4 ± 35.2	30.4 ± 30.6
Females	14	27.6 ± 25	20.3 ± 23.2	25.7 ± 30	21.4 ± 27.6	24.3 ± 25.6

*significance level (p<0.05), Mean ± standard deviation

TABLE 3.4- Occupational and demographic predictors of work limitations- regression model

	B	SE B	β	Sig.
Constant	7.45	26.4		0.8
Age	0.8	.57	.21	0.2
Gender	9.3	8.4	.17	0.3
Force	20.6	8.2	.37	0.02*
Repetition	32	9	.53	0.001*

R^2 = .52 ($p < 0.01$), *= Significant at $p<0.05$
B= Unstandardized Coefficients, SE B= Standard Error, β= Standardized Coefficients

TABLE 3.5- Differences based on workers compensation status

Variables	Yes (mean ± s.d)	No (mean ± s.d)	Sig. (2 tailed)
Age	43.8 ± 7.5	43.8 ± 7.3	0.99
Gender (M/F)	10 M/8 F	8 M/6 F	
Duration of Symptoms	25.6 ± 26 weeks	42.2 ± 55.1 weeks	0.26
Duration of follow up	29 ± 9 weeks	27.7 ± 7.2 weeks	0.77
PRTEE	39.1 ± 21.3	9.6 ± 16.6	0.000*
WL-26 score	43 ± 27.3	8.2 ± 14.2	0.000*
MEPI score	70.1 ± 13.3	90 ± 14.02	0.000*
Physical Demands	44.3 ± 23.2	9.4 ± 15.1	0.000*
Time Demands	36.8 ± 26.5	6 ± 12.3	0.000*
Mental Demands	47 ± 31.1	8.6 ± 18.3	0.000*
Interpersonal Demands	40.5 ± 34	8.5 ± 17.6	0.000*
High Repetitive work	17/22 (77%)	5/22 (23%)	0.000*
High force work	13/18 (72%)	5/18 (28%)	0.000*

s.d= Standard deviation, *= significant at p<0.05

TABLE 3.6- Impairment and disability predictors of work limitations- regression model

	B	SE B	β	Sig.
Constant	-1.96	17.22		.91
PRTEE	.79	.21	.68	.001*
Grip Strength	.24	.35	.12	.5

R^2 = .38 (p < 0.01), *= Significant at p<0.01
B= Unstandardized Coefficients, SE B= Standard Error, β= Standardized Coefficients

3.5 Discussion

This study determined that patients with LE exhibit significant at-work disability after the surgery and that occupational factors (high force and repetition) are the most significant prognostic factors for patient's self-reported work disability upon return to work.

Work disability is described as an employment problem that may arise due to a chronic health condition and/or its treatment and makes the individual unable to perform their job efficiently. [32] In this cohort of patients, the mean work limitation-26 score was 27 out of 100 which implies that in the past 4 weeks, the workers on average were unable to meet the demands of their job 27% (approximately one fourth) of the work time. This rate is similar to an average OA patient who is limited in his physical demand quarter of his work time. [24] This implies that work disability is an important issue in public health and social policy, particularly in the industrialized nations where work plays a central role in most adult's life.

Another finding of this study is that patients who were considered to be recovered from LE following surgical intervention exhibited work difficulties that match or exceed those reported in other disorders that are often perceived as having substantial work disability including OA (23%) [24] , RA (22.8%) [25] and diabetes (11.7%). [30] This suggests that return to work following surgical treatment is suboptimal and efforts are needed to reduce this burden. Such efforts might include more substantial rehabilitation prior to return to work and greater modification of work duties.

Strong association between specific work factors such as high force, high repetition and the work limitation score, as shown in this study can be explained by the theory proposed by Armstrong et al (1993).[33] They proposed that the body responds to external work stress (for example high loads, repetition) by generating internal forces which cause increased circulation, localized muscle fatigue and other responses of a biomechanical and physiological nature. Resumption of high intensity upper extremity activities following the surgery may not provide sufficient time for regeneration of body tissue capacity potentially influencing the perception of pain and causing recurrence of symptoms. This pain and functional disability can be related to work disability as supported by the association of PRTEE (pain and function measure) with WL-26 scores (beta=0.62, p=0.02). These findings suggest that modification of jobs may be needed to accommodate the persistent symptoms reported by patients with LE since these are clearly related to work demands.

Since clinicians rarely measure work limitations as an outcome measure [34], but are more likely to measure impairments and disability outcomes, we thought it would be useful to understand whether these outcomes explained work limitations. According to a recent survey of clinical practice patterns [34], grip strength measurement is the most commonly used assessment technique for patients with LE and self-reported outcome measures such as PRTEE are not as commonly used. This study showed that grip strength was less related to work limitations than the PRTEE. The PRTEE is a reliable (ICC=0.96), valid (concurrent) and responsive tool [35] specifically designed to measure pain and functional limitations in patients with LE. Given its strong association with work disability, clinicians are advised to use this tool for making decisions about prognosis and readiness for return to work.

In this study, 18 patients (56%) who were workers compensation cases reported higher work limitations as compared to 14 patients (44%) without WC. A previous systematic review has suggested that injury compensation is associated with a twofold greater risk of negative outcomes following orthopaedic surgical procedures [36]. Unfortunately, most studies do not address occupational demands and there could be possibility that work demands are the primary issue and that worker’s compensation status is only a confounding factor. In this study we found that patients on worker’s compensation had much greater rates of physical demands (high force and high repetition) at their work. In multivariate analysis, these were stronger predictors of work disability. This suggests that to a large extent the greater occupational disability reported by patients who were on worker's compensation at the time of their injury is related more to the nature of their work, than to the injury compensation itself. Higgs and colleagues also noted an association between WC and poor outcomes in surgical treatment of occupational carpel tunnel syndrome [37] but they could not establish a causal relationship. This study's findings differ from those reported by Balk et al. [21] who found a minor difference in the outcomes of surgical intervention for tennis elbow between those who received worker's compensation and those who did not, though frequency of job change was higher in the WC group. A recent survey on the health of U.S. adult workers with at least one chronic condition reported that those in the age group 45-69 have three times higher work limitation rates as compared to ages 18-44. [38] In our study, work disability was not related to age, gender or duration of symptoms which replicated the findings of a previous similar case series. [39, 40]

This study provides insight into the work limitations experienced in this patient population, but also has weaknesses that should be considered when interpreting our findings. Due to the retrospective nature of the study, the employee's salary and productivity data were not available. This limited the ability to calculate productivity or cost loss as a result of their work limitations. Despite this limitation, the results suggest that there is a large productivity impact since the percentage of time a worker was limited on average is high in comparison to other chronic health conditions. In order to better understand the nature of the occupation, the individual's job was classified into work demand categories based on job title and did not have direct measures of the force or repetition involved in the actual work. This resulted in the potential for misclassification error. Despite this limitation, it is a strength that we considered both work demands and compensation status since many studies examine only the latter and do not consider the potential for job demands to explain possible differences in outcomes between WC and non-WC patients. Another limitation of this study was that the four patients who came back for assessment had more than 80% missing values on their WL-26 responses, so were excluded which could have affected the power of the study. Future studies with accurate details on employee's wages, time off work and absence from work are recommended to accurately capture the productivity loss as a result of work disability. Rehabilitation of workers recovering from LE should consider preventative strengthening, task adaptation, ergonomic adaptations, work scheduling and work modification to minimize work limitations

3.6 Conclusion

This study demonstrated that patients exhibit persistent work limitations following LE surgery and that these difficulties are strongly associated with the nature of their work and their persistent symptoms. Workers with high work demands should be identified as at risk for successful work outcomes prior to surgery and should be targeted for more intensive rehabilitation following surgery or counseled to seek alternate work that is less demanding.

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4 Overview of the thesis

The overall theme of this thesis was to better understand early and late treatment effects of patients with lateral epicondylosis.

Early treatment is typically conservative. The first manuscript compared the effectiveness of counterforce brace versus kinesiotaping on pain free grip strength, pressure pain threshold and pain intensity following a five minute repetitive upper extremity activity.

Later treatment for resistant cases is often surgical. The second manuscript quantified the at-work disability experienced by patients after arthroscopic release for their chronic recalcitrant LE symptoms and identified the impact of demographics and work demands.

4.1 What is already known about the topic?

A large number of interventions are used clinically to manage lateral epicondylosis.[1] Two common interventions are the counterforce elbow brace, which is worn circumferentially over the wrist extensor muscle belly and kinesiotape which is applied over to the skin around the lateral epicondyle and lateral side of wrist extensor muscle belly. [2] These interventions work on different principles and have limited supporting evidence. Previous studies on the immediate effectiveness of brace and KT have only determined immediate post application effects in unloaded conditions [3-6] , while their primary use by patients is typically to increase pain-free activity (during loading).

Arthroscopic release has been shown to be a successful method of treatment for LE, [7] however, some patients continue to experience residual symptoms after the surgery. [8] These patients also suffer from at-work difficulties, [8] the reasons for which have not been identified. Work disability is an important public health and social policy issue, therefore it is important to identify the prognostic factors for optimal work outcomes following surgery.

4.2 What this thesis adds to our knowledge base?

The first study determined that kinesiotape not only improved immediate pain free grip strength (PFGS), but it also maintained the strength throughout a repetitive upper extremity physical activity. Counterforce bracing also improved immediate PFGS, but there was a statistically significant decline in strength and concurrent increase in pain level following the activity. In addition, patients reported that brace caused more pain during the activity as compared to KT. As well patient preference for kinesiotape (60%) was higher than that for counterforce bracing.

The second study identified that those with high physical job demands are more likely to have higher work disabilities than those with lesser physical demands. In addition, patients on worker's compensation were found to have higher work demands which was identified as potential reason for slower recovery and higher work difficulties. As well, the self-reported pain and function questionnaire (Patient Rated Tennis Elbow Evaluation- PRTEE) was most strongly correlated to the work limitation score suggesting that this tool can be used by clinicians to determine the prognosis of work disability in their patients. The modification of these job factors prior to return to work can drive the patient towards better recovery, less time off work and lesser productivity loss.

4.3 Implications

The findings of this study can be generalized to a population of individuals with LE with symptoms of at least three weeks duration, and whose strength deficits and pain measures were examined using similar tools. This study supports the use of kinesiotape over bracing in patients with LE particularly during a repetitive task requiring an elevated strength. The decision to use kinesiotape over bracing should be based on the activity demands of the patient and their personal preference.

Based on the results of the second study, interventions should be targeted to reduce physical work demands, modify the work ergonomics and improve functional recovery to prevent work disability. Reduction of physical job demands may be brought about through job accommodation and/or counseling the individuals with LE who have high physical job demands to switch to less demanding jobs.

4.4 Limitations

Despite the novel results, this thesis had some overall limitations.

The first manuscript examined only the immediate effects of both interventions, whether the long term usage of KT or brace will lead to similar results was not examined.

Due to retrospective nature of the second study, information on the employee’s salary and productivity data wasn’t available, so the exact productivity loss, as a result of injury was not calculated. Due to the absence of job descriptors, the reported occupations were classified by job title rather than actual measures of task performance, which might have led to a misclassification error.

4.5 Future Research Directions and Recommendations

A future study with similar study design should be conducted to determine the long term effects of these interventions. Furthermore we suggest that future studies should also investigate the effects of KT and brace in combination with other scientifically proven interventions such as ultrasound or exercises.

For the second manuscript, future studies should include the detailed descriptors of work demands including the hours and wage loss from work as a result of a LE or its treatment. As well, a future prospective study determining the effectiveness of interventions targeting specifically those who are at high risk of developing work disabilities is warranted.

4.6 References

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Appendix

Appendix A1 - Letter of Information

Western

ST JOSEPH's HEALTH CARE LONDON

LETTER OF INFORMATION

Title of Study: Determining the immediate effects of counterforce bracing versus kinesio taping on pain-free grip strength, pressure pain threshold and pain levels in patients with Tennis Elbow.

Principal Investigator: Dr. Joy MacDermid, PT, PhD
Study Doctor: Dr. Ruby Grewal MD, MSc
Research Coordinator: Kate Kelly, MSc,MPH
Student Researcher: Pritika Gogia, BPT, MSc (candidate)

What is the purpose and potential benefit of the study?

You are being asked to participate in this study because you have painful elbow condition called Tennis elbow. This study will compare the two popular method of treating tennis elbow- counterforce bracing and kinesio taping and will investigate their effect on pain free grip strength, pressure pain threshold and pain levels. The results from the study may help clinicians make an informed choice on prescription of brace versus tape in tennis elbow patients.

Research Background:

Tennis elbow is one of the most common work related musculoskeletal disorders. Patient with tennis elbow reports pain over lateral epicondyle which is further aggravated by repetitive or heavy tasks. Patient also reports the decreased grip strength due to weakness of forearm muscles. Beside other methods of treatment, counterforce bracing and kinesio taping have proven to be effective in alleviating these symptoms. Therefore, the purpose of this study is to determine which method is superior in immediate pain relief and strength & pressure pain threshold improvement in patients who suffer from tennis elbow.

Conditions to participate:

You can be part of this study if you meet the criteria for inclusion. We will need 35-40 participants for this study.

Inclusion Criteria:

- **Confirmed diagnosis of Tennis Elbow**
- **18 - 70 in age**

Exclusion Criteria:

- **<18 or >70 years of age**
- **History of surgery on the affected elbow**
- **History of recent cortisone injections on the affected elbow in past 4 weeks**
- **Inability to perform the test due to physical or mental limitations**
- **Allergic to adhesive tapes**

The study is composed of 3 tests.
You will perform the below mentioned test, first with no brace or tape and then with brace and tape-on assigned to you randomly**.** To make accustomed to the brace or tape, before performing rounds of test each time, you will be doing warm up activity. This includes reaching component of FIT-HaNSA test; you would be moving three 1 kg containers from one shelf to another for five minutes with your affected arm. We will also ask you questions in regards to your pain and ability to perform simple activities.

1. **Pain free grip strength-** To measure this, you will be asked to slowly squeeze the hand held dynamometer until you start to feel the pain. Three measurements will be recorded and then averaged to come with the final score.
2. **Pressure Pain Threshold-** The pointing device will be held perpendicular to the affected elbow and will record minimum pressure which induces pain at the tender points of tissue.
3. **Pain levels-** During each test you will be asked to report your pain on a ten point scale.

Incentives and Reimbursement:

We will reimburse you for the parking at HULC during testing session.

Where would be the testing?

Location: Hand and Upper Clinic Research Lab DB222 (basement of HULC)
Time commitment: 60 minutes maximum

Will my results be kept confidential?

Yes – your information will be kept strictly confidential between investigators only. When the results are reported, individual results are coded and only group data are reported. Your identity will be confidential in the final publication. Upon completion of the study, your personal information will be destroyed and only gender and date of birth will be retained for 3 years.

Are there any risks to participate?

No known risks involved in this study. There may be slight irritation or redness on the skin with tape use.

What if I wish to withdraw from the study?

Participation in the study is voluntary. You have the opportunity to take a break during the study, or withdraw from the study at any time, with no effect on your future care.

Who should I contact with questions?

You will receive a copy of this letter of information.
You may contact the student investigator or research coordinator with questions you may have about the study:

Student Investigator: Pritika Gogia, Masters Student, The University of Western Ontario, London, Ontario, Canada. Email: xxxx@uwo.ca Phone: xxxxxx
Research Coordinator: Kate Kelly, MPH. The Hand and Upper Limb Clinic Research Lab, St. Joseph Hospital.
Phone: xxxx
Principal Investigator: Joy Macdermid, PT PhD. Co Director. The Hand and Upper Limb Clinic Research Lab, St. Joseph Hospital.
Phone: xxxxxx
If you have questions about your rights as a research participant please contact Dr. David Hill, Scientific Director, Lawson Health Research Institute –xxxx

CONSENT TO PARTICIPATE: **Determining the immediate effects of counterforce bracing versus kinesio taping on grip strength, pressure pain threshold and pain levels in patients with Tennis Elbow.**

I have read the Letter of Information and the nature of the study explained to me. The signature below indicates that I agree to participate. All questions have been answered to my satisfaction.

Signature: ___________________________________ Date: ________________
Print Name: __________________________________

Signature of Researcher obtaining consent: ____________________
Print Name: __________________________________
Date: ________________

Appendix A2 - Poster for patient's invitation

Persons with TENNIS ELBOW/LATERAL EPICONDYLITIS needed for Study

Recruiting Period- Sep 2012- May 2013

Purpose of the study-
To determine the immediate effects of **COUNTERFORCE BRACING** and **KINESIO-TAPING** on **Pain free Grip strength** and **pressure pain threshold.**

Time Commitment-
The whole testing may take about 45-60 minutes.

Risks involved-
There are no known risks involved. There might be slight redness or skin irritation with the tape application.

Benefits of the study-
This study will determine which out of two- counterforce brace or kinesio tape is superior in treating symptoms in patients with tennis elbow.

If Interested, Kindly contact-

Pritika Gogia- Msc Candidate
The University Of Western Ontario
Email- xxxx or Phone- xxxx

Principal Investigator- Joy Macdermid PT, PhD
Hand and Upper Limb Centre, St Joseph Hospital
Email- xxxx or Phone- xxxx

Appendix A3 - Patient Rated Tennis Elbow Evaluation

ID__________________________ Date_________________

*The questions below will help us understand how much difficulty you have had with your arm in the past week. You will be describing your **average** arm symptoms **over the past week** on a scale of 0-10.* **Please provide an answer for ALL questions. If you did not perform an activity, please ESTIMATE the pain or difficulty you would expect.** If you have **never** performed the activity, you may leave it blank.

1. PAIN

Rate the average amount of pain in your arm over the past week by circling the number that best describes your pain on a scale from 0-10. A zero (0) means that you did not have any pain and a ten (10) means that you had the worst pain you have ever experienced or that you could not do the activity because of pain.

Sample scale ➡ 0 1 2 3 4 5 6 7 8 9 10
No Pain Worst Ever

RATE YOUR PAIN:	No Pain										Worst ever
When you are at rest	0	1	2	3	4	5	6	7	8	9	10
When doing a task with a repeated arm movement	0	1	2	3	4	5	6	7	8	9	10
When carrying a plastic bag of groceries	0	1	2	3	4	5	6	7	8	9	10
When it is at its least	0	1	2	3	4	5	6	7	8	9	10

When your pain was at it's worst	0	1	2	3	4	5	6	7	8	9	10

Please turn the page..........

2. FUNCTION

A. Specific Activities

*Rate the **amount of difficulty** you experienced performing each of the items listed below over the past week, by circling the number that describes your difficulty on a scale of 0-10. A **zero** (0) means you did not experience any difficulty and a **ten** (10) means it was **so difficult you were unable to do it at all**.*

Sample scale ➡ 0 1 2 3 4 5 6 7 8 9 10
No Difficulty — Unable To Do

Turn a door knob or key	0	1	2	3	4	5	6	7	8	9	10
Carry a grocery bag or briefcase by the handle	0	1	2	3	4	5	6	7	8	9	10
Lift a full coffee cup or glass of milk to your mouth	0	1	2	3	4	5	6	7	8	9	10
Open a Jar	0	1	2	3	4	5	6	7	8	9	10
Pull up pants	0	1	2	3	4	5	6	7	8	9	10
Wring out a washcloth or wet towel	0	1	2	3	4	5	6	7	8	9	10

B. USUAL ACTIVITIES

*Rate the **amount of difficulty** you experienced performing your **usual** activities in each of the areas listed below, over the past week, by circling the number that best describes your difficulty on a scale of 0-10. By usual activities, we mean the activities you performed **before** you started having a problem with your arm. A **zero** (0) means that you did not experience any difficulty and a **ten** (10) means it was so difficult you were unable to do any of your usual activities.*

Personal care activities (dressing, washing)	0	1	2	3	4	5	6	7	8	9	10
Household work (cleaning, maintenance)	0	1	2	3	4	5	6	7	8	9	10
Work (your job or usual everyday work)	0	1	2	3	4	5	6	7	8	9	10
Recreational activities or sporting activities	0	1	2	3	4	5	6	7	8	9	10

Appendix A4 - Self-Administered Comorbidity Questionnaire

Date____________ Study & ID#____________

The Self-Administered Comorbidity Questionnaire

Instructions:
The following is a list of common health problems. Please indicate if you currently have that problem listed in the first column. If you do not have that problem skip to the next problem.
If you do have the problem, please indicate in the second column if you receive medications or some other types of treatment for the problem.
In the third column indicate if the problem limits any of your activities.
Finally, indicate all medical conditions that are not listed, as "other medical problems", and list them at the end of the page.

Problem	Do you have the problem?		Do you receive treatment for it?		Does it limit your activities?	
	Yes	No	Yes	No	Yes	No
Heart disease						
High blood pressure						
Lung disease						
Diabetes						
Ulcer or stomach disease						
Kidney disease						
Anemia or other blood disease						
Cancer						
Depression						
Osteoarthritis, degenerative arthritis						
Back Pain						
Rheumatoid arthritis						
Other medical problems						

Please list other medical problems:

Appendix A5 - Rapid Assessment of Physical Activity

How physically active are you? *(Check one answer on each line)*

			Does this accuratel describe you?	
RAPA 1	1	I rarely or never do any physical activities.	Yes ☐	No ☐
	2	I do some **light** or **moderate** physical activities, but not every week.	Yes ☐	No ☐
	3	I do some **light** physical activity every week.	Yes ☐	No ☐
	4	I do **moderate** physical activities every week, but less than 30 minutes a day or 5 days a week.	Yes ☐	No ☐
	5	I do **vigorous** physical activities every week, but less than 20 minutes a day or 3 days a week.	Yes ☐	No ☐
	6	I do 30 minutes or more a day of **moderate** physical activities, 5 or more days a week.	Yes ☐	No ☐
	7	I do 20 minutes or more a day of **vigorous** physical activities, 3 or more days a week.	Yes ☐	No ☐
RAPA 2 3 = Both 1 & 2	1	I do activities to increase muscle **strength**, such as lifting weights or calisthenics, once a week or more.	Yes ☐	No ☐
	2	I do activities to improve **flexibility**, such as stretching or yoga, once a week or more.	Yes ☐	No ☐

ID # ______________________________

Today's Date ______________________

Scoring Instructions

RAPA 1: Aerobic

To score, choose the question with the highest score with an affirmative response. Any number less than 6 is suboptimal.

For scoring or summarizing categorically:

Score as sedentary:

1. I rarely or never do any physical activities.

Score as under-active:

2. I do some light or moderate physical activities, but not every week.

Score as under-active regular – light activities:

3. I do some light physical activity every week.

Score as under-active regular:

4. I do moderate physical activities every week, but less than 30 minutes a day or 5 days a week.
5. I do vigorous physical activities every week, but less than 20 minutes a day or 3 days a week.

Score as active:

6. I do 30 minutes or more a day of moderate physical activities, 5 or more days a week.
7. I do 20 minutes or more a day of vigorous physical activities, 3 or more days a week.

RAPA 2: Strength & Flexibility

I do activities to increase muscle strength, such as lifting weights or calisthenics, once a week or more. (1)

I do activities to improve flexibility, such as stretching or yoga, once a week or more. (2)

Both. (3)

None (0)

Appendix A6 - Work Limitation Questionnaire -26

WL-26

These questions ask you to rate the amount of time during the ***past four weeks*** that you had difficulty handling certain parts of your job. Please read and answer every question.

- Mark the "Does Not Apply to My Job" box only if the question describes something that is not part of your job.
- If you have more than one job, report on your main job only.

In the past 4 weeks, how much of the time did your physical health or emotional problems make it difficult for you to do the following?

DIFFICULT	**All of the Time (100%)**	**Most of the Time**	**Half of the Time (50%)**	**Some of the Time**	**None of the Time (0%)**	**Does Not Apply to My Job**
a. Get to work on time	□4	□3	□2	□1	□0	□5
b. Stick to a routine or schedule without having to rearrange your work tasks	□4	□3	□2	□1	□0	□5
c. Work without taking frequent rests or breaks to avoid discomfort	□4	□3	□2	□1	□0	□5
d. Work the required number of hours	□4	□3	□2	□1	□0	□5
e. Handle very demanding or stressful work situations	□4	□3	□2	□1	□0	□5

f. Do your work without becoming tense or frustrated	☐4	☐3	☐2	☐1	☐0	☐5
g. Do your work carefully	☐4	☐3	☐2	☐1	☐0	☐5
h. Satisfy those people who judge your work	☐4	☐3	☐2	☐1	☐0	☐5
i. Feel a sense of accomplishment	☐4	☐3	☐2	☐1	☐0	☐5
j. Finish work on time	☐4	☐3	☐2	☐1	☐0	☐5
k. Handle the workload	☐4	☐3	☐2	☐1	☐0	☐5
l. Lift, carry or move objects at work weighing 10 pounds or less	☐4	☐3	☐2	☐1	☐0	☐5
m. Lift, carry or move objects at work weighing 10 pounds or more	☐4	☐3	☐2	☐1	☐0	☐5
n. Walk more than one block or climb up or down one flight of stairs while working	☐4	☐3	☐2	☐1	☐0	☐5
o. Sit, stand, or stay in one position for longer than 15 minutes while working	☐4	☐3	☐2	☐1	☐0	☐5
p. Bend, twist, or reach while working	☐4	☐3	☐2	☐1	☐0	☐5

q. Use hand operated tools or equipment (for example: pen, drill, sander, keyboard, or computer mouse)	☐4	☐3	☐2	☐1	☐0	☐5
r. Us your upper body to operate tools or equipment (upper body means arms, head, neck, shoulders or upper back)	☐4	☐3	☐2	☐1	☐0	☐5
s. Us your lower body to operate tools or equipment (lower body means legs, knees, feet or lower back)	☐4	☐3	☐2	☐1	☐0	☐5
t. Keep your mind on your work	☐4	☐3	☐2	☐1	☐0	☐5
u. Keep track of more than one task or project at the same time	☐4	☐3	☐2	☐1	☐0	☐5
v. Concentrate on your work	☐4	☐3	☐2	☐1	☐0	☐5
w. Remember things having to do with your work	☐4	☐3	☐2	☐1	☐0	☐5
x. Talk with people in person, in meetings, or on the phone	☐4	☐3	☐2	☐1	☐0	☐5

y. Control irritability or anger toward people when working	□4	□3	□2	□1	□0	□5
z. Help other people get work done	□4	□3	□2	□1	□0	□5

Appendix A7 - Work Limitations -26 Scoring Instructions

SCORING THE WORK LIMITATION QUESTIONNAIRE

The WLQ has 26 items with 5 Sub-Items. Each item is scored 4= All of the Time, 3= Most of the Time, 2= Half of the Time, 1= Some of the Time, 0= None of the Time

TIME DEMANDS

Sum the score for items: a, b, c, d, j, k — Y1/24* 100

MENTAL DEMANDS

Sum the score for items: e, f, g, i, t, u, v, w — Y2/32* 100

INTERPERSONAL DEMANDS

Sum the score for items: h, x, y, z — Y3/16* 100

PHYSICAL DEMANDS

Sum the score for items: l, m, n, o, p, q, r , s — Y4/32* 100

Appendix A 8 - Ethical Approval Forms

re-issued.

Western

Research Ethics

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Joy MacDermid
File Number:103099
Review Level: Delegated
Approved Local Adult Participants:36
Approved Local Minor Participants:0
Protocol Title: Determining the immediate effects of counterforce bracing versus kinesio taping on pain-free grip strength, pressure pain threshold and pain levels in patients with Tennis Elbow.
Department & Institution: Schulich School of Medicine and Dentistry\Surgery,Western University
Sponsor:
Ethics Approval Date: November 23, 2012 **Expiry Date:**September 30, 2013
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
	Comorbidity scale	
	Physical Activity scale	
	Screening tool	
Western University Protocol		
	Letter of Information	
	Poster with suggested changes	
	Patient Rated Tennis Elbow Evaluation	

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Signature

Ethics Officer to Contact for Further Information

___ Janice Sutherland (jsutherl@uwo.ca)	✓ Grace Kelly (grace.kelly@uwo.ca)	___ Shantel Walcott (swalcot@uwo.ca)

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LAWSON FINAL APPROVAL NOTICE

RESEARCH OFFICE REVIEW NO.: R-12-551

PROJECT TITLE: Determining the immediate effects of counterforce bracing versus kinesio taping on pain-free grip strength, pressure pain threshold and pain levels in patients with Tennis Elbow.

PRINCIPAL INVESTIGATOR: Dr. Joy MacDermid

LAWSON APPROVAL DATE: December 20, 2012

Health Sciences REB#: 103099

Please be advised that the above project was reviewed by the Clinical Research Impact Committee and the project:

Was Approved

PLEASE INFORM THE APPROPRIATE NURSING UNITS, LABORATORIES, ETC. BEFORE STARTING THIS PROTOCOL. THE RESEARCH OFFICE NUMBER MUST BE USED WHEN COMMUNICATING WITH THESE AREAS.

Dr. David Hill
V.P. Research
Lawson Health Research Institute

All future correspondence concerning this study should include the Research Office Review Number and should be directed to Sherry Paiva, CRIC Liaison, Lawson Health Research Institute, 750 Baseline Road, East, Suite 300.

cc: Administration

Western

Research Ethics

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Joy MacDermid
File Number:102951
Review Level: Delegated
Approved Local Adult Participants:0
Approved Local Minor Participants:0
Protocol Title: Predictors of work limitations in patients with tennis elbow who undergo arthroscopic release for lateral epicondylitis.
Department & Institution: Schulich School of Medicine and Dentistry\Surgery,Western University
Sponsor:
Ethics Approval Date: October 25, 2012 **Expiry Date:**August 31, 2013
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Western University Protocol		
Other	WL Page 2	
Other	WL Page 1	
Other	WL page 3	
Revised Western University Protocol	Addressing Queries page 14, sec 7.1 page 18 sec 8.3	2012/10/10

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Signature

Ethics Officer to Contact for Further Information

___ Janice Sutherland (jsutherl@uwo.ca)	___ Grace Kelly (grace.kelly@uwo.ca)	___ Shantel Walcott (swalcot@uwo.ca)

This is an official document. Please retain the original in your files.

Western University, Support Services Bldg Rm. 5150 London, ON, Canada N6A 3K7
t. 519.661.3036 f. 519.850.2466 www.uwo.ca/research/ethics

LAWSON HEALTH RESEARCH INSTITUTE

FINAL APPROVAL NOTICE

RESEARCH OFFICE REVIEW NO.: R-12-422

PROJECT TITLE: Predictors of work limitations in patients with tennis elbow who undergo arthroscopic release for lateral epicondylitis.

PRINCIPAL INVESTIGATOR: Dr. Joy Macdermid

DATE OF REVIEW BY CRIC: November 1, 2012

Health Sciences REB#: 102951

Please be advised that the above project was reviewed by the Clinical Research Impact Committee and the project:

Was Approved

PLEASE INFORM THE APPROPRIATE NURSING UNITS, LABORATORIES, ETC. BEFORE STARTING THIS PROTOCOL. THE RESEARCH OFFICE NUMBER MUST BE USED WHEN COMMUNICATING WITH THESE AREAS.

Dr. David Hill
V.P. Research
Lawson Health Research Institute

All future correspondence concerning this study should include the Research Office Review Number and should be directed to Sherry Paiva, CRIC Liaison, Lawson Health Research Institute, 750 Baseline Road, East, Suite 300.

cc: Administration

Curriculum Vitae

Name:	Pritika Gogia
Post-secondary Education and Degrees:	**MSc Candidate in Health and Rehabilitation Science** The University of Western Ontario, London ON 2011-Present
	Post graduate certificate- Exercise Science and Lifestyle Management Humber College, Toronto, ON 2010-2011
	Bachelors in Physiotherapy Guru Nanak Dev University, Phagwara, India 2005-2010
Honours and Awards:	Ontario Student Opportunity Trust Fund Bursary 2013
Related Work Experience:	Teaching Assistant for PT 9522 Regional Treatment And PT 9525 Rehab 1 The University of Western Ontario 2011-2013
	Consultant Physiotherapist Arti Physiotherapy Clinic, India Apr 2010-Aug-2010
Academic Scholarships:	Western Graduate Research Scholarship (WGRS) from Sep 2011-Aug 2013

Publications:

Pritika Gogia, Joy C Macdermid, Ruby Grewal and Graham JW King
Immediate Effectiveness of Counterforce Bracing versus Kinesiotaping during Activity: A Randomized Crossover Trial in patients with Lateral Epicondylosis, Journal of Sports and Physical Therapy