Mapping Electro-acupuncture in the treatment of lower back pain. A Scoping Review

Karishma Dahya

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Declaration

I Karishma Dahya declare that this research report is my own, unaided work. It is being submitted for the Master of Science in Physiotherapy degree at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Karishma Dahya
Name of candidate


Signature of candidate

____31st____ day of ___May_____ 2024_____ in Johannesburg_____

Abstract

Background:

Lower back pain (LBP) accounts for 7.4% of the global years lived with disability. Due to the disability associated with LBP, complementary alternative methods (CAM) are often sought after. Electro-acupuncture (EA) is a type of CAM therapy, and there is emerging evidence on its use in patients with LBP. The aim of this study was to map literature on the use of EA in the treatment of LBP.

Methods:

A scoping review methodology was conducted in accordance with the Johanna Briggs Institute methodology for scoping reviews. An initial search of MEDLINE and CINAHL was undertaken followed by a full search of the remaining included databases. Studies published in multiple settings from 2013 onwards that specifically looked at EA in LBP that were included which resulted in a total of (n=43) studies included in this review.

Results

A review of the literature showed that common treatment outcome measures included the visual analogue scale (VAS), Oswestry disability index (ODI) and the EuroQol Five Dimensions (EQ-5D). The most common parameters were 2Hz for frequency, EX-B2 for acupoints, 30 min for duration and patient tolerance for intensity. The most common comparison in this review was manual acupuncture (MA) and electro-acupuncture (EA) and most common combination treatment was EA and usual care (UC). Lastly the overall treatment outcomes (pain, function) were favourable for the use of EA in LBP.

Conclusions:

This scoping review mapped the information on EA in LBP from 2013 onwards. Specifically, this review showed the most common treatment parameters and outcome measures used for LBP patients treated with EA. Lastly with regards to treatment outcomes; 22 showed improvement in pain scores, 11 showed improvement in disability and function and two studies showed no change.

Keywords: Electro-acupuncture, Lower Back Pain, Outcome measures, Parameters

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List of Abbreviations

CAM: Complementary Alternative Medicine
CLBP: Chronic lower back pain
CTS: Carpal Tunnel Syndrome
DALY's: Disability-adjusted life years
EA: Electroacupuncture
EQ-5D: EuroQol Five Dimensions
HRQoL: Health-related quality of life
IASP: International Association for the Study of Pain
KZN: Kwazulu-Natal
LBP: Lower back pain
MA: Manual Acupuncture
MCIC: Minimal clinical important change
MDT: Mechanical Diagnosis and Therapy
MFE: Medium Frequency Electrotherapy
MRI: Magnetic resonance imaging
NMES: Neuromuscular Electrical Stimulation
NRS: Numerical rating scale
OA: Osteoarthritis
ODI: Oswestry Disability Index
PROM: Patient-reported outcome measures
PROMIS: Patient-reported Outcomes Measurement Information System
QST: Quantitative sensory testing
ROM: Range of motion
RMDQ: Roland Morris Disability Questionnaire
SF-36: 36-Item Short Form Survey
TENS: Transcutaneous Electrical Nerve Stimulation
TCM: Traditional Chinese Medicine
UC: Usual Care
VAS: Visual Analogue Scale
YLDs: Years lived with disability

Chapter 1 Introduction

1.1 Background

Lower back pain (LBP) is pain in the back of the body between the lower twelfth ribs and the lower gluteal folds which may or may not radiate into one or both legs (Hoy et al., 2014). In 2019, the leading level three cause of years lived with disability (YLDs) was LBP, accounting for 7.4% percent of global YLDs (Institute for Health Metrics and Evaluation, 2019). Specifically in South Africa LBP accounts for 4.9% of total YLDs (Institute for Health Metrics and Evaluation, 2019). Furthermore, the disability-adjusted life years (DALY's) due to LBP was 2.5% globally and 1.2% specifically in South Africa.

Conservative measures such as physiotherapy are often the first choice of treatment in patients with LBP (Olafsson et al., 2017). While treatment modalities vary, exercise and manual therapy are amongst the common treatment modalities used (Hayden et al., 2021; Bronfort et al., 2010). Patients often seek relief for their LBP through complementary and alternative medicine (CAM), of which acupuncture was one of the most popular forms of CAM used (Ng & Mohiuddin, 2020). Over the years research has shown contradictory conclusions to the efficacy of acupuncture in LBP. However, acupuncture combined with conventional therapy produced short-term benefits in pain and functional results when used to treat chronic lower back pain (CLBP), according to an overview of systematic reviews (Liu et al., 2015). Electro-acupuncture (EA) is a type of acupuncture that involves applying electrical stimulation to the needles, the evidence for this type of acupuncture is emerging with research looking at its effect in LBP patients (Comachio et al., 2015). Studies have already shown a reduction in disability, in patients with CLBP that were treated with EA (Kong et al., 2020).

One of the indirect pathways in the descending pain inhibition system is made up of serotonin-positive neurons in the dorsal raphe and raphe magnus (Kuo et al., 2013). The serotonergic system plays a crucial role in the control of nociception through the descending pain pathways, this role is performed by a neurotransmitter serotonin (5-HT) that activates different receptors (Tao et al., 2019). A study by Josie *et al.* (2011) looked at the effects of different frequencies on EA induced analgesia using certain

opioid antagonists to block the effects, through this they noted that the analgesic effects of low and high frequency EA can be attributed to the activation of various descending mechanisms such as the noradrenergic, serotonergic, muscarinic and GABA(b) mechanisms (Silva, Silva & Prado, 2011). The physiological effects of EA may lead to pain relief, muscle joint contraction and an increase in muscle strength. In comparison to manual acupuncture (MA), EA had the advantage of a decreased margin of error in terms of needle placement (Schoeman, 2003). EA is being used more often in clinical practice and this can be attributed to the fact that it has readily quantifiable parameters in terms of frequency, intensity and duration (Langevin et al., 2015). Overall low frequencies were found to give a longer duration of antinociception compared to high frequencies (Kuo et al., 2013).

EA has been studied in terms of its effects in CLBP. A study by Yeung *et al.* (2003) found significant changes in the numerical rating scale and Aberdeen LBP scale in the EA and exercise group compared to patients that just received normal back exercises in patients with CLBP, furthermore this improvement was maintained at 3 months. This was also found in a study comparing it with transcutaneous electrical nerve stimulation (TENS), EA as an adjunct to exercises reduced pain and improved function significantly more than the TENS group and the exercise group (Depaoli Lemos et al., 2021). EA also showed an increased long-term effect in terms of leg pain intensity scores measured by the NRS, and function which was measured by the Oswestry disability index (ODI) when followed up at 28 weeks, in comparison to medium frequency electrotherapy (MFE) (Zhang et al., 2017).

1.2 Problem Statement

LBP continues to be an issue globally and is likely to increase (Hoy et al., 2012), with up to 65% of individuals experiencing pain one year after onset (Itz et al., 2013). LBP is linked with many negative effects such as impaired physical function, depression and low quality of life when it comes to one's health (Ge et al., 2022). Considering that the issue is significant, it raises a concern into the therapeutic methods being used. Exercise and manual therapy are amongst the common treatments used in treating LBP (Hayden et al., 2021) and have been researched extensively, however new therapies for LBP such as EA therapies require further research, with minimal randomized controlled trials and reports done on its use in LBP (Comachio et al., 2020).

Most patients are interested in trying methods for treating LBP that are not of the conventional medical spectrum (Sherman et al., 2004b). By providing a summary of information on the effects of EA in LBP we can broaden the knowledge of therapists in terms of their understanding regarding methods that are not of the conventional medical spectrum. Hence, with EA being an evolving topic the need to scope the literature and identify the current evidence is necessary.

A preliminary search prior the initial search was conducted to identify if any scoping reviews were conducted on the topic. Databases searched included; CINAHL, MEDLINE, the Cochrane Database of Systematic Reviews and JBI Evidence Synthesis and no scoping reviews (published or in progress) or systematic reviews mapping this topic were identified.

The lack of a published scoping review highlights a research gap and provides justification for this scoping review, without a summary of the available information on the subject there may be a lack of understanding of the treatment method and its effects which may in turn affect its use in the treatment of lower back pain. Hence the question at hand is; what is known from the literature regarding the use of electro-acupuncture in the treatment of lower back pain?

1.3 Aims and Objectives

Aim

The aim of this study was to map literature within the last 10 years (2013-2023) on the use of electro-acupuncture in the treatment of lower back pain.

Objectives

1.3.1. To describe the outcome measures and treatment outcomes reported on the use of electro-acupuncture in the treatment of lower back pain

1.3.2. To describe the electro-acupuncture treatment parameters used in the treatment of lower back pain

1.3.3. To describe the types of combination treatment strategies used with electro-acupuncture in the management of lower back pain

1.4 Significance of the study

EA is a relatively new treatment method and has shown some positive effects in terms of pain relief and function in patients with LBP (Awad & Allah, 2018; Leite et al., 2018). LBP has a high re-occurrence rate and therefore it is important to ensure current best evidence-based practices are implemented as treatment methods evolve. Therefore there is a need to synthesize the information on EA in LBP to give clinicians an overview on the topic in terms of; treatment parameters, outcome measures and functional and health-related quality of life outcomes. This summary may help clinicians into a better understanding of how this treatment modality works and its possible influence in the management of LBP.

1.5 Outline of this Research Report

This scoping review will provide an update on more recent research published on EA as the last meta-analysis done on acupuncture included only 6 studies on EA that were published before 2011 (Lam, Galvin & Curry, 2013). Furthermore, this study will look at research published within the last 10 years to ensure the most relevant and up to date research is considered in this review. Specifically, this study will look further into treatment parameters, treatment outcomes and outcome measures of EA, in the treatment of LBP.

Chapter 2 Literature Review

2.1 Introduction

The literature review will give a background on CAM, the history and origins of EA, how EA is defined and the use of EA in neuromusculoskeletal conditions. The gate control theory of pain will be described and the physiological influence of electro-acupuncture on this system will be discussed. Lastly, we will review the current treatment interventions for LBP and their efficacy, as well as a small glimpse of previous studies of EA in LBP.

2.2 Complementary alternative therapy

Complementary alternative therapy or methods are believed to have stemmed from traditional medicine and are widely used to treat a spectrum of conditions, often when conventional methods are unsuccessful (Si-Yuan et al., 2012). The world health organisation found that 65% to 80% of health care practice includes some involvement of CAM (Si-Yuan et al., 2012). CAM is often the choice of therapy to try to eliminate the negative side effects of drugs used in conventional medicine(Si-Yuan et al., 2012). The increased use of CAM has resulted in further research on this type of medicine and more studies published looking at its safety and efficacy (Si-Yuan et al., 2012). CAM seems to have a closer link to nature and is often seen as a more comprehensive practice (Si-Yuan et al., 2012). In contrast to conventional medicine, CAM is generally less invasive and cheaper (Si-Yuan et al., 2012). Interestingly it was found that general practitioners with training in CAM had zero to 30% lower health-care costs and mortality rates (Si-Yuan et al., 2012). There are over 16 to 20 types of CAM therapies and therefore classification of these types was necessary to allow for the creation of regulatory policies (Si-Yuan et al., 2012). These types of CAM therapies are based on different traditions and cultures and involve a holistic approach to health care (Si-Yuan et al., 2012).

CAM can be divided into two categories namely herbal and non-herbal therapies, further which non-herbal therapies can be subclassified into biological, body, mind, mind-body and body-biological patterns (Si-Yuan et al., 2012). Musculoskeletal conditions are one of the many conditions treated with CAM(Si-Yuan et al., 2012).

Specifically, patients with LBP often make use of CAM as a choice of therapy (Ernst, 2004). Some of the common modalities chosen include acupuncture, massage therapy and spinal manipulation (Ernst, 2004). Acupuncture which is a form of CAM falls into the last category of body-biological patterns (Si-Yuan et al., 2012).

2.3 Pain

Pain is multi-dimensional, including a combination of sensory, motivational, cognitive and affective factors (Kumar & Elavarasi, 2016). Although there are several definitions of pain, one of the most widely used ones is provided by the International Association for the Study of Pain (IASP) which describes pain as “An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage”(Merskey, 1979). However, this definition was revised by Williams and Craig to highlight the importance of integrating the social, emotional and subjective experiences (Williams & Craig, 2016). The adjusted definition describes pain as “A distressing experience associated with actual or potential tissue damage with sensory, emotional, cognitive and social components” (Williams & Craig, 2016).

Over the years the approach to pain management has evolved, the initial approach to pain management was through the biomedical model, however this model uses the bodies somatic processes as a basis for explaining illness without the consideration of psychological and social aspects (Bevers et al., 2016). This approach created unrealistic expectations that pain could be cured through the treatment of these somatic processes, however as time went on more research highlighted the important connection between the biological and psychosocial factors (Bevers et al., 2016). This gave rise to the biopsychosocial model which recognises not only the biological aspect of pain but also the psychological and social components, hence providing a more holistic approach to pain management (Bevers et al., 2016).

2.4 Gate control theory

The mechanism of pain can be described through Melzack and Wall’s gate control theory. They proposed that a gate type mechanism controlled the pain signals from the spinal cord to the brain either allowing them through or blocking the signals, and various factors can influence the opening and closing of these gates (Melzack & Wall, 1965). Information is carried by primary afferent neurons which can either be A-beta,

A-delta or C fibres, each of these fibres have properties that differ in conduction speed and types of pain signals carried (Melzack & Wall, 1965). A-beta fibres are large and lined with myelin, therefore they have a quick conduction and they carry light touch and pressure (Melzack & Wall, 1965). A-delta fibres are slightly smaller and less myelinated, they carry pain and temperature (Melzack & Wall, 1965). Lastly C-fibres are slow and unmyelinated and also carry pain and temperature (Melzack & Wall, 1965). This theory also proposes that A-beta fibres play a role in supressing the nociceptive information through a feedforward mechanism (Melzack & Wall, 1965).

A study looking at EA in inflammatory pain found that activating A-fibres through low frequency EA, causes the inhibition of nociceptive information to the brain therefore closing the gate and reducing the overall inflammatory pain (Duan-Mu et al., 2021). Whereas high frequency EA activated C-fibres which caused a local increase in pain (Duan-Mu et al., 2021). This was further supported by a study that looked at the effect of different frequencies and duration of EA on rats that had carrageenan-induced inflammation (Taguchi & Taguchi, 2007). The results found that the greatest analgesia was produced at three hertz for 60minutes at an intensity of three milliamperes and that 15Hz and 100Hz did not produce any analgesia (Taguchi & Taguchi, 2007). In summary the effects of EA on inflammatory pain can be understood through the pain gate theory.

2.5 Physiological Effects of electro-acupuncture

Two proposed mechanisms of EA analgesia were described in a study done in 1979, one of the mechanisms were endorphin related and the second involved was non-endorphin related (Cheng & Pomerana, 1979). Naloxone which is an opioid receptor antagonist has a significant reversal effect at a low frequency of EA however at a high frequency naloxone did not reverse the EA analgesia effect (Cheng & Pomerana, 1979). They also found that parachlorophenylalanine which depletes serotonin, partially blocked the high frequency EA effect and had no effect on the low frequency (Cheng & Pomerana, 1979). Thus, indicating that low frequency EA is mainly controlled by endorphins whereas high frequency EA is partially controlled by serotonin (Cheng & Pomerana, 1979).

The study by Cheng & Pomerana did not differentiate the types of endorphins that are released, hence a study by Han looked at using an anti-serum to inhibit the function of

beta-endorphin in rats that received EA (Ulett, Han & Han, 1998). The study found that the analgesic effect of the EA was reduced the most by a low frequency, moderately by a medium frequency and no effect was found at a high frequency (Ulett, Han & Han, 1998). A similar approach was used to test the levels of neuropeptides such as enkephalin and dynorphin with different frequencies of EA (Ulett, Han & Han, 1998). They found that low frequency effects of EA were diminished by an enkephalin antiserum and that high frequency effects of EA were decreased by a dynorphin antiserum (Ulett, Han & Han, 1998). This is further supported by a study done by Fei that found an increase in enkephalin with low frequency stimulation of two hertz and an increase in dynorphin for high frequency stimulation of 100Hz (Ulett, Han & Han, 1998).

However, when an alternating frequency of 2/15Hz of EA was administered they found almost a complete loss of the analgesic effect, when any of the three opioid receptor antagonists were injected (mu, delta & kappa) (Chen & Han, 1992). Thus, indicating that in order to create a significant analgesic effect a mixture of the opioid peptides need to be at work and a block of one of these can affect the entire system (Chen & Han, 1992).

Studies have gone to the extent of looking at functional magnetic resonance imaging (MRI) changes during EA. They discovered that the anterior middle cingulate cortex showed a significant signal increase with EA as opposed to standard acupuncture, which plays a role in processing and modulating the pain effect (Napadow et al., 2005). The study also found that low frequency EA specifically produced a signal increase in the pontine raphe region which is involved in the serotonergic system (Napadow et al., 2005)

On the contrary EA may also play a role in the anti-analgesic system. A study on rats administered two different routes of morphine (i.c.v and i.t) and looked at the interaction of EA on the anti-analgesic system (Fukazawa et al., 2005). The study found that stimulation of the ST-36 acupoint attenuated the analgesic effect of morphine which could be attributed to the release of endogenous opioid peptides by EA (Fukazawa et al., 2005). They also found that EA only attenuated i.t and not i.c.v morphine thus indicating the role of the spinal cord rather than the brain in the activation of the downstream effects (opioid receptor-mediated effects) (Fukazawa et al., 2005).

Overall, EA analgesia is proposed to work through two mechanisms namely the endorphin and non-endorphin mechanisms (Cheng & Pomerana, 1979). Furthermore, in terms of opioid peptides; low frequency EA was associated with enkephalin, high frequency with dynorphin and alternating frequencies with a mixture of opioid peptides (Chen & Han, 1992).

2.6 Definitions of electro-acupuncture

EA involves the insertion of needles into acupuncture points followed by an electrical current administered through the needles (Depaoli Lemos et al., 2021). It can also be described as a transdermal electrical stimulation of the nerves with effects that may be voltage-dependant (Ulloa, Quiroz-Gonzalez & Torres-Rosas, 2017). Lastly EA can also be described as an acupuncture technique that combines electrical stimulation with acupuncture treatment (Heo et al., 2021). The most fitting definition for this study would be “A modified form of acupuncture technique that combines traditional manual acupuncture with modern electrotherapy. The principle of electroacupuncture is that a small electric current is passed between pairs of needles (Wu et al., 2021). The reason for this choice in definition is because it highlights that needles are used; therefore, we know its invasive. Furthermore, the mention of electrical stimulation ties into its effect in pain modulation which is a result of this stimulation (Depaoli Lemos et al., 2021).

2.7 History of electro-acupuncture

The history of EA dates back to the 1800’s (Macdonald, 1993). At the time, two types of electrotherapies existed namely, Frankalism which used static electricity to generate numbness and Galvanism, which included a direct current for therapeutic uses (Macdonald, 1993). Macdonald (1993) reported on information by Sarlandiere who looked at the two types of electric currents and stated that Frankalism should be used for the treatment of movement lesions, and sensation lesions should be addressed with Galvanism (Macdonald, 1993).

In 1825 Sarlandiere began attaching acupuncture needles to the poles of a weak voltaic battery instead of surface electrodes, using mostly Galvanism (Macdonald, 1993). Unfortunately, Galvanism had some dangers which included tissue necrosis, hence in the 1900’s Faradism was introduced which provided a safer alternative (Macdonald, 1993). Michael Faraday introduced an intermittent and alternating current

which allowed for stimulation without any negative effects (Macdonald, 1993). Some of the barriers that were faced with the introduction of Faradism included controlling the intensity and frequency in order to achieve the desired effect and this along with other barriers such as machinery cost and lack of knowledge on the concept lead to the concept fading (Macdonald, 1993).

In 1965, Jisheng Han a professor in China dove deeper into the physiological mechanisms of electroacupuncture-induced analgesia, and since then more research has been published into understanding the concept, parameters and mechanisms of EA (Macdonald, 1993). Figure 2.1 below outlines a summary of the history.

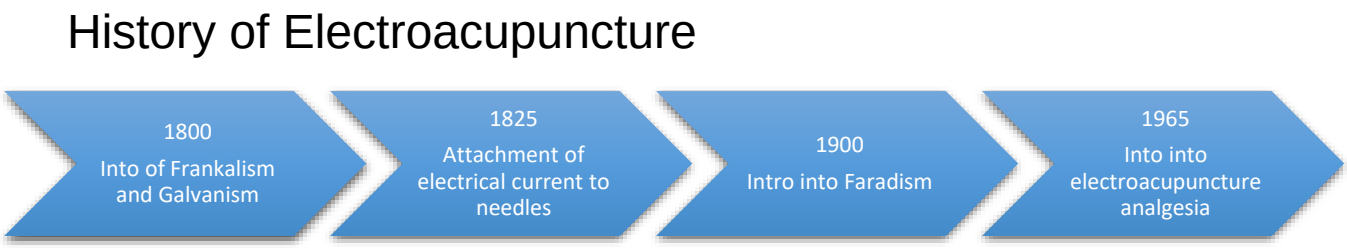

Figure 2.1 Summary of EA history

2.8 Safety of electro-acupuncture

EA involves applying a current through needles (stainless steel), hence it was important to find out the correct materials that need to be used when making these needles to avoid any corrosion. If there is corrosion it can lead to cytotoxicity and therefore implicate the safety of the patient being treated (Choi et al., 2019). A study looked at the critical point of corrosion of two types of needles with different thicknesses stimulated with EA for 60 minutes on rats (Choi et al., 2019). Overall the study found that uncoated stainless-steel needles are appropriate for the use in clinical settings, and no relationship was noted between corrosion and tissue necrosis thus indicating a low risk with the use of EA (Choi et al., 2019).

It is important to understand that with any treatment modality there are risks associated. Skin pigmentation, vertigo, vomiting, chest tightness, unconsciousness, and skin pigmentation were among the often-reported side effects of electroacupuncture, according to a systematic review that examined 37 studies on the

subject (Park et al., 2020). Of these adverse effects majority (62%) showed full recovery, 6% had partial recovery and 6% resulted in death (Park et al., 2020).

Due to the application of EA, there are some precautions and contraindications that need to be considered. Due to the analgesic effects of EA, patients may not feel the pain and therefore need to be educated on restricting physical activity after the treatment to avoid risking injury (Lee, 2008). Furthermore, elderly patients should be advised on getting someone to fetch them from their appointment as they may experience post treatment drowsiness (Lee, 2008). Lastly, caution must be taken with high amplitude EA near acute strains/sprains as the contractions or twitches may irritate the area (Lee, 2008). Contraindications of EA include the use of EA in the left chest region in patients with cardiac pacemakers, EA in the lower abdomen area in pregnant women and high frequency or high amplitude EA in patients with hypertension (Lee, 2008). Other contraindications include not stimulating the carotid sinuses or recent fracture sites, avoiding the eyes and other sensitive areas and avoiding patients with demand-type pacemakers (Walsh, 2010).

2.9 Current evidence on electro-acupuncture in neuromusculoskeletal conditions

Osteoarthritis (OA) is a common neuromusculoskeletal condition in the elderly with knee OA being one of them (Shim, Jung & Kim, 2016). A systematic review looked at the effect of EA on knee OA and found that EA improved the pain intensity better than drug therapy or sham EA (Shim, Jung & Kim, 2016). Furthermore, it improved the overall quality of life of knee OA patients compared to control interventions (Shim, Jung & Kim, 2016). However, this systematic review had a few factors contributing to the heterogeneity, specifically the variation in acupuncture points used as well as the difference in EA frequencies utilised (Shim, Jung & Kim, 2016). Studies also found a reduction in pro-inflammatory cytokines and cartilage degradation biomarkers in patients treated with knee OA that were specifically treated with EA (Shi et al., 2020).

Carpel tunnel syndrome (CTS) is a condition in the wrist affecting the median nerve resulting in pain, numbness, tingling and weakness in the wrist (Chung et al., 2016). Splinting is often used as a conservative method when addressing CTS (Chung et al., 2016). A study found that combining EA with nocturnal splinting showed significant

improvements in disability and dexterity (Chung et al., 2016). A meta-analysis looking at the efficacy of EA in CTS found that EA showed an improvement in the visual analogue scale score and functional status scale and overall was found to be safe and effective (Li, Yan, et al., 2022). It is important to note that the control groups of the included studies were not uniform and the description of EA parameters were not specified in the included studies (Li, Yan, et al., 2022).

Neck pain is a frequently experienced musculoskeletal condition, with myofascial pain syndrome being a common source of symptoms (Eslamian et al., 2020). A study therefore looked at the efficacy of EA in these patients and found that compared to normal acupuncture, EA had a better improvement in local pain (Eslamian et al., 2020). They also found that 6 sessions of EA not only improved pain but also improved cervical range of motion in these patients (Eslamian et al., 2020).

Lateral epicondylalgia a musculoskeletal condition that affects the outer region of the elbow specifically the extensor tendon, is a common condition of the upper extremity (Navarro-Santana et al., 2021). Therapies for it include injections (corticosteroid & platelet rich plasma) however their effects have been questioned (Navarro-Santana et al., 2021). A study therefore looked at the effect of EA and manual acupuncture (MA) on this condition, however low levels of evidence were found in support of acupuncture and no evidence was found to support EA in terms of pain, disability and strength (Navarro-Santana et al., 2021). This was different to an older study that found a significant reduction in pain and improvement in grip strength in patients treated with EA in comparison to patients that received manual acupuncture with chronic tennis elbow (Tsui & Leung, 2002). In addition to OA, CTS, neck pain and lateral epicondylalgia; EA has also been used in the treatment of LBP.

2.10 Aetiology and risk factors of Lower back Pain

LBP is a common musculoskeletal condition experienced by many people at least at some point in their life. Disc, facets, joints, ligaments, bones, neural structures and blood vessels could be one of the many sources of dysfunction in patients experiencing LBP (Hoy et al., 2010). Although extensively researched, the exact aetiology of LBP is still not known, despite being mainly idiopathic many risk factors of LBP have been identified (Cole& Grimshaw, 2003). Most studies found that lifestyle and personal characteristics were related to the development of LBP, however certain studies also

found that mechanical risk factors also played a role (Cole & Grimshaw, 2003). Some of the risk factors include age, fitness, smoking, excess body weight, strength of abdominal and back muscles and lastly psychosocial factors such as anxiety and stress (Cole & Grimshaw, 2003). Lifestyle factors such as a sedentary lifestyle can also influence the occurrence of LBP, this includes sitting for long periods or decreased physical activity levels (Rozac & Miksic, 2021). These results were further supported by another study which found a significant correlation between reoccurring LBP and a sedentary lifestyle (Citko et al., 2018). Research suggests that patients often have a reoccurrence of the episodes and some do not have complete resolutions of their symptoms (Woolf & Pfleger, 2003).

2.11 Prevalence of Lower back Pain

The lifetime prevalence of LBP is around 38% and the point prevalence 18.3% worldwide (Hoy et al., 2012). Furthermore, lower back pain accounts for 2.5% of DALYs globally (Institute for Health Metrics and Evaluation, 2019). It is evident that LBP has a high prevalence, and these percentages are even higher in African nations with the lifetime prevalence around 47% and the point prevalence 39% (Morris et al., 2018). The higher prevalence in African countries could be due to the fact that African health care budgets are underprepared to deal with the management of LBP (Morris et al., 2018). When considering these percentages, it is important to note that some bias does exist as not all African countries were considered and majority of the studies were conducted in Nigeria and South Africa (Morris et al., 2018). Specifically in a province in South Africa named Kwazulu-Natal (KZN), CLBP has an overall prevalence of 18.1% (Kahere & Ginindza, 2021). They also found that the prevalence of CLBP in females were more than males in KZN (Kahere & Ginindza, 2021). This is further supported by a systematic review that looked at LBP prevalence, and found that it was more common in females than in males especially around the ages of 40 to 80 (Hoy et al., 2012).

2.12 Evidence on current treatment approaches to Lower Back Pain

2.12.1 Evidence levels for acute lower back pain

LBP has become increasingly problematic around the world, physiotherapy treatment approaches have changed over time with a larger focus on non-pharmacological and non-invasive methods (Shipton, 2018). The American physical therapy association

released and updated guideline on the management of acute and CLBP management (George et al., 2021). The levels of evidence were rated from A-D with A being the strongest evidence and D conflicting or no evidence, furthermore the types of studies were rated from I-V with I being high quality studies and V being expert opinions (George et al., 2021). Regarding exercise in patients with acute LBP without referral into the leg, there was a level C recommendation for specific trunk strengthening whereas with referral into the leg there was a level B recommendation for trunk, muscle strength and endurance exercises of the back (George et al., 2021). Manual therapy had a Level A recommendation for thrust and non-thrust mobilisation and a Level B recommendation for soft tissue mobilisations in patients with acute LBP (George et al., 2021). Lastly active patient education including self-management strategies rather than passive strategies had a level B recommendation for acute LBP pain patients (George et al., 2021).

2.12.2 Evidence levels for chronic lower back pain

In terms of CLBP with no referral into the leg, there is level A evidence for a combination exercise strategy including trunk, endurance, aerobic, aquatic and general exercise (George et al., 2021). Furthermore, CLBP patients with referral into the leg showed a level A recommendation for specific trunk activation and movement control exercises (George et al., 2021). This is supported by research that found that LBP persisting over 12 weeks should include exercise as the first line of treatment (Shipton, 2018).

In patients with CLBP a combination of one to two sessions of Pilates or strength exercises, less than 60 minutes of core or mind body exercises and a training programme were found to be the most beneficial (Fernández-Rodríguez et al., 2022). Thrust and non-trust mobilisation had a level A recommendation for CLBP with no referral into the leg, and level B for CLBP with a referral (George et al., 2021). Furthermore, soft tissue mobilisation had a level B in conjunction with other treatments and acupuncture a level C for patients with CLBP (George et al., 2021).

Lastly pain neuroscience education along with other physiotherapy interventions such as exercise and manual therapy had a level A recommendation for patients with CLBP, in comparison to a level B recommendation for standard education strategies (George et al., 2021). These education strategies could relate to the fact that addressing

psychosocial factors had a strong association with reducing pain and disability in patients with LBP (Shipton, 2018).

2.12.3 Evidence for Pilates, yoga and walking

Pilates, yoga and walking are also forms of exercise that has become more popular in patients with LBP (Shipton, 2018). A systematic review looking at Pilates found that it was an effective rehabilitation method to help reduce pain and disability (Shipton, 2018). This was further supported by a meta-analysis that found Pilates to be the most effective for reducing pain and disability in CLBP, especially if it is carried out 1-2 times a week (Fernández-Rodríguez et al., 2022). Yoga on the other hand had benefits in CLBP in some people but with others it increased their pain (Shipton, 2018). Lastly walking had moderate evidence to support its use in improving pain and decreasing disability and the benefit is that it was easy to carry out (Shipton, 2018). Overall, each patient is different and therefore it is important to consider the patient's needs, abilities and preferences when prescribing exercise as a treatment (Shipton, 2018).

2.12.4 Pelvic floor exercises

Pelvic floor exercises are another type of exercise used in the conservative management of LBP (Kazeminia, Rajati & Rajati, 2023). Kegel exercises were introduced in 1948 to prevent weaking of the pelvic floor and over the years its efficacy in improving LBP has been studied (Kazeminia, Rajati & Rajati, 2023). Kegel exercises involve contracting and relaxing the pelvic floor muscles, first the muscles need to be identified by contracting the muscles we use to stop urination (Kazeminia, Rajati & Rajati, 2023). Once identified the exercise can be done in various positions with varying intensities (Kazeminia, Rajati & Rajati, 2023). The pelvic floor has 3 layers and consists of 12 muscles that run from the pubic symphysis to the walls of the coccyx and ileum, due to its positioning any weakness in this area can result in LBP (Kazeminia, Rajati & Rajati, 2023). A meta-analysis published in 2023 found that pelvic floor strengthening exercises significantly reduced LBP and also had a positive effect on pelvic organ prolapse, urinary incontinence and overall quality of life (Kazeminia, Rajati & Rajati, 2023).

2.12.5 Mckenzie Method

The Mckenzie method of Mechanical Diagnosis and Therapy (MDT) is another type of treatment method used in LBP and is based on the directional preference of the patient (Lam et al., 2018). The directional preference can be described as the patient's preferred direction in which their symptoms improve with repeated movements or sustained positions (Lam et al., 2018). A meta-analysis looking at the efficacy of this type of treatment found that in acute LBP there was no difference in disability compared to other treatments, however there was a larger improvement in pain compared to a combination of manual and exercise therapy (Lam et al., 2018). This was slightly different in chronic pain which found that MDT had a larger improvement in pain and disability when compared to manual therapy and exercise therapy alone, but had similar effects to the combination of manual and exercise therapy (Lam et al., 2018). The efficacy of MDT over manual therapy was also seen in a systematic review which compared them in patients with CLBP, however the reliability of this study was questionable due to the limited blinding of the involved studies (Namnaqani et al., 2019).

2.12.6 Complementary Alternative medicine (CAM)

CAM is the choice of treatment in over one third of patients with LBP, the choice of CAM could be attributed to the empathy and understanding that patients felt they received from CAM practitioners (Chou et al., 2018). Furthermore, patients also felt a sense of dissatisfaction from normal health care practitioners regarding the poor communication on the aetiology of LBP and the lack of treatment options (Chou et al., 2018). CAM involves a wide spectrum of therapies as explained above, one of the most common types of CAM therapy used in LBP is Traditional Chinese Medicine (TCM) and the most popular type of TCM treatment included acupuncture (Tsang et al., 2017). The popularity of this modality could be attributed to the increased use of acupuncture by conventional medical professionals (Tsang et al., 2017).

Around 25-30% percent of pregnant women with LBP use some mode of CAM therapy to manage their LBP (Close et al., 2014). Studies noted that part of the reason for this choice was due to the belief that it was safer and allowed for greater control specifically with the childbearing experience and it aligned with their health beliefs (Close et al., 2014). A systematic review found statistically significant improvements in patients with LBP that were treated with acupuncture in comparison to the control treatments such

as sham treatment, usual care, stabilizing exercises and physiotherapy (Close et al., 2014).

Due to the high burden of LBP, a systematic review looked at if an integrated model of treatment combining CAM and conventional medicine would be more effective in treating LBP (Kizhakkeveettil, Rose & Kadar, 2014). The studies were categorised into clinically effective if the outcome measures used in that study showed a significant difference using a p-value of less than 0.05, taking that into consideration the results showed that an integration of CAM and conventional medicine was more effective than either modality on their own (Kizhakkeveettil, Rose & Kadar, 2014). Furthermore, CAM combined with active care rather than passive care was found to be more effective in this integrated approach (Kizhakkeveettil, Rose & Kadar, 2014).

Research has found that patients tend to consult with both CAM and conventional therapists however they often do not inform their physician if they use any CAM treatments (Ng & Gilotra, 2021). Studies also noted that patients go to the internet for advice on CAM treatments for LBP (Ng & Gilotra, 2021). An assessment of the quality of information from these sites found that recommendations for LBP often included the strengths of CAM but not the weaknesses, some sites made recommendations that had minimal scientific background and could be dangerous (Ng & Gilotra, 2021). However, acupuncture was the most popular type of CAM therapy recommended for LBP (Ng & Gilotra, 2021).

In the United States research found that at least 40% of the patients suffering with LBP reported using CAM, and majority of these patients found a large benefit from using it (Ghildayal et al., 2016). They also found that there was a higher CAM use in patients with limiting back pain in comparison to those without limiting back pain, which could be due to the exhaustion of any other treatment options (Ghildayal et al., 2016). Overall, many patients with LBP are interested in trying treatment methods that are outside of the conventional medical spectrum (Sherman et al., 2004). Lastly, of the CAM treatments available, acupuncture seems to be the most popular choice.

2.12.7 Electro-acupuncture

Recent studies have shown the increased use of CAM in patients with LBP (Ghildayal et al., 2016). A randomised trial comparing EA to sham in patients with CLBP found a

significant improvement in disability in patients treated with EA (Kong et al., 2020). EA in combination with drug therapy also seems to improve the autonomic status of patients with CLBP as well as reduce their pain (Shankar et al., 2011). Patients with CLBP seem to show an involvement of the autonomic nervous system, some studies found an increase in sympathetic tone and decrease in vagal tone in these patients (Shankar et al., 2011). This being said, the exact relationship between a reduction in pain and changes in the autonomic status is yet to be researched (Shankar et al., 2011).

People often use a variety of techniques to help improve their LBP, a single subject case study found that when EA was combined with exercises and other CAM modalities, the intensity and consequences of the patients LBP could be managed (Koski, Dunn & Shebuski, 2009). This was further supported by a randomised control trial that looked at EA combined with exercise compared to just exercise alone in patients with CLBP (Yeung, Leung & Chow, 2003). The study found a significant reduction in not only pain but also disability in the EA and exercise group which was maintained at 3 months follow up (Yeung, Leung & Chow, 2003). They attributed the positive results to research that found EA may accelerate the central nervous system's release of opioid peptides (Yeung, Leung & Chow, 2003).Although some positive results were noted by Yeung, Leung & Chow (2003), a study by Penza *et al.* (2011) found that when using EA to treat patients with chronic painful neuropathy there was no efficacy found with regards sleep, quality of life and neuropathic pain.

Transcutaneous electrical nerve stimulation (TENS) is another electrical modality that is commonly used in musculoskeletal disorders to help reduce pain through the descending inhibitory system of the central nervous system (Vance et al., 2014). A study that compared the effectiveness of EA to TENS in patients with LBP, found an improvement in pain in both groups however the improvement in the EA group was greater than the TENS group (Tsukayama et al., 2002). The study also found that the EA group showed an improvement in the Japanese orthopaedic association score which looks at the subjective symptoms and limitations of daily activities (Tsukayama et al., 2002). Interestingly acupuncturists working with CLBP patients in the United States reported that the reason behind using EA was due to the fact that simpler methods did not work (Langevin et al., 2015).

2.13 Conclusion

The conservative management of LBP is constantly evolving, and more people are seeking the use of CAM. With acupuncture being one of the most popular choices and the use of EA increasing in musculoskeletal conditions, the understanding behind the physiological mechanisms of EA, the correct dosage and the use of EA in LBP may be useful information to clinicians into understanding this treatment modality as a whole.

Chapter 3 Methods

3.1 Introduction

The aim of this study was to map literature on the use of EA in the treatment of LBP. This chapter describes the scoping review process and includes the research design, search strategy, extraction of results, data analysis and ethical considerations.

3.2 Study Design

This scoping review was conducted in accordance with the JBI methodology for scoping reviews (Peters et al., 2015). Scoping reviews allow for the exploration of literature and therefore a scoping review methodology was chosen for this study. EA in LBP is still being researched and therefore this methodology allowed for the exploration of any possible literature, including grey literature on EA in LBP (Peterson et al., 2017).

Following the JBI guidelines for scoping reviews, there was a preliminary search conducted at the protocol development stage. A preliminary search prior the initial search of CLINAHL, MEDLINE, the Cochrane Database of Systematic Reviews, and JBI Evidence Synthesis was conducted and no scoping reviews (published or in progress) or systematic reviews mapping this topic were identified (Peters et al., 2015). This confirmed the need to conduct such a study.

3.3 Inclusion Criteria

3.3.1 Types of studies

All studies from 2013 (the year after a systematic review was published on acupuncture) until 2023 that focused on EA in LBP were included. Open-source articles, as well as those available through the University of the Witwatersrand library were also included. Published and unpublished literature were included. Studies in English, including those translated, were included. Animal-based studies were also included provided that they provided information pertaining to the objectives of the study. The types of studies included; experimental, observational, descriptive, mixed methods, comparative and systematic review studies.

3.3.2 Concepts

This scoping review reports on the following concepts; treatment parameters, treatment outcome measures, treatment application and treatment outcomes (pain, function and muscle influence) of EA in the management of LBP.

3.3.3 Context

This scoping review did not limit the studies to a specific geographical location and all studies published worldwide were included. All relevant studies conducted in any setting including inpatients and outpatients were included. Studies that involved professionals that are not a physiotherapist to administer electro-acupuncture were also included provided that the professional was qualified in the administration of electro-acupuncture.

3.4 Exclusion Criteria

Studies were excluded for the following reasons; studies published before 2013, studies that did not have a professional qualified in the administration of EA, studies published in another language that did not have a translation and studies that did not provide information on the objectives of the review.

3.5 Types of sources

This review included literature published since 2013 relevant to the current topic including both published (journal articles, book chapters) and unpublished literature (dissertations and theses).

3.6 Search Strategy

A three-step search strategy was utilized in this review to ensure a comprehensive search as recommended by the JBI guideline (Peters et al., 2015). The search strategy was comprehensive and aimed at gathering relevant information from both published and unpublished literature.

Step 1: An initial limited search of MEDLINE (PubMed) and CINAHL was undertaken. This initial search used key words taken from the research title, research question, aims and objectives. Initial keywords used were “Electro-acupuncture” AND “Lower back pain”.

Step 2: Following the initial search, an analysis of the text words contained in the title and abstract of retrieved papers and the index terms used to describe the articles were noted (Peters et al., 2015). The index terms and text words identified were linked to two concepts as presented in Table 3.1: initial concept is related to electro-acupuncture and concept 2 is related to lower-back pain

Table 3.1 Keywords and search terms used in the search strategy

Terms connected by “OR”		Terms connected by “OR”
Lower back pain Lumbago Low back ache Sciatica	“AND”	Electro-acupuncture Electrical acupuncture

A second search using all identified keywords and index terms was then undertaken across all the included research databases. Databases for the second search were ClinicalKey, Cochrane Library, Google Scholar, Physiotherapy Evidence Database (PEDro), ProQuest Health, EBSCO, Science Direct, SPORTDiscus with Full Text and Scopus. Other databases that were searched included OpenGrey, Mednar and Greylit for any grey literature. Appendix A outlines the full search strategy of one database (Cochrane) as required by the PRISMA-ScR checklist for scoping reviews (Tricco et al., 2018).

Step 3: Lastly the reference lists of all identified reports and articles were searched for any possible additional studies.

3.7 Study selection and inclusion

The records identified through database searching totalled (n=3872). Additional records (n=9) were identified through other sources, including reference list searching. Records were upload to Mendeley to assist with the data collection process. Duplicate records were removed (n=991), which resulted in records 2890 (n=2890) for screening. Titles and abstracts were screened for assessment against the inclusion criteria by the researcher and an independent reviewer to reduce reviewer bias in line with JBI protocol, any disagreements were resolved through a discussion to reach consensus

and a third reviewer was not required. This resulted in 2766 exclusions based on inclusion criteria and further (n=40) that the main researcher was unable to retrieve. Full-text review by the main researcher of (n=84) papers for eligibility resulted in a final of (n=43) papers suitable for inclusion in this scoping review. Appendix B lists the full-text articles excluded with reasons. The study selection and inclusion process are presented in the PRISMA flow diagram (Figure 3.1) (Moher et al., 2009).

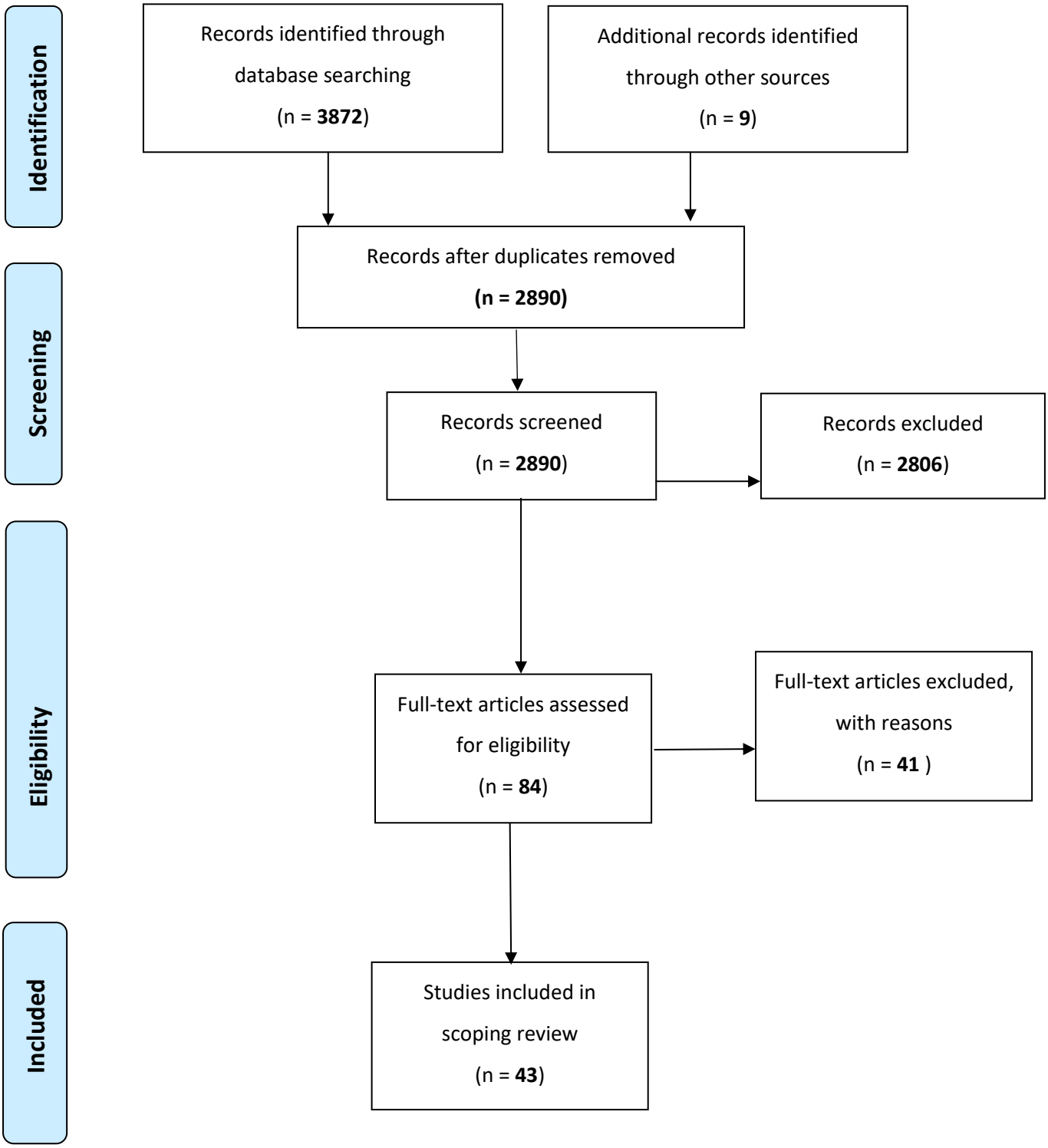

Figure 3.1 Flow Diagram of study selection and inclusion process (Moher et al., 2009)

3.8 Extraction of results

The data extraction process of the study involved documenting information in relation to the research questions, aims and objectives. The data was extracted by the main reviewer through a data extraction table that was developed in the protocol stage of the research process. The following information was collected: author(s), study title, study design, year of publication, origin/country of origin (where the study was published or conducted), aims/purpose, study population and sample size, treatment modalities used, outcome measures, treatment parameters and treatment outcomes of the research study. A pilot study was not conducted prior to this review.

3.9 Ethical Considerations

This research study is a scoping review and all information gathered was done through publicly accessible channels to address the research objectives. No human participants were involved in this study; therefore, according to the University of the Witwatersrand's Human Research Ethics Committee, an ethical clearance certificate or waiver was not required for this scoping review. However, the inclusion of any grey literature was allowed to reduce the risk of both publication and search bias. Lastly in order to maximise the ethical impact of the review results the researcher has allowed no personal biases to influence the interpretation of review findings (Suri, 2020).

3.10 Conclusion

This chapter outlined the methodology section of this research report in line with JBI methodology for scoping reviews. Furthermore, this chapter described the search strategy used as recommended by the JBI guideline and thereafter the management of the data collected. Lastly a summary of the study selection and inclusion process is presented in the form of a PRISMA flow diagram.

Chapter 4 Results

4.1 Introduction

This chapter will provide a detailed analysis on the information extracted from the included articles of this study with specific regards to the objectives. It will look at the characteristics of the included studies in the form of charts and tables and furthermore will present the main findings of the studies in both a descriptive and tabular or graph format.

4.2 Characteristics of included studies

A data extraction sheet (Appendix C) presents an overall summary of each included article in this review. All 43 articles included were published between 2013 and 2022. The study designs of the articles were mostly experimental (n=30), descriptive study design (n=6), observational studies (n=2), comparative studies (n=2), mixed methods (n=2) and a systematic review (n=1). Figure 4.1 presents this data in the form of a pie chart.

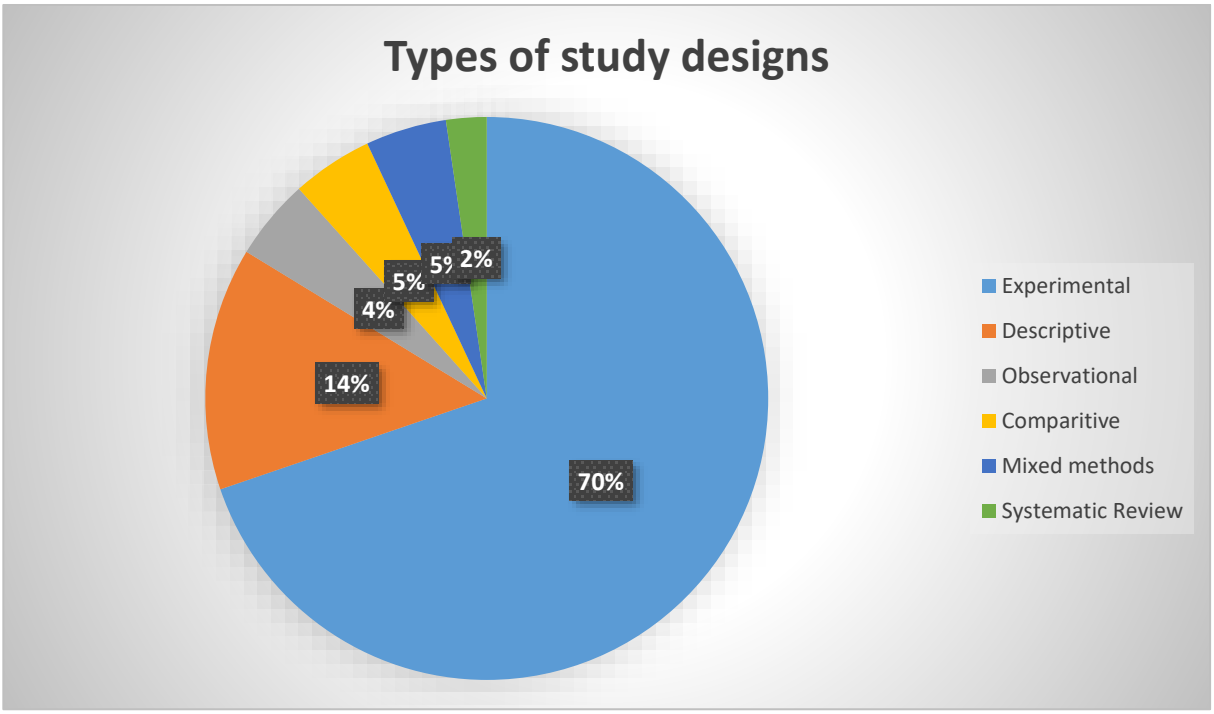

Figure 4.1 Pie chart showing the percentage of the types of included study designs

Most of the included studies were in China(n=17), other counties included South Korea (n=5), America(n=4), Brazil (n=4), Japan(n=3), Taiwan(n=1), New Zealand(n=1), Egypt (n=1), Australia(n=1), Iran(n=1) and India(n=1). Figure 4.2 indicates the origins of these studies.

Figure 4.2 Choropleth world map indicating origins of included studies

Majority of the experimental studies were done on human participants (n=29); however, some studies were done on either rats (n=5) (Aval et al., 2016; Fang et al., 2018; Jin et al., 2021; Huo et al., 2022; Li et al., 2022) or rabbits (n=2) (Huang et al., 2015; Sun et al., 2013). Human subjects were not used in these studies as they were physically more invasive regarding testing and some studies required parts to be harvested or the animal to be sacrificed. These non-human studies were included as they provided valuable information pertaining to the objectives of the study. The terminology used when referring to electroacupuncture did not differ much in the included studies with only (n=2) studies referring to “electrical acupuncture” and the rest to “electroacupuncture”.

4.3 Review findings and results synthesis

4.3.1 Outcome measures

Human research studies looking at the impact of EA in LBP may use different outcome measures to do so. Within the included studies some of the common outcome measures described is outlined in Table 4.1 below

Table 4.1 Common outcome measures measuring the impact of EA in LBP

Outcomes	**Outcome Measure**	**Percentage of studies**
Pain Intensity	• Visual Analogue scale (VAS) • Numerical Pain Rating Scale (NPRS)	• 37.2% • 11.6%
Functional Disability	• Oswestry Disability Index (ODI) • Roland Morris Disability Questionnaire (RMDQ)	• 16.3% • 11.6%
Health Related Quality of life	• EuroQol Five Dimensions (EQ-5D) • Short Form 36 (SF-36) • Patient-reported outcomes measurement information system (PROMIS)	• 6.9% • 4.7% • 4.7%

Other not so common outcome measures that were also included in the studies can be seen in in the form of a bar graph in Figure 4.3 below. Some of the common outcome measures used for rat/rabbit studies are also included such as; Mechanical paw withdrawal threshold (MPQT), MTT and Tunel Assay, Muscle force displacement value (FDVs), MRI, histological analysis and pain threshold.

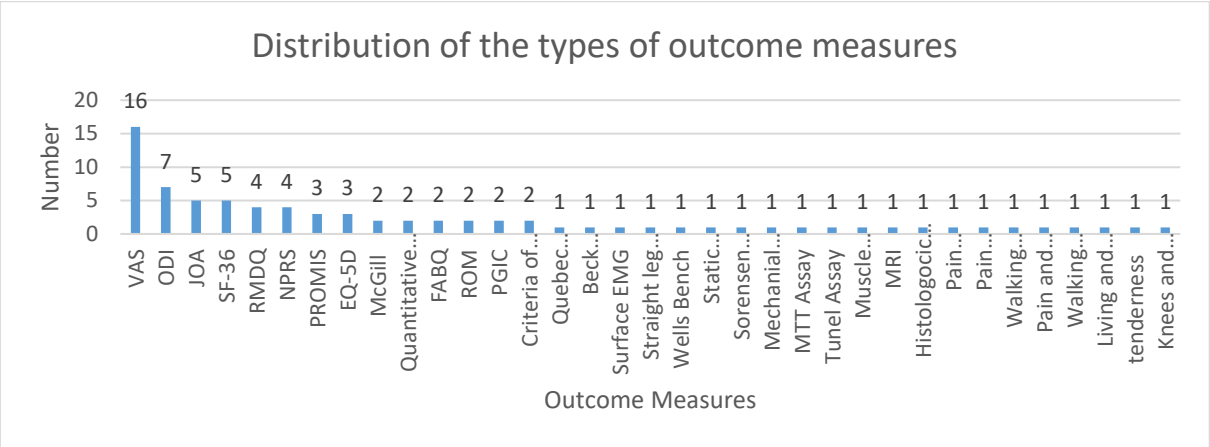

Figure 4.3 Distribution of the number of times different outcome measures were used

4.3.2 Treatment parameters

The treatment parameters described in the studies include the following; acupuncture points/ needle placement, frequency of electrical stimulation, intensity of electrical stimulation and lastly the duration of stimulation. The most common EA point used in the studies was the Jiaji (Ex-B2) acupoint and the second most common point was the BL23 acupoint. Only 33 of the 43 articles described the acupoints used. Figure 4.4 shows the distribution of the acupoints used in the studies.

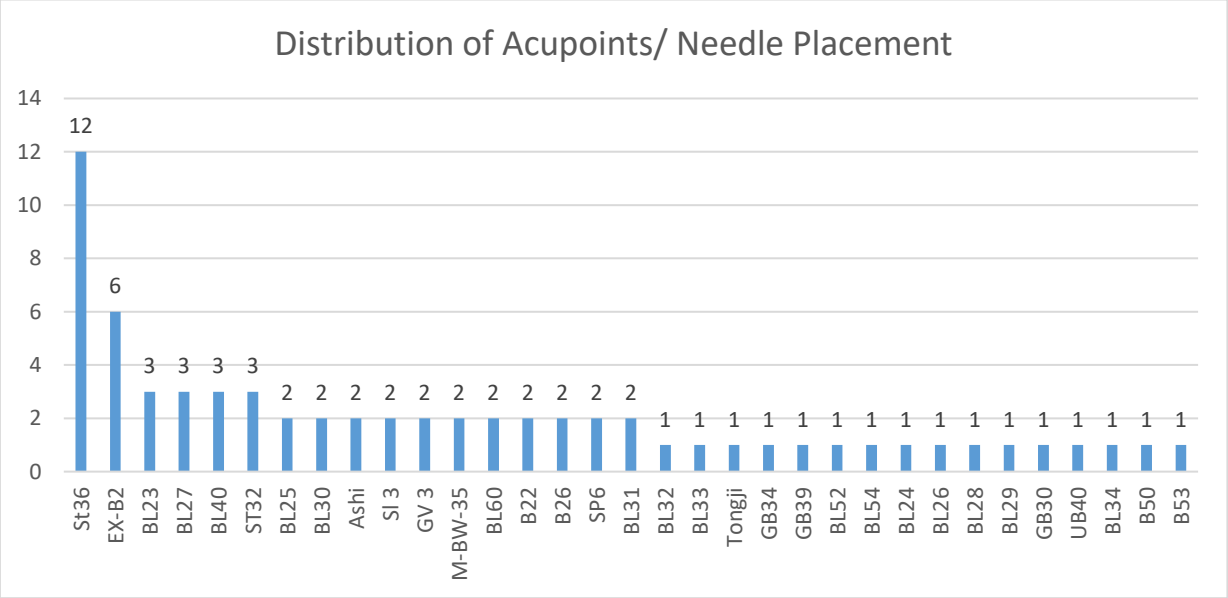

Figure 4.4 showing the distribution of acupoints used in the studies

The next parameter commonly described in the studies is the frequency of the electrical stimulation. Higher frequencies are commonly associated with influencing sensory nerve fibres such as pain, temperature, pressure and touch. Whereas lower frequencies are associated with motor nerve fibres such as weakness and trigger points(Walker, 2022). Within the included studies, the most common used single frequency was 2Hz followed by 10Hz, 50hz and 100Hz, whereas the most common alternating frequency was 2/100Hz. Some studies looked at the effect of more than one frequency and only 34 out of the 43 articles reported on the frequencies used. Table 4.2 below shows the different frequencies and number of studies that used those frequencies.

Table 4.2 Frequency of electrical stimulation used by studies

Frequency	Number of studies
2Hz	9
10Hz	5
100Hz	4
50Hz	4
10/100Hz	1
2/50Hz	1
4Hz	1
2/10Hz	1
1Hz	2
2/100Hz	4
20Hz	2
15/100Hz	1
15/30Hz	1
6/2Hz	1
10/20Hz	1
10/25Hz	1
120Hz	1
15Hz	1

Of the included studies 42% did not report on the intensity of the electrical stimulation. Patient tolerance was used as a guideline by 30% of the studies and the remainder of the studies varied in terms of intensity amounts. Figure 4.5 shows the distribution of the intensity of electrical stimulation.

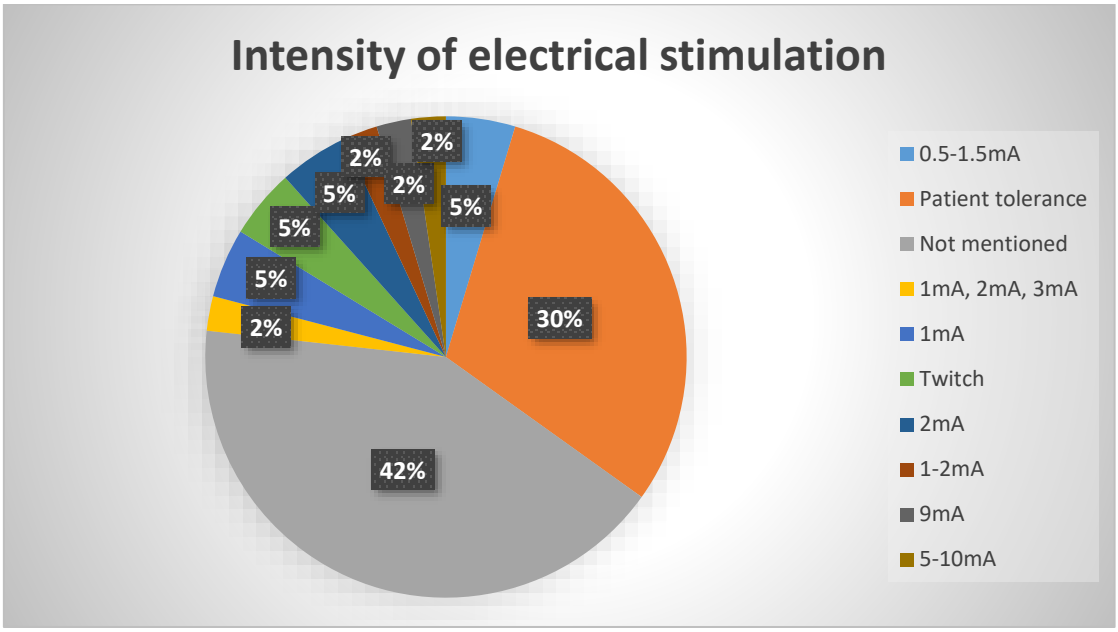

Figure 4.5 Pie chart showing the intensity of electrical stimulation

Many of the included studies did not mention the duration of the electrical stimulation (21%), however of those that did specify the duration; 23% did 30 minutes, 16% did 20 minutes, 14% did 10 minutes, 12% did 15 minutes and five percent did 60 minutes. The remainder times were 45 minutes, 20-25 minutes, 15-20 minutes and frequency dependant and they each made up two percent each of the included studies.

4.3.3 Treatment combinations/comparisons

The included studies mostly (53.5%) involved EA as the sole treatment modality; however, the remainder of the studies looked at a combination or comparison of EA and other treatment modalities used for LBP. Manual acupuncture or electroacupuncture followed by followed by EA or medium frequency electrotherapy was the most common comparison treatment in the included studies. EA and usual care were the most common combination treatment . Table 4.3 shows a summary of the different types of treatment combinations or comparisons.

Table 4.3 Summary of treatment combinations/ comparisons

Treatment types	*No. of studies*
Electro-acupuncture	23
No comparison	2
EA and TENS	1
EA and Usual Care (Medication, physio, Education)	1
EA and Usual Care (Heat, IF, Education)	3
EA or NMES	1
EA or Low-level laser	1
EA and Basic treatment or EA and basic treatment and hydrochloride injection	1
EA and Analgesics	1
EA & Exercise or NMES & Exercise or Exercise	1
EA acupoint or EA no-acupoint or Medication	1
EA & Squat or EA & Soft tissue massage	1
EA or Manual acupuncture	3
EA or Medium Frequency Electrotherapy	2
EA or Acupotomy	1

4.3.4 Treatment outcomes

Only 39 out of the 43 included studies looked at the treatment outcomes of EA in LBP. Treatment outcomes were rated as a positive outcome only if the study stated that outcome measures showed a statistically significant outcome using a p-value of less than 0.05 ($p<0.05$). Considering this rating, 84.6% showed a positive effect of EA in the treatment of LBP and five-point one percent showed no change or effect of EA in the treatment of LBP. Lastly seven-point seven percent showed a positive but not superior effect of EA in the treatment of LBP in comparison to other treatment methods studied. In the studies where EA was not superior, EA was compared to neuromuscular

electrical stimulation, exercise, manual acupuncture and acupotomy. Table 4.3 below shows a summary of the studies that included the treatment outcomes of EA in LBP and specifically outlines the overall effect of EA in terms of LBP treatment.

Table 4.4 Summary of treatment outcomes and overall treatment effect of EA in LBP

Study (n=39)	Treatment Outcomes	EA outcome
(Jin et al., 2021)	EA inhibited the progression of acute pain into chronic pain and raised the mechanical pain threshold.	Positive
(Depaoli Lemos et al., 2021)	When compared to exercise alone or TENS, EA with exercise significantly improved pain, function, and lumbopelvic stability	Positive
(Kuo et al., 2013)	When opposed to a high EA frequency (100 Hz), lower EA frequencies (<10 Hz) may offer steadier and more prolonged antinociception.	Positive
(Kong et al., 2020)	EA had a statistically and clinically significant effect on disability regarding patients with CLBP.	Positive
(Heo et al., 2018)	8-week ODI drop that was statistically significant in the EA plus UC group compared to the UC alone	Positive
(Heo et al., 2021)	EA plus UC treatment reduced pain and restored function more effectively than UC alone.	Positive
(Leite et al., 2018)	Patients with chronic non-specific lower back pain were not able to have central sensitization reduced or quantitative sensory tests altered significantly by EA.	No change
(LI & ZHOU, 2021)	All three wave patterns stimulated by EA effectively improved pain & lumbar function in an acute attack of lumbar disc herniation. Disperse wave was better for pain relief & continuous wave was better for improving lumbar function	Positive

(Xiao-yan et al., 2022)	Compared to NMES, EA may have a prolonged analgesic effect for LBP one/three months following therapy.	Positive
(SHAO et al., 2018)	EA at EX-B2: great improvement in strength and straight leg raises. Conventional acupoint: great improvement in walking ability and skin feeling Best effect time for both was after the first treatment	Positive
(Wu et al., 2021)	EA reduced VAS scores better than MA, but both acupuncture techniques showed efficacy in reducing ROM score and overall, both we better than pharmacotherapy/ placebo in acute LBP patients	Positive
(Awad, Hamid & Allah, 2019)	Statistically significant difference in VAS & ODI in both EA and low-level laser group but a higher improvement in both outcomes were seen in the EA group for patients with post-natal LBP	Positive
(Chia, 2014)	Single Case- Improvement in pain from 5/10 to 3/10 at day 3 and no pain at day 7	Positive
(Yang et al., 2018)	The combination of an injection of sinomenine hydrochloride and EA at Jiaji (EX-B2) points should be better than EA alone.	Positive
(Huang et al., 2015)	EA improved ultrastructure changes in degenerated disc. According to the study, after receiving EA therapy, the degeneration grade on MRI was slightly but considerably reduced.	Positive
(Huo et al., 2022)	In both young and old rats with back muscular injury, EA of Weizhong (BL-40) acupoints shown significant recovery effects. EA also increases satellite cell differentiation and self-renewal potential.	Positive
(Inoue et al., 2012)	Both immediately following the first treatment and three months later, spinal nerve root EA	Positive

	demonstrated a significant improvement in LBP, lower limb discomfort, and lower limb dysesthesia.	
(Kim et al., 2020)	Compared to UC alone, EA and UC combination therapy resulted in better clinical outcomes.	Positive
(Kondo, Miyamoto & Miyakawa, 2014)	EA delayed the multifidus muscle response time, indicating that this method can help people with LBP by improving muscle tone.	Positive
(Kondo et al., 2014)	Following EA stimulation, the percentage difference in the left-right asymmetry and the intensity of lower back discomfort decreased.	Positive
(Kong, 2020)	A statistically significant clinical effect of verum EA versus sham EA was shown in one of the two investigations.	Positive
(Li et al., 2021)	Single Case: Gradual relief after seven sessions of EA & resolution of pain and numbness at one and a half months MRI re-done at 10months confirmed resorption of herniated disc	Positive
(Li, Zhao, et al., 2022)	When lumbar multifidus muscle injury occurs in a rat model, EA can reduce myocyte Ca2+ overload.	Positive
(Liang et al., 2013)	In comparison to traditional EA, the medium-frequency EA had a significantly higher reduction in terms of VAS scores.	Positive
(Liang et al., 2020)	When "Tongi" EA and oral analgesics were combined, there was a noticeable improvement in lumbar function and VAS scores.	Positive
(Salehi et al., 2020)	Pain and disability improved in the EA, NMES and exercise group however the treatment effect was the same across all three groups with one not more superior than the other.	Positive but not superior
(Sun et al., 2013)	EA un-acupoints and loxoprofen sodium tablets were not as effective as EA acupoints in reducing mechanical pressure and increasing motor nerve conduction velocity.	Positive

(Vara, Bhagora & Saiyad, 2015)	17 out of 26 patients had respond positively to EA treatment	Positive
(Ding & Yang, 2015)	EA assisted with squat stances improved walking ability and could prevent reoccurrence of disc herniation	Positive
(de Carvalho et al., 2018)	Single session of EA at two hertz effectively reduced pain intensity but RMDQ was not significantly reduced after one session However, patients with VAS more than 3 that were treated with EA weekly showed a steady decrease in functional disability	Positive
(Fang et al., 2018)	EA had a greater analgesic impact at 100 Hz than it did at 2 Hz.	Positive
(Langevin et al., 2015)	In comparison to brief manual acupuncture, better analgesia appears to be achieved when prolonged electrical stimulation is added to manual stimulation.	Positive
(Kim et al., 2016)	Regarding secondary outcomes and functional improvements, there was no difference observed when comparing the acupuncture and EA group to the control group (usually care).	No change
(Zhang et al., 2017)	The study's findings demonstrated a statistically significant difference between the EA groups and the medium frequency electrotherapy group's changes in leg pain, NPRS, and ODI questionnaire scores during the short- and long-term treatment periods.	Positive
(Comachio et al., 2020)	For patients with chronic lower back pain, EA and MA show comparable effects on pain, disability, quality of life, global perceived effect, and depression.	Positive but not superior
(Yuanzhi & Yaochi, 2015)	The force displacement value increased more in the EA group than in the medication group, indicating that	Positive

	EA is superior to medicine in treating acute lumbar muscle sprains.	
(Zhao et al., 2015)	Pain relief in primary sciatica patients were achieved through electrical acupuncture of the bilateral "Zusanli" points (ST36) for 60 min.	Positive
(Aval et al., 2016)	There was no discernible difference between the acupotomy and EA groups, despite an increase in POMC levels in both groups, which led to an increase in pain reduction.	Positive but not superior
(Lee, 2021)	The effect of the treatment was that the patient could immediately stand up straight and walk with less pain	Positive

*Usual Care (Drug therapy, physiotherapy, educational programme)
*POMC: Pro-Opiomelanocortin

4.4 Conclusion

This chapter highlighted the results of the current study, of the 43 articles included majority of the studies were experimental studies and were published in China. Most of the included studies were completed on human participants however some studies were done on rats or rabbits. Overall, the three most common outcome measures used in the included studies were the VAS scale for pain, ODI and RMDQ for functional assessment and the EQ-5D for health-related quality of life. Treatment parameters were also highlighted in this chapter, specifically acupuncture points, frequency, intensity and duration of the EA treatments. The EX-B2 and BL-23 acupoints were the most common acupuncture points used. 2Hz was the most common single frequency used and 2/100Hz was the most common alternating frequency utilised. In terms of intensity most studies noted that patient tolerance was the benchmark and although many studies did not mention the duration of EA treatment, in those that did 30 minutes was the most frequently used. Lastly in terms of treatment outcomes majority of the included studies showed a positive treatment relationship between EA and LBP, with only a few studies showing no change at all or showing EA was not superior to other types of treatment methods. A discussion of these results will be presented in the next chapter

Chapter 5 Discussion

5.1 Introduction

This scoping review aimed to map the literature regarding the use of EA in the treatment of LBP. The study had three main objectives which involved; describing the outcome measures & treatment outcomes on EA in the treatment of LBP, to describe the EA treatment parameters used in the management of LBP and lastly to describe the types of combination/comparison treatment strategies used with EA in the treatment of LBP. In this chapter the results outlined in Chapter 4 will be discussed relative to the objectives of the study highlighted above.

5.2 Principal findings

The study included a total of 43 studies of which only 39 looked at the effects of EA in the management of LBP. The remaining four were descriptive studies and literature reviews which simply highlighted information pertaining towards the objectives of the study. Overall the current study showed that: (i) VAS, ODI, RMDQ & EQ-5D are the most commonly used outcome measures when looking at the effect of EA in the treatment of LBP, (ii) treatment parameters varied however EX-B2 and BL23 were the common acupoints used, 2Hz was the most common single frequency used and 2/100Hz the most common alternating frequency used, and lastly 30minutes was the most frequent duration utilised, (iii) majority of the studies only looked at EA as the main treatment modality however the most common treatment combination was EA and UC and the most common comparison was EA and MA, (iv) finally the most common treatment outcome was positive for EA in the management of LBP with only a few studies showing no change at all.

5.3 Outcome measures

5.3.1 Pain intensity

The VAS pain scale is one of the most common utilised patient-reported outcome measures (PROM) for pain intensity alongside the numerical rating scale (NRS) (Chiarotto et al., 2019), both are subjective descriptions of pain (Ostelo & de Vet, 2005). According to research, the VAS scale has shown good reliability and both the NRS and the VAS scale are outcome measures with construct validity; both of these factors are important when ensuring the quality of a PROM (Ostelo & de Vet, 2005). Within this study the VAS scale was used by 16 of the included studies for the measurement of pain intensity and NRS was used by five. Due to the efficiency of its administration the NRS is often preferred over VAS by researchers and patients, despite this the VAS scale has been found to be more frequently used in LBP trials (Chiarotto et al., 2019). The smallest change in score that has clinical significance for patients is known as the minimal clinical important change (MCIC) (Kovacs et al., 2008). The MCIC for the VAS scale for acute LBP is around 36.2mm whereas for chronic and subacute LBP its 20mm (Ostelo & de Vet, 2005). The MCIC for NRS is around 3.5 for acute LBP and 2.5 for CLBP (Ostelo & de Vet, 2005). None of the included studies mentioned the MCIC; however, majority of the studies that used VAS or/and NRS as an outcome measure used a P value of less than 0.05 to indicate if the data was significant.

5.3.2 Functional Disability

In the current study the ODI and RMDQ were the most common outcome measures used to measure functional disability with the number of studies being seven and five respectively. Both outcome measures seem to be widely approved in terms of LBP specific measurement tools (Garg et al., 2020) In a study comparing ODI and RMDQ in patients with non-specific LBP, the evidence was not strong enough to show preference of one over the other (Chiarotto et al., 2016). In support of this, both ODI and RMDQ were found to be the most comprehensively validated with respect to responsiveness in a study assessing the dimensionality and responsiveness of outcome measures for patients with LBP (Cleland et al., 2011). However, research has shown that ODI showed better reliability whereas RMDQ had better construct validity (Chiarotto et al., 2016). Interestingly, ODI can be used as a dual outcome measure for

pain and functional assessment however the RMDQ can only be used as the latter (Garg et al., 2020). All five of the articles in the current study that included the RMDQ outcome measure for functional assessment focused on patients with CLBP. This is in line with current research that found RMDQ was both reliable and valid to measure the functional impact of CLBP (Burbridge et al., 2020). Out of the total of seven studies that used ODI for functional assessment, three looked specifically at acute LBP, two at chronic, one at post-surgical and the last one at post-natal LBP. The ODI has been studied extensively and was found to be responsive to change in women with pregnancy related LBP (Ogollah et al., 2019). The ODI has been validated in 14 languages and due to the extensive research on this outcome measure it provides a scoring system with degrees of disability described which in turn provides good interpretability (Vianin, 2008). Lastly ODI has therefore been recommended as a core outcome measure for clinical trials in non-specific LBP (Chiarotto, Boers, et al., 2018).

5.3.3 Health-related quality of life

Aside from pain and functional disability, another important aspect in patients with LBP is their HRQoL. In the current review the EQ-5D was used by three of the included studies, followed by the SF-36 and PROMIS that were each used by two of the included studies in the measurement of HRQoL. The validity and responsiveness of the EQ-5D, a commonly used instrument to assess HRQoL, have been demonstrated in both patients following LBP surgery and those with CLBP (Solberg et al., 2005; Obradovic, Lal & Liedgens, 2013).

On the other hand, the SF-36 was found to be one of the most frequently used tools to measure HRQoL specifically in clinical trials assessing patients with CLBP (Chiarotto, Terwee & Ostelo, 2016). Although extensively studied, the validity and responsiveness of the SF-36 was found to be satisfactory in patients with LBP (Chiarotto, Terwee & Ostelo, 2016). The SF-12 which is a shorter version of the SF-36 but focuses more on physical and mental health, was recommended alongside the EQ-5D to measure HRQoL in patients with LBP due to its construct validity (Chiarotto, Terwee & Ostelo, 2016). Furthermore, the use of SF-12 and PROMIS in patients with non-specific LBP has been recommended as a core outcome measure for HRQoL as they were the closest to the consensus based on a 2-round Delphi survey conducted (Chiarotto, Boers, et al., 2018). Some research has shown that PROMIS may be useful to identify both psychosocial and HRQoL factors in patients with CLBP (Pak, Miller & Cheuy,

2021). Despite all this research, a recent systematic review has found that there is low content validity for the HRQoL outcome measures such as SF-36, EQ-5D and PROMIS, furthermore evidence on the measurement properties of these outcome measures in relation to LBP was inconclusive (Chiarotto, Terwee, et al., 2018).

5.4 Treatment Parameters

5.4.1 Acupuncture points/Needle placement

Acupoints are named based on their anatomical structure and their position (Kim & Kang, 2014). Some of the most common acupoints used by the included studies were; EX-B2(Jiaji), BL23(Shenshu), ST36, BL40, BL25 and Ashi points. EX-B2 and BL23 were used by twelve and six articles respectively and were the highest utilised acupoints in this study. They were followed by ST26, BL40, BL25 and Ashi points which were used by three articles each. The EX-B2 acupoint also known as “Jiaji” are points found on the back of the body 0.5 cun lateral to the lower border of the spinous process(Djaali et al., 2021). EX-B2 and BL23 were amongst the common acupoints utilised in chronic/ non-specific LBP patients (Yuan et al., 2008). Interestingly in this study, EX-B2 was only used in one study that looked at the effect of EA in CLBP and BL-23 by two studies. The reduction in LBP through the EX-B2 acupoints is through the posterior ramus of the spinal cord, which causes blood flow and changes to the sciatic nerve thus stimulating the skin and muscle around the vertebrae (Djaali et al., 2021). EX-B2 is often utilised due to its safety and efficacy in patients with LBP (Djaali et al., 2021).

The BL23 acupoint falls on the bladder meridian and governing vessel and is considered a local acupoint in traditional Asian medicine(Lee et al., 2013). Majority of the uses for the BL-23 acupoint in this review was for CLBP and non-specific LBP patients, of which both showed positive treatment outcomes. These positive outcomes could be attributed to the fact that the this acupoint acts by improving blood flow to tissues which results in tissue recovery and resolution of myofascial dysfunction (Lim et al., 2018). For this reason, the BL23 is a widely used acupoint in LBP and aside from being one of the most common acupoints in CLBP patients, the BL23 acupoint was also found to be effective in reducing LBP in pregnant women in their third trimester (Lee et al., 2013; Sabariyah & Ratnasari, 2022). The efficacy of this acupoint in pain reduction specifically in pregnant women, could be as a result of an increased

endorphin release and reduction in muscle tightness that occurs due to the stimulation of this point (Putrianti, Andini & Karuniawati, 2023).

5.4.2 Frequency of electrical stimulation

The frequency of EA in patients with LBP may vary depending on the patient's condition. In the current study 2hz and 10hz were the most often employed single frequencies with nine studies using 2hz and five of the studies using 10Hz. Interestingly a study looking at the effect of different frequencies of EA on CLBP found that the placebo group had better results than the EA group (Torres, Macedo, et al., 2023). In support of those results, a study by Penza *et al.* (2011) found no efficacy in the use of EA in the treatment of chronic painful neuropathies. These results come as a surprise as Zhang *et al.* (2014) shown that EA can alleviate both inflammatory and neuropathic pain, furthermore EA at a frequency of 10Hz was found to have a longer lasting alleviation of inflammatory pain. Additionally, research has also found that different frequencies of EA can activate different regions in the brain, 2Hz specifically increases 15 areas in the brain and 100Hz around nine regions in the brain (Napadow et al., 2005).

An alternating frequency of 2/100Hz was the most common alternating frequency utilised in the included studies. It is theorised that with an alternating frequency the opioid system activated by 2Hz and the one activated by 100Hz may work in synergy to create an enhanced synergistic reaction, thus resulting in increased nociception (Wang et al., 2005). These effects were seen where an alternating frequency of 2/100Hz was found to be 40 percent stronger in antinociception compared to 2Hz or 100 Hz (Wang et al., 2005).

Lastly it is essential to consider the type of condition being treated when deciding on a frequency to use for EA, as it has been suggested by Walker (2022) that lower frequencies influence motor fibres and higher frequencies affect sensory nerve fibres. This could mean that lower frequencies could influence muscle weakness, trigger points and chronic pain; and higher frequencies may influence pain, temperature and touch (Walker, 2022).

5.4.3 Intensity of electrical stimulation

Although majority of the studies don't mention the intensity of the electrical stimulation, those that did mostly determined the intensity according to patient tolerance which is in line with what Walker (2022) suggested. He also suggested that for motor issues the intensity should be enough to elicit a non-noxious muscle contraction, and for sensory it should be enough to elicit a non-noxious paraesthesia (Walker, 2022). This essentially would mean that the aim is to try achieve the treatment effects without causing adverse effects or severe discomfort. Although only two percent of the included studies used an intensity of above five milliamperes, some research has shown that when a low frequency of EA is applied at a high but sub-noxious intensity, the hypo-analgesic effect is not only significantly larger than the low intensity but also shows a steady increase in the analgesic profile that is maintained post intervention (Barlas et al., 2006). What is important to note in that study, was that it was conducted on pain free volunteers hence it may differ in patients with LBP.

5.4.4 Duration of electrical stimulation

In the current study the duration of electrical stimulation was not mentioned in majority of the included studies, however 30 and 20minutes were amongst the most common that did mention the duration. There have been variable analgesic responses related to the duration of electrical stimulation with EA (Hamza et al., 1999). A parametric study done on EA found that a prolonged stimulation (20minutes) may result in a summation of the central nervous system mechanisms, which in turn can result in a longer analgesic effect (Romita et al., 1997), more specifically an electrical stimulation of 30minutes was found to be the most suitable for patients with LBP (Hamza et al., 1999).

Although a longer duration may result in an extended analgesic effect, studies show that beyond a certain period (longer than 20 minutes) of stimulation there may be a reduction in the analgesic effect (Romita et al., 1997). Hence it is possible that an extended period of electrical stimulation can result in tolerance (Walker, 2022). Research has suggested that the cholecystokinin octapeptide system could be behind the counteraction of the endogenous opioid substance, as this is released during prolonged electroacupuncture stimulation (Hamza et al., 1999). Lastly Walker (2022) suggested that a stimulation of more than 20minutes may stimulate the parasympathetic tone which is often the goal to reduce pain (Walker, 2022).

5.5 Treatment combinations/comparisons

5.5.1 Electro-acupuncture or Manual Acupuncture

Three of the included studies compared EA to MA. The first study found that EA was better than MA in improving VAS but had similar results in terms of range of motion in patients with acute LBP (Wu et al., 2021). These results differed slightly in the second study which looked at CLBP patients, Comachio (2020) found that when comparing MA to EA there were no significant differences in both pain and disability outcomes (Comachio et al., 2020). This difference could be attributed to a combination of the lack of literature on optimal acupuncture parameters and the fact that in most cases EA and MA are used in combination and not as a stand-alone treatment method (Comachio et al., 2020). For instance, prior to electrical stimulation MA is often briefly carried out to obtain “deqi” (unique sensation elicited with acupuncture needling) (Hui et al., 2007), hence those studies are essentially comparing MA to a combination of EA and MA (Langevin et al., 2015). Furthermore, in the clinical trials that compared EA to MA the variable in question was not isolated and there were other confounding factors such as duration of stimulation that may have influenced the outcome, for example in many trials MA is applied for a much shorter duration than the EA (Langevin et al., 2015).

5.5.2 Electro-acupuncture and Usual Care (UC)

Within this review, three of the included studies looked at the combination of EA and UC in comparison to UC alone. Two of the studies used the same types of treatments for usual care whereas the other study differed slightly. The study that differed used drug therapy, physiotherapy and education as their UC group and it was applied to patients with LBP after back surgery (Heo et al., 2018). In that study a significant improvement was seen in ODI scores, indicating functional improvement in the EA and UC combination group in comparison to the UC group alone (Heo et al., 2018). Furthermore, although significant improvements were seen in VAS and EQ-5D in both groups, one group did not show a more significant change compared to the other (Heo et al., 2018). However, these results could be due to the fact that it was a pilot study and thus a small sample size was utilised.

Thereafter, Heo (2021) conducted a randomised controlled trial where the UC group was changed to heat, interferential therapy (IF) and education, and within this study a

significant change was seen in both pain intensity and functional disability in the EA and UC group compared to the UC group alone (Heo et al., 2021). Essentially the aim of the combination types of treatment methods is to target pain using a multimodal approach, rather than having to rely solely on medication which may cause other side-effects and health issues (Heo et al., 2021). Not only is the utilisation of EA in conjunction with UC safe and effective, but it also showed the potential for enhanced cost-effectiveness in the treatment of LBP patients post back surgery (Kim et al., 2020).

The effect of UC and EA together on CLBP has not been studied in the research thus far, however a meta-analysis looking at acupuncture in comparison and in combination with conventional treatment/ usual care in patients with CLBP involved some studies on EA(Giovanardi et al., 2023). Overall, the results were in line with studies done in LBP patients post back surgery, acupuncture in addition to conventional therapy was not only effective in reducing pain, but also disability in patients with CLBP (Giovanardi et al., 2023). These results were slightly different in a pilot study looking at patients with spinal stenosis, the research compared the combination of MA, EA and UC to UC alone and no significant differences were found regarding functional improvement (Kim et al., 2016). However, it is important to note that these results could be attributed to the study being a pilot study. Furthermore, because the term "usual care" is vague and not clearly defined by studies, it may be misunderstood and lose some of its clinical applicability because different therapists may have different interpretations of what it means (Giovanardi et al., 2023). For this reason, it's critical that any future research in this area specifies the particular intervention in detail (Giovanardi et al., 2023).

5.5.3 Electro-acupuncture or Medium Frequency Electrotherapy

Medium frequency electrotherapy (MFE) is a treatment method that involves placing electrodes on the skin and through electrostimulation produces a tingling sensation (Zhang et al., 2017). MFE has the potential to alleviate pain and associated symptoms and can be compared to TENS (Zhang et al., 2017).

Two of the included studies in this review compared EA to MFE, the one study specifically looked at discogenic sciatica patients whereas the other study looked at third lumbar transverse process syndrome. In comparison to MFE, EA was found to have increased clinical effects based on the minimal clinical important difference (MCID) criteria specifically relating to leg pain and dysfunction in patients with sciatica

(Zhang et al., 2017). Furthermore, despite discontinuation of treatment, the treatment effects of EA persisted whereas MFE did not, implying that the long-term effects of EA were superior to that of MFE (Zhang et al., 2017). It is important to note that although the parameters remained the same for both, some heterogeneity exists as MFE is applied through electrodes whereas EA is through needle penetration (Zhang et al., 2017). Additionally, studies indicate that low frequency electroacupuncture may enhance blood flow, which in turn plays a major role in spinal claudication and therefore results in improved walking distance and a reduction in lower limb dysesthesia (Inoue et al., 2005). These results are supported by research which found an improvement in an injured sciatic nerve in rats with sciatica after deep EA stimulation (Liu et al., in press).

The second study compared traditional EA to medium frequency EA in patients with third lumbar transverse process syndrome, this study was slightly different as it used medium frequency EA and not MFE (Liang et al., 2013). However, the results found that due to its substantial effect, shorter time and gentler invasion, medium frequency EA was superior to traditional EA in treating third lumbar transverse process syndrome (Liang et al., 2013). This was further supported in another study which found EA to have a better analgesic effect than acupuncture knife therapy in the treatment of this syndrome (Ni Yu et al., 2014).

5.6 Treatment outcomes

This review included a total of 43 studies of which 39 of the included studies looked specifically at the treatment outcomes of EA in LBP. It was an intriguing discovery that 33 of the 39 trials showed that EA demonstrated a beneficial effect in the treatment of LBP. Of the studies that showed a positive effect of EA in LBP, 22 demonstrated a positive improvement in pain scores. Research has shown that the underlying physiology behind the analgesic effects of EA is through the release of endorphins, strong correlations have been found between beta-endorphin immunoreactivity in the brain and EA induced analgesia (Ulett, Han & Han, 1998). Furthermore, research suggests that EA modifies pain through changes in inhibitory neurotransmitters such as opioids, serotonin and norepinephrine which act on the dorsal horn of the spinal cord following an electrical stimulation (Depaoli Lemos et al., 2021).

When specifically looking at different wave patterns of EA on acute lumbar disc herniation, research has found that disperse-dense wave was the most effective in reducing pain (LI & ZHOU, 2021). According to research the disperse-dense wave is believed to reduce inflammatory oedema, enhance blood circulation and tissue nutrition and lastly boost metabolism, these are all the underlying reasons as to why this pattern is beneficial in pain alleviation (LI & ZHOU, 2021).

Within the studies in this review, when compared to other electrical modalities such as NMES, TENS, low level laser therapy and MFE, EA showed better outcomes in terms of pain relief in patients with LBP. However, with regards to NMES the evidence seems to be controversial, research by Salehi (2020) found there was no significant difference in pain outcomes when comparing NMES to EA in patients with CLBP due to intervertebral disc disease (Salehi et al., 2020). Another study on active-duty personnel with CLBP discovered that although there was no better treatment group for reducing pain intensity short-term, the EA group experienced a greater reduction in pain intensity over the long term when compared to the NMES group (Xiao-yan et al., 2022).

When looking at functional outcomes and improvement in disability in patients with LBP treated with EA, 11 of the 39 articles showed an improvement in these areas. Majority of the functional improvements were seen in patients with disc herniations, followed by non-acute LBP after back surgery and lastly CLBP. Only one study showed functional improvements in patients with post-natal LBP and NSLBP respectively. However, these functional improvements were not seen in a study done on patients with lumbar spinal stenosis, this may be attributed to it being a pilot study (Kim et al., 2016).

Aside from EA being effective in comparison to other electrical modalities, it has also shown a significant improvement on disability outcomes when compared to sham acupuncture specifically in patients with CLBP (Kong et al., 2020). These improvements were measured by the RMDQ which has been found to be both valid and reliable in the measurement of physical functioning in patients with CLBP (Burbridge et al., 2020). Functional outcomes could also be affected by the amount of EA received, de Carvalho (2018) found that although one session improved pain intensity it was not sufficient to improve functional outcomes and reduce disability (de Carvalho et al., 2018). However, when patients were treated for 30 minutes once a

week for three weeks, there was a notable improvement in functional disability (de Carvalho et al., 2018). These results raise awareness into the lack of parameter reporting on EA and thus providing reasoning why other research may have not found enhanced effects of EA when comparing it to sham EA in patients with LBP (de Carvalho et al., 2018).

Five of the included studies in this review specifically looked at the effect of EA in terms of muscle injury or sprain. One of the crucial muscles in the stability of the lumbar spine is the multifidus muscle, it plays an important role in the maintenance of the neutral zone of the lumbar spine, and dysfunction to this muscle group is often related to non-specific LBP (Li, Zhao, et al., 2022). Two of the included studies in this review found that EA may play an important role in improving the functioning of this muscle. The first study noted that the body causes an increase in tonus of the muscles when it is under a threat (Kondo, Miyamoto & Miyakawa, 2014). In this study the multifidus muscle showed a delay in the muscle reaction time after EA, which suggests that EA may influence the muscle tonus of multifidus positively and therefore improve patients with non-specific LBP due to a multifidus injury (Kondo, Miyamoto & Miyakawa, 2014).

The second study found that EA may promote adenosine triphosphate (ATP) expression, help mitochondrial recovery and inhibit over expression of the mitochondrial calcium uniporter (MCU) when applied at the BL40 acupoint (Li, Zhao, et al., 2022). Thus, EA may reduce myocyte calcium overload which occurs due to a multifidus muscle injury (Li, Zhao, et al., 2022). This was further supported in a rat study which showed a significant improvement in back muscle injury after EA was stimulated at the BL40 acupoint (Huo et al., 2022). The muscle repair occurs due to the enhanced satellite differentiation and self- renewal capacity after being stimulated by EA (Huo et al., 2022).

Another important muscle group in LBP is the erector spinae, research has suggested that asymmetry in this muscle group plays a significant role in LBP (Kondo et al., 2014). A study by Kondo (2014), found an improvement in trunk asymmetry during flexion after stimulation of the erector spinae with EA (Kondo et al., 2014). Due to its attachments in the lumbar spine and the front of the hip, the psoas is the last muscle group implicated in lower back pain (LBP), particularly in individuals who sit for extended periods of time (Lee, 2021). Patients with CLBP have been found to have a

larger cross-sectional area of the psoas major muscle compared to those without, indicative of increased activity of the muscle due to instability of the lumbar spine (Arbanas et al., 2013). A single case study looking at the effect of EA in patients with LBP due to the psoas muscle, found positive results in both pain (patient could stand up straight) and functional outcomes (patient could walk further without pain) (Lee, 2021).

Lastly of the included studies that measured treatment outcomes, only two studies showed no change in terms of the EA outcome in LBP. The first study was specifically regarding quantitative sensory testing (QST) in patients with chronic non-specific LBP (Leite et al., 2018). QST is a technique that has been used to measure central pain processing, it utilizes temporal summation which calculates spinal cord level ascending pain facilitation (Kong et al., 2018). In the study ten sessions of EA were unable reduce central sensitisation, hence no significant changes were seen in QST in patients with chronic non-specific LBP (Leite et al., 2018). The second study looked at the effect of EA on lumbar spinal stenosis, the study found no functional improvements in the EA and UC combined group in comparison to UC alone (Kim et al., 2016). However, this study was a pilot study and is therefore not equipped to detect significant changes in outcomes (Kim et al., 2016). These results were contrary to a case series which found significant improvements in lower limb symptoms after spinal nerve root EA in patients with lumbar spinal stenosis (Inoue et al., 2012). The improvement in lower limb symptoms could be attributed to the fact that EA improves intermittent claudication, however it must be noted that this treatment method is more invasive and therefore carries higher neurological risks (Inoue et al., 2012).

When considering the information presented in this review, it is important to note that the findings extrapolated from the articles need to be interpreted with caution. This review has confounding variables that may influence the interpretation of the results. The articles included in this review underwent an additional independent researcher review at the abstract phase only, this process was not repeated during the full-text review hence increasing the risk of selection bias. Furthermore, the articles included in the final study did not undergo a critical appraisal process, hence the validity and reliability of the studies cannot be commented on.

Chapter 6 Conclusion and Recommendations

6.1 Conclusion

Due to its influence on the opioid system, EA has become increasingly used in musculoskeletal disorders such as CLBP, it is believed to reduce the reliance on medications such as non-steroidal anti-inflammatories (Sung et al., 2021). Furthermore, research has suggested that in comparison to other conventional therapies, EA is safer and less expensive (Depaoli Lemos et al., 2021). Due to the disability associated with LBP and the increased use of EA in musculoskeletal conditions, this scoping review was carried out to map the literature on EA in LBP. Specifically covering the treatment combinations/comparisons to EA, outcome measures, EA parameters and lastly EA treatment outcomes in patients with LBP. A search of the literature within the last 10 years resulted in the inclusion of 43 articles. The current study did not limit the research to published data and no methodological assessments of the studies were carried out in this review, hence the results of this study is to be interpreted with discretion.

An overall review of the literature within this study highlighted some important information regarding EA in patients with LBP. Of the outcome measures used in LBP, the VAS, ODI, RMDQ and EQ-5D were the most commonly used in order to measure treatment outcomes in patients with LBP treated with EA. The use of these outcome measures is consistent with recent studies mentioned in section 5.3 of this review.

Previous studies have noted the need for clinical trials exploring the relationship between EA parameters and therapeutic efficacy (Torres, Brandt de Macedo, et al., 2023). In this review EA parameters were only reported in 33 of the 43 included studies. Common parameters in this review included the BL23 and EX-B2 acupoints, 2Hz single frequency and 2/100Hz alternating frequency, 30minutes duration and lastly patient tolerable intensity.

In line with research this review found MA to be the most commonly compared treatment modality to EA in the treatment of LBP, however the efficacy of one over the other could not be determined. In terms of combination treatments, EA and UC were the most common combination treatments with some research showing significant

changes in treatment outcome measures such as VAS and ODI (Heo et al., 2021) . However, Heo *et al.* (2018) showed significant but not superior improvements in VAS when compared to UC alone. These results are to be interpreted with caution as the UC treatment was not standardised across the studies. Lastly 39 of the 43 included studies specifically reported on treatment outcomes and overall, EA showed positive results in the treatment of LBP. Taking into consideration the above information on EA in LBP, further studies regarding the efficacy of EA in LBP and the standardisation of treatment parameters is highly recommended.

6.2 Strengths and Limitations

This study followed the JBI guidelines for scoping reviews which involved the inclusion of a secondary reviewer in the selection process, the inclusion of this reviewer helps decrease the risk of selection bias in this study. Furthermore, the wide range of study designs and methodologies adds to the strength of this review as it allows for the inclusion of unpublished studies that may provide useful information in the overall review of this topic. The aim of this study was to map literature within the last 10 years (2013-2023) on the use of electro-acupuncture in the treatment of lower back pain. This review has potential limitations, the methodological quality of the selected studies in this review were not investigated which could implicate the quality and validity of the current review in terms of bias, hence any findings from this review needs to be interpreted with caution. Secondly the study only included articles within the last 10 years which means previous research was not summarised in this review. Thirdly, the classification of positive outcomes was done without regard to any particular outcome other than statistical significance, which may distort the interpretation of the results in this review. Lastly animal- based studies were included which involved animals with back pathology but not specifically lower back pain which may not be in line with the objectives of the current review.

6.3 Implications of the findings for practice

This review highlighted some gaps in the research and important findings that may indicate reason for further research. Within the review the lack of parameter reporting was evident and the specificity of parameter selection for different LBP conditions were minimal, which can implicate the therapeutic efficacy of EA in the treatment of LBP. Hence further research should explore the standardisation of EA parameters on

different LBP conditions. Additionally, this review demonstrated positive treatment outcomes of EA in various LBP conditions, therefore the scope for a systematic review on this topic may be beneficial as it may allow for a more standardised approach for this type of treatment modality and further implications for practice.

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Wu, B., Yang, L., Fu, C., et al. 2021. Efficacy and safety of acupuncture in treating acute low back pain: A systematic review and bayesian network meta-analysis. *Annals of Palliative Medicine*. 10(6):6156–6167. DOI: 10.21037/apm-21-551.

Xiao-yan, M., Lan, B., Jia-ying, C., et al. 2022. Comparative effectiveness of electroacupuncture VS neuromuscular electrical stimulation in the treatment of chronic low back pain in active-duty personals: A single-center, randomized control study. *Frontiers in Neurology*. 1–10.

Yang, F., Zhou, F., Wang, C., et al. 2018. Clinical observation on electroacupuncture plus hydro-acupuncture for low back pain caused by compression fractures. *Journal of Acupuncture and Tuina Science*. 16(3):180–184. DOI: 10.1007/s11726-018-1047-x.

Yeung, C.K.N., Leung, M.C.P. & Chow, D.H.K. 2003. The Use of Electro-Acupuncture in Conjunction with Exercise for the Treatment of Chronic Low-Back Pain. *The Journal of Alternative and Complementary Medicine*. 9(4):479-490.

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Yuanzhi, F. & Yaochi, W. 2015. Effect of electroacupuncture on muscle state and infrared thermo-gram changes in patients with acute lumbar muscle sprain. *J Tradit Chin Med*. 35(5):499–506. Available: http://www.journaltcm.com.

Zhang, R., Lao, L., Ren, K., et al. 2014. Mechanisms of acupuncture-electroacupuncture on persistent pain. *Anesthesiology.* 120(2): 482-503. DOI: 10.1097/ALN.0000000000000101.

Zhang, X., Wang, Y., Wang, Z., et al. 2017. A Randomized Clinical Trial Comparing the Effectiveness of Electroacupuncture versus Medium-Frequency Electrotherapy for Discogenic Sciatica. *Evidence-based Complementary and Alternative Medicine*. DOI: 10.1155/2017/9502718.

Zhao, X.Y., Zhang, Q.S., Yang, J., et al. 2015. The role of arginine vasopressin in electroacupuncture treatment of primary sciatica in human. *Neuropeptides*. 52:61–65. DOI: 10.1016/j.npep.2015.06.002.

Appendix

Appendix A: Search Strategy

Search: Cochrane Library	Query	Records Retrieved
#1	Back Pain, Low OR Back Pains, Low OR Low Back Pains OR Pain, Low Back OR Pains, Low Back OR Lumbago OR Lower Back Pain OR Back Pain, Lower OR Back Pains, Lower OR Lower Back Pains OR Pain, Lower Back OR Pains, Lower Back OR Low Back Ache OR Ache, Low Back OR Aches, Low Back OR Back Ache, Low OR Back Aches, Low OR Low Back Aches OR Low Backache OR Backache, Low OR Backaches, Low OR Low Backaches OR Low Back Pain, Postural OR Postural Low Back Pain OR Low Back Pain, Posterior Compartment OR Low Back Pain, Recurrent OR Recurrent Low Back Pain OR Low Back Pain, Mechanical OR Mechanical Low Back Pain OR low back pain therapy OR chronic low back pain OR low back pain physiopathology OR low back pain surgery OR back pain rehab	14299
#2	Electroacupuncture OR electroacupuncture methods OR electroacupuncture stimulation or electroacupuncture analgesia	2345
#3	#1 AND #2	140
	Date Limit: 2013-2023	
	Search Date: 15-03-2023	

Appendix B: Full-text articles excluded with reasoning

(n=41) Exclusions

Armstrong, K. 2016. Electrotherapy Exposed. *Rehab Management: The Interdisciplinary Journal of Rehabilitation*. 29(1):30–34. Available:http://0search.ebscohost.com.innopac.wits.ac.za/login.aspx?direct=true&AuthType=ip&db=s3h&AN=112809056&site=ehost-live&scope=site.

Reason for exclusion: Study looked at electrotherapy in general and did not look at electro-acupuncture, hence did not meet objectives of the study.

Bauml, J., Xie, S.X., Farrar, J.T., Bowman, M.A., Li, S.Q., Bruner, D., DeMichele, A. & Mao, J.J. 2014. Expectancy in real and sham electroacupuncture: Does believing make it so? *Journal of the National Cancer Institute - Monographs*. 2014(50):302–307. DOI: 10.1093/jncimonographs/lgu029.

Reason for exclusion: The study investigates the effect of acupuncture in breast cancer patients hence doesn't meet the objectives of the study.

Comachio, J., Oliveira Magalhães, M., Nogueira Burke, T., Vidal Ramos, L.A., Peixoto Leão Almeida, G., Silva, A.P.M.C.C., Ferreira de Meneses, S.R., Costa-Frutuoso, J.R., et al. 2015. Efficacy of acupuncture and electroacupuncture in patients with nonspecific low back pain: Study protocol for a randomized controlled trial. *Trials*. 16(1). DOI: 10.1186/s13063-015-0850-7.

Reason for exclusion: Only study protocol available

Duan-Mu, C.L., Zhang, X.N., Shi, H., Su, Y.S., Wan, H.Y., Wang, Y., Qu, Z.Y., He, W., et al. 2021. Electroacupuncture-Induced Muscular Inflammatory Pain Relief Was Associated With Activation of Low-Threshold Mechanoreceptor Neurons and Inhibition of Wide Dynamic Range Neurons in Spinal Dorsal Horn. *Frontiers in Neuroscience*. 15. DOI: 10.3389/fnins.2021.687173.

Reason for exclusion: The study looks at the physiology of electro-acupuncture which is not one of the objectives of the study.

Eskander, J.P., Beakley, B.D., Zhang, S., Paetzold, J., Sharma, B., Kaye, A.D. & Sharma, S. 2019. DOI: 10.1007/s11916-019-0790-0.

Reason for exclusion: Study investigated a multi-modal approach to pain management for patients with chronic back pain, however the interventions did not involve electro-acupuncture.

Francescato Torres, S., Brandt De MacEdo, A.C., Dias Antunes, M., Merllin Batista De Souza, I., Dimitre Rodrigo Pereira Santos, F., De Sousa Do Espírito Santo, A., Ribeiro Jacob, F., Torres Cruz, A., et al. 2019. Effects of electroacupuncture frequencies on chronic low back pain in older adults: Triple-blind, 12-months protocol for a randomized controlled trial. *Trials*. 20(1). DOI: 10.1186/s13063-019-3813-6.

Reason for exclusion: Only study protocol available

Furlan, A.D., Yazdi, F., Tsertsvadze, A., Gross, A., Van Tulder, M., Santaguida, L., Gagnier, J., Ammendolia, C., et al. 2012. DOI: 10.1155/2012/953139.

Reason for exclusion: Study investigates acupuncture and not electro-acupuncture therefore doesn't meet objectives of the study

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Han, K., Zhang, A., Mo, Y., Mao, T., Ji, B., Li, D., Zhuang, X., Qian, M., et al. 2019. Islet-cell autoantigen 69 mediates the antihyperalgesic effects of electroacupuncture on inflammatory pain by regulating spinal glutamate receptor subunit 2 phosphorylation through protein interacting with C-kinase 1 in mice. *PAIN*. 160(3):712–723. DOI: 10.1097/j.pain.0000000000001450.

Reason for exclusion: Study looks at general inflammatory pain and doesn't specifically look at the effect on patients with low back pain. Hence doesn't meet study objectives.

Hisamitsu, T. & Ishikawa, S. 2014. DOI: 10.1016/j.jams.2014.04.008.

Reason for exclusion: Study investigates the influence of electroacupuncture on blood fluidity not on lower back pain. Hence doesn't meet study objectives.

Hu, J., Hu, W., Tang, L. & Wang, Y. 2022. Fundamental Neurocircuit of Anti-inflammatory Effect by Electroacupuncture Stimulation Identified. *Neuroscience Bulletin*. 38(7):837–839. DOI: 10.1007/s12264-022-00849-2.

Reason for exclusion: Study looks at the general anti-inflammatory effect of EA and not specifically the effect on LBP. Hence doesn't meet study objectives.

Huang, F., Chen, X. & Mu, J. ping. 2014. Clinical study on extracorporeal shock wave therapy plus electroacupuncture for myofascial pain syndrome. *Journal of Acupuncture and Tuina Science*. 12(1):55–59. DOI: 10.1007/s11726-014-0748-z.

Reason for exclusion: Study looks specifically at myofascial pain syndrome and not lower back pain. Hence doesn't meet study objectives.

Huang, Z., Zhao, J., Pei, X. & Wang, B. 2020. Effectiveness of deep electroacupuncture with strong deqi and shallow electroacupuncture with no deqi for lumbar disk herniation: Study protocol for a randomised controlled trial. *BMJ Open*. 10(11). DOI: 10.1136/bmjopen-2019-036528.

Reason for exclusion: Only study protocol available

Jiang, Y.-L., Yin, X.-H., Shen, Y.-F., He, X.-F. & Fang, J.-Q. 2013. Low Frequency Electroacupuncture Alleviated Spinal Nerve Ligation Induced Mechanical Allodynia by Inhibiting TRPV1 Upregulation in Ipsilateral Undamaged Dorsal Root Ganglia in Rats. *Evidence-based Complementary & Alternative Medicine (eCAM)*. 2013:1–9. DOI: 10.1155/2013/170910.

Reason for exclusion: Study looks at general neuropathic pain and specific to lower back pain. Hence doesn't meet study objectives

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Kelly, R.B. 2009. *Acupuncture for Pain*. Available: www.aafp.org/afpAmericanFamilyPhysician.

Reason for exclusion: Study published in 2009, doesn't fit inclusion criteria dates.

Kim, J.H., Na, C.S., Cho, M.R., Park, G.C. & Lee, J.S. 2022. Efficacy of invasive laser acupuncture in treating chronic non-specific low back pain: A randomized controlled trial. *PLoS ONE*. 17(5 May). DOI: 10.1371/journal.pone.0269282.

Reason for exclusion: study investigates invasive laser and not electroacupuncture.

Kong, J.T., MacIsaac, B., Cogan, R., Ng, A., Law, C.S.W., Helms, J., Schnyer, R., Karayannis, N.V., et al. 2018. Central mechanisms of real and sham electroacupuncture in the treatment of chronic low back pain: Study protocol for a randomized, placebo-controlled clinical trial. *Trials*. 19(1). DOI: 10.1186/s13063-018-3044-2.

Reason for exclusion: Only study protocol available

Ledford, C.J.W., Crawford Iii, P.F., O', M. & Mili, C. 2019. *Editorials Integrating Medical Acupuncture into Family Medicine Practice*. Available: www.aafp.org/afp.

Reason for exclusion: The study investigates acupuncture not electro-acupuncture. Hence does not meet the study objectives.

Lee, H.J., Choi, B. Il, Jun, S., Park, M.S., Oh, S.J., Lee, J.H., Gong, H.M., Kim, J.S., et al. 2018. Efficacy and safety of thread embedding acupuncture for chronic low back pain: A randomized controlled pilot trial. *Trials*. 19(1). DOI: 10.1186/s13063-018-3049-x.

Reason for exclusion: The study investigates thread embedding acupuncture and not electro-acupuncture. Hence does not meet study objectives

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Lee, J.-S., Yu-Jin Choi, K., Ph, M., student, D. & Cho, S.-H. 2019. *Effect of Electroacupuncture Stimulation at Different Frequencies on Brain Waves*.

Reason for exclusion: The study looks at the effect on brain waves and hence does not meet study objectives.

Mayor, D. 2013. DOI: 10.1136/acupmed-2013-010324.

Reason for exclusion: The study investigates the endorphin mechanisms of electroacupuncture and not it's effect on LBP, hence does not meet study objectives.

Mayor, D. & Bovey, M. 2017. DOI: 10.1136/acupmed-2015-010929.

Reason for exclusion: The study did a survey on the use of electro-acupuncture however the results don't provide answers that meet the study objectives.

Mehta, Z., English, M., Trybus, C., Magda, V. & Kamal, K. 2018. DOI: 10.1016/j.jams.2018.11.004.

Reason for exclusion: The article is a response to an article on the cost-utility analysis of electroacupuncture and NSAIDs on chronic lower back pain. Hence doesn't address study objectives

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Oh, Y., Han, C.H., Kim, Y., Kim, J., Yang, C., Choi, Y.E., Kang, B.K., Yang, G.Y., et al. 2023. Add-on Effect and Safety of Pharmacopuncture Therapy in the Treatment of Patients with Lumbar Spinal Stenosis. *JAMS Journal of Acupuncture and Meridian Studies*. 16(1):40–48. DOI: 10.51507/j.jams.2023.16.1.40.

Reason for exclusion: Study investigates pharmaco-acupuncture and not electroacupuncture.

Parmen, V., Taulescu, M., Ober, C., Pestean, C. & Oana, L. 2014. Influence of Electroacupuncture on the Soft Tissue Healing Process. *Journal of Acupuncture & Meridian Studies*. 7(5):243–249. DOI: 10.1016/j.jams.2014.03.003.

Reason for exclusion: Study investigates the effect of EA on the skin and superficial tissue and not on lower back pain. Hence doesn't meet study objectives.

Setiawardhani, A.L., Srilestari, A. & Simadibrata, C. 2017. Electroacupuncture effect at the LI 4 Hegu point on the plasma β-endorphin level of healthy subjects. In *Journal of Physics: Conference Series*. V. 884. Institute of Physics Publishing. DOI: 10.1088/1742-6596/884/1/012027.

Reason for exclusion: Study investigated the EA effect on endorphin levels in healthy patients and not LBP hence doesn't meet study objectives.

Shen, Y., Zhou, Q., Zhang, L., Gao, L., Zhang, D., Wang, X., Yu, Y., Zhang, Z., et al. 2020. DOI: 10.1097/MD.0000000000019867.

Reason for exclusion: Only study protocol available.

Sheng, X., Yue, H., Zhang, Q., Chen, D., Qiu, W., Tang, J., Fan, T., Gu, J., et al. 2021. Efficacy of electroacupuncture in patients with failed back surgery syndrome: study protocol for a randomized controlled trial. *Trials*. 22(1). DOI: 10.1186/s13063-021-05652-4.

Reason for exclusion: Only study protocol available.

Shin, B.-C., Cho, J.-H., Ha, I.-H., Heo, I., Lee, J.-H., Kim, K.-W., Kim, M., Jung, S.-Y., et al. 2018. A multi-center, randomized controlled clinical trial, cost-effectiveness and qualitative research of electroacupuncture with usual care for patients with non-

acute pain after back surgery: study protocol for a randomized controlled trial. *Trials*. 19:1-N.PAG. DOI: 10.1186/s13063-018-2461-6.

Reason for exclusion: Only study protocol available.

Silva, J.B.G. 2014. About Acupuncture and Electroacupuncture. *Anesthesiology*. 121(3):662. DOI: 10.1097/ALN.0000000000000341.

Reason for exclusion: The article is a letter to the editor and the information within does not address the objectives of the study.

Da Silva, J.B.G., Yoshizumi, A.M. & Robinson, N. 2013. DOI: 10.1016/j.eujim.2013.02.001.

Reason for exclusion: Study investigates acupuncture and not electroacupuncture.

Sung, W.S., Park, J.R., Park, K., Youn, I., Yeum, H.W., Kim, S., Choi, J., Cho, Y., et al. 2021. DOI: 10.1097/MD.0000000000024281.

Reason for exclusion: Only study protocol available.

Ulloa, L. 2021. DOI: 10.1038/d41586-021-02714-0.

Reason for exclusion: Study looks at physiological effect of EA which doesn't address objectives of the study.

Unwin, J. (2019) 'Electro Acupuncture Handbook for Musculoskeletal Problems', *The Journal of Chinese Medicine*, (119), 65+, available: https://link.gale.com/apps/doc/A578156345/HRCA?u=anon~aee46e81&sid=googleScholar&xid=d6734ec5 [accessed 30 Oct 2023].

Reason for exclusion: Information provided in the study doesn't meet study objectives.

Wang, Y., Gehringer, R., Mousa, S.A., Hackel, D., Brack, A. & Rittner, H.L. 2014. CXCL10 controls inflammatory pain via opioid peptide-containing macrophages in electroacupuncture. *PLoS ONE*. 9(4). DOI: 10.1371/journal.pone.0094696.

Reason for exclusion: The study investigates electroacupuncture for peripheral pain and not specifically LBP hence doesn't meet study objectives.

Wei, J., Yang, Z., Lin, Q., Xu, H., Lai, F., Han, Y., Li, J. & Cui, S. 2022. Bibliometric and visualized analysis of electroacupuncture in the past 10 years. *Complementary Therapies in Medicine*. 69. DOI: 10.1016/j.ctim.2022.102846.

Reason for exclusion: Study is a bibliometric study and doesn't meet study objectives.

---**Xue, C.C., Helme, R.D., Gibson, S., Hogg, M., Arnold, C., Somogyi, A.A., Da Costa, C., Wang, Y., et al. 2012. Effect of electroacupuncture on opioid consumption in patients with chronic musculoskeletal pain: protocol of a randomised controlled trial. *Trials*. 13(1):169. DOI: 10.1186/1745-6215-13-169.**

Reason for exclusion: Only study protocol available

Yaru, L., Jianxin, Z. & Yuanxiang, T. 2019. Efficacy and safety of electroacupuncture in treatment of lumbar disc herniation: a protocol for a cohort study. *J Tradit Chin Med*. 39(1):127–132. Available: http://www.journaltcm.com.

Reason for exclusion: Only study protocol available

Yeh, B.Y., Liu, G.H., Lee, T.Y., Wong, A.M.K., Chang, H.H. & Chen, Y.S. 2020. Efficacy of Electronic Acupuncture Shoes for Chronic Low Back Pain: Double-Blinded Randomized Controlled Trial. *Journal of Medical Internet Research*. 22(10). DOI: 10.2196/22324.

Reason for exclusion: Study investigates electronic acupuncture shoes, not in line with objectives of the study.

Yuan, W.A., Huang, S.R., Guo, K., Sun, W.Q., Xi, X.B., Zhang, M.C., Kong, L.J., Lu, H., et al. 2013. Integrative TCM conservative therapy for low back pain due to lumbar disc herniation: A randomized controlled clinical trial. *Evidence-based Complementary and Alternative Medicine*. 2013. DOI: 10.1155/2013/309831.

Reason for exclusion: Study looks at Traditional Chinese medicine as a whole and not specifically EA.

Zhang, B., Shi, H., Cao, S., Xie, L., Ren, P., Wang, J. & Shi, B. 2022. Revealing the magic of acupuncture based on biological mechanisms: A literature review. *BioScience Trends*. 16(1):73–90. DOI: 10.5582/bst.2022.01039.

Reason for exclusion: The study looks at acupuncture and not EA.

Zhang, R., Lao, L., Ren, K. & Berman, B.M. 2014. DOI: 10.1097/ALN.0000000000000101.

Reason for exclusion: Study looks at persistent pain and not LBP specifically

Appendix C: Table summarizing the included articles

Author	Study Title	Study Design	Year of publication	Study setting	Aim/Purpose	Study population& Sample size	Treatment modalities used	Outcome measures	Treatment parameters	Treatment outcomes
(Jin et al., 2021)	Electroacupuncture alleviates the transition from acute to chronic pain through the p38 MAPK/TNF-α signalling pathway in the spinal dorsal horn	Experimental	2021	China	To determine whether EA could prevent the transition from acute to chronic pain by affecting the p38 MAPK/TNF-α pathway in the spinal dorsal horn in a rat model	60 Rats	Electro-acupuncture	Mechanical paw withdrawal threshold	Frequency: 2/100Hz (EA with alternating administration at 3 s intervals Acupoint: ST36 (Zusanli) and BL60 (Kunlun) Intensity: 0.5–1.5 mA (0.5 mA increases at 10-min intervals) Duration: 30min per day from day 1 until behavioural test completion	EA intervention increased the mechanical pain threshold and inhibited the transition from acute to chronic pain.
(Depaoli Lemos et al., 2021)	Electroacupuncture and TENS in Chronic Nonspecific Low Back Pain: A Blind Randomized Clinical Trial	Blind Randomised Clinical trial	2021	Brazil	To compare the effects of EA and TENS in subjects with chronic nonspecific low back pain	48 people	TENS Electro-acupuncture	VAS Wells Bench Static trunk endurance test Sorensen test RMDQ	Frequency: continuous pulse train, with pulse frequency of 10 Hz. Acupoint: B22 and B26 Intensity: patients' tolerance Duration: 20 minutes.	The association between EA and exercise significantly improved pain, function, and lumbopelvic stability in comparison to exercise alone or in association with TENS
(Walsh, 2010)	Electroacupuncture and TENS: Putting theory into practice	Descriptive study	2020	Sydney	Study aims to explain the neurophysiological mechanisms of electroacupuncture and transcutaneous electrical nerve	N/A	TENS Electroacupuncture	N/A	Muscular dysfunction or injury use lower frequencies (1 to 10Hz). Sensory signs and symptoms (e.g. neuropathies) use higher frequencies (80 to 100Hz).	N/A

					stimulation (TENS) and outlines their methods of application for a range of conditions.				e. The alternation between dense and disperse is the most commonly used and effective mode setting for EA.	
(Kuo et al., 2013)	Spinal Serotonergic and Opioid Receptors Are Involved in Electroacupuncture-Induced Antinociception at Different Frequencies on ZuSanLi (ST 36) Acupoint	Experimental	2013	Taiwan	The study evaluated the effect of electroacupuncture induced antinociception at different currents and frequencies in rat spinal cord	Not mentioned	Electro-acupuncture	Pain threshold	Frequency: 2 Hz, 10 Hz, and 100 Hz Intensity: 1 mA, 2 mA, and 3 mA Acupoint: ST36 Duration: 10 minutes	Lower frequencies of EA (<10 Hz) may provide more stable and longer duration of antinociception when compared with a high EA frequency (100 Hz) EA analgesia occurred via μ-opioid receptors at a low frequency
(Kong et al., 2020)	Effect of Electroacupuncture vs Sham Treatment on Change in Pain Severity Among Adults with Chronic Low Back Pain	double-blind randomized clinical trial	2020	California	To evaluate the treatment effect of real electroacupuncture vs placebo in pain and disability among adults with chronic low back pain	121 participants	Electro-acupuncture	National Institutes of Health PROMIS pain intensity scale RMDQ	Frequency: 2Hz frequency Intensity: visible muscular twitching Acupoints: BL23, BL25, BL40, GB30, GV3 Needle size: 30mm long and 0.2mm in diameter Duration: 45 minutes (20-25min of stimulation) 12 sessions (2x a week for 6 weeks)	Study demonstrated a statistically and clinically significant treatment effect of electroacupuncture on disability associated with chronic low back pain in a randomized clinical trial no significant difference in chronic low back pain scores

(Heo et al., 2018)	Electroacupuncture as a complement to usual care for patients with non-acute low back pain after back surgery: a pilot randomised controlled trial	Pilot Randomised controlled trial	2018	Korea	The aim of this pilot study was to estimate the sample size for a large pragmatic study of the comparative effectiveness of electroacupuncture (EA) for low back pain (LBP) after back surgery	40 participants	Electro-acupuncture Usual care: drug therapy, physiotherapy and an educational programme on management of LBP	VAS ODI EQ-5D	Frequency: 50 Hz Acupoint: Jia-ji (Ex-B2, L3/L5; bilaterally) Needle size: stainless steel needles 0.25mm in diameter and 0.40mm in length Current: Biphasic wave-form current Duration: 15 minutes (2x week for 4 weeks)	Statistically significant decrease in the ODI after 8 weeks in the EA plus UC group when compared with the UC alone No statistical difference in VAS and EQ-5D between the two groups
(Heo et al., 2021)	Multicentre randomised controlled clinical trial of electroacupuncture with usual care for patients with non-acute pain after back surgery	Multicentre randomised controlled clinical trial	2021	South Korea	Investigate the effectiveness and safety between electroacupuncture (EA) combined with usual care (UC) and UC alone for pain reduction and functional improvement in patients with non-acute low back pain (LBP) after back surgery	108 participants	Electroacupuncture Usual care: interferential and Heat therapy for 15 minutes and a 20minute educational video and brochure on LBP	VAS ODI EQ-5D	Frequency: 50Hz Disposable stainless-steel needles (0.25 x 40 mm) Acupoint: Jia-ji acupuncture points (bilateral EX-B2 at L3 and L5) Duration: 15 minutes, 8 sessions, 2x a week	EA with UC treatment was more effective than UC alone in reducing pain and recovering function at every assessment None of the AEs had a causal relationship with the EA treatment.
(Leite et al., 2018)	Does Electroacupuncture Treatment Reduce Pain and Change Quantitative Sensory Testing Responses in Patients with	Randomised Controlled Clinical Trial	2018	Brazil	To verify if electroacupuncture treatment reduces pain and changes quantitative sensory testing responses in patients with	69 participants	EA in the treatment group: 30 minutes of EA stimulation Control group 1: 45 second electrical stimulation	Numerical rating scale (NRS) Mcgill Pain Questionnaire	Frequency: 10 Hz and 100Hz alternation every 5 seconds Sterile acupuncture needles, 25 x 30 mm sized	Although ten sessions of electroacupuncture have reduced pain intensity in both resting and movement, it could

	Chronic Nonspecific Low Back Pain? A Randomized Controlled Clinical Trial				chronic non-specific low back pain.		Control group 2: only needles and no electrical stimulation Control group 3: Needles placed and withdrawn immediately	Quantitative sensory testing	Acupuncture points: (1) B22, located 1,5 cm laterally to L1 vertebrae; (2) B26, located 1,5 cm laterally to L5 vertebrae; (3) B50, located 3 cm laterally to T12 vertebrae; (4) B53, located 3 cm laterally to S2 vertebrae Duration: 30 Minute stimulation	not change significantly quantitative sensory testing and diminish central sensitization in patients with chronic non-specific low back pain
(LI & ZHOU, 2021)	Electroacupuncture of different wave patterns for acute attack of lumbar disc herniation	Randomised Controlled Trial	2021	China	To observe the differences in clinical therapeutic effect on acute attack of lumbar disc herniation (LDH) treated with electroacupuncture (EA) of different wave patterns	104 participants	Electroacupuncture: Disperse-dense wave group Intermittent wave group Continuous eave group	VAS Japanese Orthopaedic association (JOA)	Disperse-dense wave Frequency: 2/50 Hz Needle size: 0.25 mm × 40 mm Depth: 30mm Duration: 20 minutes Intensity: Patient tolerance Acupoint: BL31, BL32, BL33 and BL34 Intermittent wave Needle size: 0.25 mm × 40 mm, Depth: 30mm Frequency: 2Hz Duration: 20minuties Intensity: Patient tolerance Acupoint: al BL31, BL32, BL33 and BL34 Continuous wave Needle size: 0.25 mm × 40 mm, Depth: 30mm Frequency: 2Hz Duration: 20minuties Intensity: Patient tolerance Acupoint: al BL31, BL32, BL33 and BL34	EA stimulation with 3 wave patterns at Baliáo all effectively relieved pain and improved lumbar function in acute attack of lumbar disc herniation (LDH) patient Disperse-dense wave obtained a much better effect of relieving pain in the patient Difference in JOA score before and after treatment showed that continuous wave was more conducive to improving lumbar function

(Xiao-yan et al., 2022)	Comparative effectiveness of electroacupuncture vs neuromuscular electrical stimulation in the treatment of chronic low back pain in active-duty personals: A single-centre RCT	Randomised controlled trial	2022	China	To investigate the effectiveness of EA vs. NMES in reducing pain intensity among active-duty soldiers with chronic LBP (CLBP), and with the additional aim of identifying outcome predictors in a pragmatic setting	85 participants	Electroacupuncture Neuromuscular electrical stimulation (NMES)	Numerical rating scale (NRS) ODI Fear avoidance beliefs questionnaire (FABQ)	EA: Dilatational wave Frequency: 50Hz Depth: 5cm Duration: 30minutes, 6-7x in 2 weeks Intensity: comfortable Acupoint: EX-B2 (Jiaji) NMES: 40 x 40mm electrodes Same acupoints as EA Duration: 30minutes 6-7x in 2 weeks	EA may be associated with a longer analgesic effect for LBP one month or three months after treatment
(SHAO et al., 2018)	Electroacupuncture for lumbar intervertebral disc herniation: A randomized controlled trial	Randomised controlled trial	2018	China	To compare the effect differences of electroacupuncture (EA) at Jiaj (EX-B2) and conventional acupoints for lumbar intervertebral disc herniation (LIDH)	160 participants	Electroacupuncture: EX-B2 group Conventional acupoints group	Japanese Orthopaedic Association (JOA) Visual Analogue Scale (VAS)	EX-B2 group: Needle size: 0.35 mm × 75 mm Depth: 20mm Asymmetric Biploar pulse, continuous wave Pulse width: 0.6ms Frequency: 20Hz Duration: 45min, 3x a week Intensity: patient tolerance Conventional acupoints group: Needle size: 0.25 mm × 40 mm Depth:15-20mm Frequency: 20Hz Intensity: patient tolerance	The therapeutic effect of EA at EX-B2 was the greatest improvement on Muscle strength, life skills, SLR. The therapeutic effect of EA at conventional acupoints was the greatest improvement on skin feeling, walking ability, life skills The best curative effect time of EA at EX-B2 was the first treatment after 24 h, and the best

										curative effect of EA conventional acupoints therapy was after the first treatment,
(Wu et al., 2021)	Efficacy and safety of acupuncture in treating acute low back pain: a systematic review and Bayesian network meta-analysis	Systematic Review	2021	Not restricted to a specific location	To evaluate and compare the efficacy and safety of different acupuncture therapies for acute low back pain	19 RCT	Manual acupuncture Electro-acupuncture Motion Style acupuncture	VAS ROM	Not specified	EA was better than MA in reducing VAS scores, but both acupuncture techniques showed efficacy in reducing ROM score Overall, we found that all acupuncture treatments (MSA, MA, and EA) are more effective in both alleviating pain and improving lumbar activity of ALBP patients compared with pharmacotherapy or placebo

(Awad, Hamid & Allah, 2019)	Effect of electroacupuncture versus low level laser therapy on post-natal low back pain	Experimental Study	2019	Cairo-Egypt	This study was conducted to compare the effect of Electroacupuncture and Low-Level Laser Therapy on post-natal low back pain	50 participants	Electro-acupuncture Low Level Laser therapy	VAS ODI	Electro-acupuncture: Dense-Disperse wave (Low frequency interspersed with periods at higher frequencies) Dense frequency: 100 Hz Pulse duration: 0.5ms Duration: 15 min 3x a week for 6 weeks Intensity: Patient tolerance Acupoint: UB40 and UB25 Low Level Laser: Duration: 20min, 3x a week for 6 weeks Wavelength: 904nm Frequency: 3000 Hz Power: 70 mW Power Density: 20 mW/cm Dose: 3J/cm 150 sec on each point	Statistically significant difference in VAS and ODI in both treatment groups with a higher improvement in the electroacupuncture group Electroacupuncture is more effective than low level laser therapy in reducing pain and improving functional status by decreasing disability of patients with post-natal low back pain.

(Chia, 2014)	Electroacupuncture treatment of acute low back pain: unlikely to be a placebo response	Case Summary-descriptive	2014	Not Mentioned	A case summary to explain where EA was more than a placebo response	1 Case	Electro-acupuncture	VAS	Frequency: 4Hz Needle size first session: 40mm Needle size second: 70mm Inserted at 70 degree angle Acupoint: BL52 and BL54	Improvement in pain from 5/10 to 3/10 at day 3 and no pain at day 7
(Yang et al., 2018)	Clinical observation on electroacupuncture plus hydro-acupuncture for low back pain caused by compression fractures	Clinical Observation	2018	China	To observe the effect of electroacupuncture (EA) at Jiaji (EX-B 2) points plus hydro-acupuncture with sinomenine hydrochloride for low back pain caused by compression fractures in the elderly	95 participants	Basic Treatment: Intravenous infusion of calcitonin injection, oral calcium carbonate, oral vitamin D EA group: Electroacupuncture Observation group: Hydro-acupuncture with sinomenine hydrochloride at Jiaji points and EA	VAS ODI	Electro-acupuncture: Acupoints: Jiaji (EX-B 2) Needle size: 0.30mm diameter and 60mm length Depth: 15-30mm Sparse dense wave Frequency: 10 Hz Duration: 30min, 1x a day, 6x a week for 3 weeks Intensity: Patient tolerance	Results suggested that on the basis of conventional drug therapy, EA at Jiaji (EX-B 2) points plus injection of sinomenine hydrochloride should be superior to EA alone

(Huang et al., 2015)	Electroacupuncture Stimulates Remodelling of Extracellular Matrix by Inhibiting Apoptosis in a Rabbit Model of Disc Degeneration	Randomised controlled trial	2014	China	To determine whether EA stimulates remodelling of extracellular matrix by inhibiting apoptosis in degenerated disc	40 rabbits	Electroacupuncture	MRI Tunnel assay Histological analysis	Electroacupuncture: Acupoint site: Ex-B2 Duration: 30mins, once every day x 28days Frequency: 2/15Hz Intensity: 1mA	Study found that the degeneration grade on MRI was slight but significantly decreased after EA treatment. EA significantly reduced Pfirrmann's MRI grade scores and improved ultrastructure change in degenerated disc.
(Hubacher et al., 2016)	Standards for Reporting Electroacupuncture Parameters	Descriptive	2016	Washington	A proposal for more-vigorous electronic-stimulation parameters is described in this article	N/A	Electroacupuncture	N/A	7 Parameters to report on: Frequency, pulse repetition rate Waveform Pulse width Voltage Current Position of clips Environmental electromagnetic noise	Recommendation that standardised electronic parameter reporting is established in EA research
(Huo et al., 2022)	Electroacupuncture of Weizhong (BL-40) Acupoint Inspires Muscular Satellite Cell Regeneration and Promotes Muscle Repair Capacity after Back Muscle Injury in Sprague-Dawley Rat Model	Experimental	2022	China	To explore the possible mechanisms associated with electro-acupuncture at the Weizhong acupoint (BL 40) promoting muscle repair	58 rats	Electro-acupuncture	N/A	Acupoint: BL-40 Needle size: 0.16mm x 10mm Magnitude: 15V Frequency: 2hz/ 10Hz Intensity 1mA Duration: 10mins a day for 10 days	EA of Weizhong acupoints show significant recovery effects on back muscle damage in both young and aged rats It enhances satellite cell differentiation and self-renewal

										capacity, therefore, strengthening muscle repair
(Inoue et al., 2012)	Spinal nerve root electroacupuncture for symptomatic treatment of lumbar spinal canal stenosis unresponsive to standard acupuncture: a prospective case series	Case Series-observational	2017	Japan	To study the effectiveness of electroacupuncture of the spinal nerve root using a selective spinal nerve block technique for the treatment of lumbar and lower limb symptoms in patients with lumbar spinal canal stenosis.	17 participants	Electroacupuncture	VAS Continuous walking distance >500m	Needle size: 90mm long x 0.25mm diameter Frequency: 10 Hz Duration: 10 min, 1x a week, for 5 weeks Location: Near the applicable nerve root Intensity: patient tolerance	Results showed that, compared with baseline, there was a significant improvement in low back pain, lower limb pain and lower limb dysesthesia immediately after the first treatment, as well as a tendency for continuous walking distance to increase A significant sustained improvement of symptoms was also observed after 3 months
(Kim et al., 2020)	Electroacupuncture with Usual Care for Patients with Non-Acute Pain after Back Surgery: Cost-Effectiveness Analysis Alongside a	Randomised Controlled Trial	2020	Korea	The purpose of this study was to examine the cost-utility of using EA with UC versus UC alone for post-back surgery pain by conducting an	106 participants	Electroacupuncture and usual care Usual Care	Euroqol five-dimension scale three-level version (EQ-5D-3L).	Electroacupuncture: Duration: 2x a week for 4 weeks Acupoints: Jia-ji (bilateral Ex-B2 at L3 and L5) Needle size (0.25 x 40mm)	In sum, the EA and UC combination therapy resulted in better clinical outcomes

	Randomized Controlled Trial				economic evaluation study alongside a randomized controlled trial				Usual Care: Interferential, superficial heat, standardised educational program	
(Kondo, Miyamoto & Miyakawa, 2014)	Electro-acupuncture significantly delayed multifidus muscle reaction time in athletes with lower back pain	Non-blind comparative study	2014	Japan	The aim of the present study was to investigate the effect of electro-acupuncture of the lumbar region on the reaction time of the trunk muscles during postural sway	15 participants	Electroacupuncture	Surface EMG	Electro-acupuncture: Acupoints: Jiaji: EX-B2 Needle size: 60mm length, 0.2mm diameter Depth: 3cm Frequency: 1Hz Duration: 10 minutes Intensity: until twitch	The present study found that electro-acupuncture delayed multifidus muscle reaction time, suggesting that this technique is useful in improving muscle tonus in those with lower back pain It is also unclear how long this delay is sustained.
(Kondo et al., 2014)	Effects of Electro-acupuncture stimulation on the left–right asymmetry of lumbar erector spinae muscle EMG activity in subjects with lower back pain	Non-blind comparative study	2014	Japan	To examine the effects of acupuncture stimulation on the left–right asymmetry of lumbar erector spinae muscle EMG activity during trunk flexion exercises.	12 participants	Electroacupuncture	VAS EMG	Electroacupuncture: Acupoints: Jiaji (EX-B2) Needle size: 60mm length x 0.2mm diameter Depth: 3cm Frequency: 1Hz Duration: 10 min Intensity: until twitch	We found that the % difference in the left–right asymmetry and the degree of lower back pain decreased after electro-acupuncture stimulation

(Kong, 2020)	Electroacupuncture for Treating Chronic Low-Back Pain: Preliminary Research Results	Mixed method	2020	California	To describe 2 independent but similarly designed, clinical trials, conducted to investigate the effectiveness, mechanisms, and predictors of electroacupuncture (EA) for treating chronic low-back pain (CLBP)	Study 1: 99 participants Study 2: 102 participants	Electroacupuncture	RMDQ PROMIS (Patient-Reported Outcomes Measurement Information System) Numeric Rating Scale	Electroacupuncture: Duration: 2x a week for 6-8 weeks Acupoint: not measured	In terms of functional improvement one of the 2 studies demonstrated a statistically significant clinical effect of verum EA over sham EA
(Li et al., 2021)	Electroacupuncture Might Promote the Spontaneous Resorption of Lumbar Disc Herniation: A Case Report	Case Report-descriptive	2021	China	To present a case of the resorption of large herniated discs in an LDH patient treated merely by multiple sessions of electroacupuncture (EA).	1 Case	Electroacupuncture	JOA	Electroacupuncture: Acupoints: Ashi points, Jia-ji (EX-B2), GB34, GB39 Frequency: 2/100Hz Duration: 30min, 7 sessions	After 7 sessions of EA patients' symptoms gradually relieved Patient's pain and numbness of the left limb had completely recovered at 1.5 months after discharge 10-month follow-up after discharge from the hospital, MRI re-examination confirmed the resorption of herniated lumbar discs.

(Li, Zhao, et al., 2022)	Electroacupuncture alleviates multifidus muscle injury by modulating mitochondrial function and Ca2+ uptake	Experimental	2021	China	Study aims to clarify the mechanism by which EA treatment could reduce Ca2+ overload in rats with multifidus muscle injury and the effect of EA treatment on mitochondrial function.	92 rats	Control Group: No intervention Electroacupuncture	Electromyography (EMG)	Electroacupuncture Acupoints: BL40 Needle size: 0.18mm x 13mm Depth: 3-5mm Frequency: 2/15Hz Intensity: 2mA Duration: 30min, once a day	Results of present showed that EA can alleviate myocyte Ca2+ overload in a rat model with lumbar multifidus muscle injury EA intervention reduced the expression of mitochondrial calcium uniporter (MCU) and increased the Ca2+ uptake of mitochondria to a certain extent
(Liang et al., 2013)	Therapeutic Efficacy Observation on Electroacupuncture of Different Frequencies for the Third Lumbar Transverse Process Syndrome	Experimental	2013	China	To observe the clinical effect of electroacupuncture (EA) of different frequencies for the third lumbar transverse process syndrome.	80 cases	Medium frequency EA Traditional EA	VAS Criteria of diagnosis and Therapeutic Effects of diseases and syndromes in Chinese medicine	Medium Frequency EA: Acupoint: Ashi points Needle size: 0.35mm diameter x 40mm length Duration 1x day, 5min and 10times Frequency: 1-10kHz Traditional EA: Acupoints and needle size same as above Frequency: 20Hz, continuous wave Duration: 30min, 1x day, 10times	VAS scores in both groups were significantly reduced, however the medium frequency group was significantly more. Compared to traditional EA, the medium-frequency EA is a better option for the third lumbar transverse process syndrome because of its notable effect,

										shorter time and milder invasion
(Liang et al., 2020)	Effect of “Tongji” electroacupuncture on pain and inflammatory factors in patients with lumbar disc herniation in remission stage	Randomised controlled trial	2020	China	This study aims to verify the effects of “Tongji” electroacupuncture treatment on lumbar disc herniation and its underlying mechanism	116 cases	Control Group: oral analgesics Observation group: “Tongji” electro-acupuncture & oral analgesics	VAS JOA	Electroacupuncture: Acupoints: 1.3 inch away from midline at T12, L1, L2, L3, L4, L5 and S1 Dense Wave Frequency: 15/100Hz Intensity: 1-2mA Duration: 30 min, once a day for 10 days	VAS score in the observation group decreased significantly “Tongji” electroacupuncture plus oral analgesics can significantly improve the lumbar function of LDH patients “Tongji” electroacupuncture not only significantly relieves the postoperative pain of the patients, but reduces the content of inflammatory factor IL-6, regulates the secretion of painful substance SP, and inhibits the local immune and inflammatory reaction.

(Salehi et al., 2019)	Evaluation of Efficacy of Neuro Muscular Electrical Stimulation and Electro Acupuncture in Improving the Pain and Disability in Patients with the Lumbar Degenerative Intervertebral Disk Disease	Randomised case-controlled trial	2019	Iran	To compare the efficacy of the neuromuscular electrical stimulation (NMES) and electro acupuncture (EA) with exercise therapy alone in patients with chronic low back pain	60 participants	Group 1: EA and exercise Group 2: Neuromuscular electrical stimulation (NMES) and exercise Group 3: exercise only	VAS Quebec back pain disability scale	Electroacupuncture: Durations: 15min, 12 sessions (3 sessions a week for one month) Frequency: 15/30Hz Acupoint: Not mentioned Neuromuscular: Duration: 15 minutes, 12 sessions Unipolar current NMES Frequency: 15/30Hz	Severity of pain and disability significantly improved in the three groups of EA, NMES and exercise therapy after one and four months Almost identical efficacy of exercise therapy alone versus in combination with electrical stimulation techniques
(Sun et al., 2013)	Effects of Electroacupuncture on Muscle State and Electrophysiological Changes in Rabbits with Lumbar Nerve Root Compression	Experimental	2013	New Zealand	To observe the effects of electroacupuncture on force-displacement value (FDV) of muscle state and electrophysiology of the muscle in rabbits with lumbar nerve root compression	30 rabbits	Control group Model Group EA acupoint group Medication group EA un-acupoint group	Force displacement Value Surface EMG	Electroacupuncture (acupoint): Acupoints: bilateral Shenshu (BL23) and Dachangshu (BL25) Depth: 15 mm Frequency: 2 Hz. Duration: 20 min per day for a total of 14 times Medication group: Loxoprofen sodium by gastrogavage at 4 mg/kg per day for 14 days EA un-acupoint: same parameters as EA with acupoint except at different acupoint	EA could improve muscle state in activation and relaxation in the presence of persistent mechanical pressure EA acupoints had better effects in relieving mechanical pressure and improving motor nerve conduction velocity compared with loxoprofen

										sodium tablets and EA un-acupoints
(Vara, Bhagora & Saiyad, 2015)	Effect of Electro acupuncture Therapy on back pain Subjects	Experimental	2015	India	To evaluate the effectiveness of Electroacupuncture therapy in 26 subjects of Backpain	26 participants	Electroacupuncture	N/A	Procedure was carried out using the machine named POINTER EXCEL II Parameters not mentioned	17 out of 26 patients had respond positively to electroacupuncture treatment Treatment efficacy was higher in the patients with LBP under a year compared to those more than a year
(Walker, 2022)	Bedside Electro-Acupuncture	Descriptive study	2022	USA	N/A	N/A	Electroacupuncture	N/A	Intensity: Based on patients' tolerance and condition treated Enough to elicit a non-noxious muscle contraction (motor) Enough to elicit a non-noxious paraesthesia (sensory nerve) Monitor HR before and after Frequency: High Frequency (80-100)- sensory nerve fibres (pain, temperature, pressure, touch) Low Frequency (1-10)- motor nerve fibres (weakness, trigger points, chronic pain)	N/A

									Waveform: Continuous-constant, body can quickly acclimatise, may have to change intensity frequently Intermittent- paced pulsations with equal periods of no activity Dense/Disperse-proportional periods of high frequency and low frequency pulsations. Provides longer lasting pain relief. Duration: Less than 20 mins- increases sympathetic tone More than 20min- increases parasympathetic tone Needle placement: Craig percutaneous electrical nerve stimulation (0.5-1cm lateral to spinous process) -affects the CNS Osteopuncture- affects ANS and sclerotomes, needles inserted into periosteum Govaki Transverse technique- affects pain on myotome level (needle transversely at myotome level) Systemic Regulatory points- at distal areas of lower extremity, for systemic effect	

(Ding & Yang, 2015)	Electroacupuncture assisted by squatting stances for lumbar disc herniation	Experimental	2015	China	To observe the efficacy of lumbar disc herniation treated with EA and assisted with squatting stances	128 participants	EA group and soft issue massage EA and squat stances group	Pain and numbness Walking ability Living and working ability Tenderness Knees and tendon reflex Straight leg raise test	Electroacupuncture: Continuous wave Low frequency 15min 5x a week for 2-3 weeks Acupoint: GB30 Squat stance: core muscle training, two legs parallel and squat with toes straight forward, knees before toes. Once a day, until fatigue	Significant difference in both groups post treatment No significant difference in improvement between groups
(de Carvalho et al., 2018)	Single or Multiple Electroacupuncture Sessions in Nonspecific Low Back Pain: Are We Low-Responders to Electroacupuncture?	Quasi-experimental study	2018	Brazil	To compare the effects of one or multiple sessions of electroacupuncture (EA) in patients with chronic low back pain.	50 participants	Electroacupuncture for 1 week After 1 week they split into 2 groups: VAS < 3 points and VAS > 3. VAS <3-Returned after 3 weeks VAS >3 received more EA	VAS Pain pressure threshold Mcgill pain questionnaire RMDQ	Electroacupuncture: Frequency: 2 Hz Duration: 30 minutes Acupoints: bilaterally at the SP6, BL23, BL31, BL32, BL33, and BL60 Needle size: 0.25x 30mm Depth: 0.8-1.5cm	Single session of EA was effective to reduce pain intensity momentarily, one session of EA did not improve disability RMDQ was not significantly reduced after 1 session Meanwhile, patients with VAS > 3 and treated with EA weekly showed a gradual decrease in functional disability 2 Hz-EA is effective in temporarily reducing pain but

										not enough to improve disability or maintain long term effect. However, some patients who did not have pain reduction after one session experienced reduced pain intensity and improved functional capacity after 3 weeks of treatment.
(Fang et al., 2018)	Parameter-specific analgesic effects of electroacupuncture mediated by degree of regulation TRPV1 and P2X3 in inflammatory pain in rats	Experimental	2018	China	Observing the parameter-specific anti-hyperalgesia effects of EA with different stimulation times and frequencies on painful hyperalgesia	210 rats	Experiment 1: Control group, CFA, CFA + 2Hz, CFA +100Hz, CFA + 2/100Hz Experiment 2: Same first four groups, last group changed to CFA and sham EA Experiment 3: CFA + vehicle group, CFA + 2 Hz + vehicle group, CFA + 2 Hz + αβ-meATP group and CFA + 100 Hz + vehicle group	Paw withdrawal threshold	Electroacupuncture: Acupoints: ST36 and BL60 Needle size: 0.25mm x 13mm Depth: 5mm Intensity: range from 0.5-1.5mA Frequency different for each group 2Hz for 20miin 100Hz for 30min 2/100 Hz for 45 min	The analgesic effect of EA at 100 Hz was better than that at 2 Hz. This study supports the hypothesis that alterations in acupuncture (dose) parameter affect therapeutic outcomes EA had parameter-specific effects on chronic inflammatory pain relief that primarily depended on stimulation frequency and less on stimulation time

							n Experiment 4: vehicle group, CFA + 2 Hz + vehicle group, CFA + 2 Hz + capsaicine group, CFA + 100 Hz + vehicle group, and CFA + 100 Hz + capsaicine group			High frequency of EA had a stronger effect on reducing TRPV1 and P2X3 (causes pain) expression.
(Choi et al., 2019)	Biological safety of Electroacupuncture with STS316 needles	Experimental	2019	Korea	This study aimed to experimentally confirm a safe range of conditions for the use of acupuncture needles composed of STS304 or STS316 based on the corrosion associated with current intensity, pulse frequency, and duration.	Rats	Electroacupuncture	Tunel Assay MTT Assay	Electroacupuncture: Intensity: 9 Frequency: 120Hz Duration: 60min Acupoints: ST32 & ST36 Needle size: 0.18 or 0.2 or 0,25 or 0.3mm Needle type: Coated / Non coated STS316 or STS304 needles	STS316 coated needles, corrosion was observed after performing EA at an intensity greater than 8 and for a duration of 90 min STS304 coated needles, corrosion was observed after EA was performed at an intensity at least 7 and for a duration of 60min Corrosion was not observed for non-coated STS316 needles of any thickness after electrical stimulation Based on the results above, it is appropriate to use uncoated (bare) needles composed

										of STS316 material for EA treatment in a clinical setting
(Langevin et al., 2015)	Manual and Electrical Needle Stimulation in Acupuncture Research: Pitfalls and Challenges of Heterogeneity	Literature review	2015	N/A	This article reviews the literature comparing manual to electrical acupuncture in basic science studies, clinical trials, and meta-analyses	38 studies	Manual Acupuncture Electroacupuncture	Not Mentioned	Not Mentioned	Clinical trials for pain conditions, better analgesia appears to be obtained when prolonged electrical stimulation is added to manual stimulation compared with brief manual acupuncture Modest evidence suggests a potential difference between the physiologic effects of electrical and manual stimulation of acupuncture needles The use of EA appears to be based on the perception that it will improve clinical effectiveness in

										patients with more severe conditions
(Kim et al., 2016)	Acupuncture for patients with lumbar spinal stenosis: a randomised pilot trial	Randomised pilot trial	2015	Korea	To assess the safety and feasibility of acupuncture for participants with symptomatic lumbar spinal stenosis	50 patients	Acupuncture group: acupuncture, option of electroacupuncture and usual care Control group: Usual care	Oswestry Disability Index (ODI) Short Form Health Survey (SF-36)	Acupuncture: Needle size: 0.25x 40mm or 0.30 x 60mm Depth: 15-50mm Electroacupuncture: Acupoints: LI4, LI11, TE5, SI3, TE3, ST36, SP6, SP9, LR3, GB34, GB39, BL40, BL57, Jiaji points, and BL23 Frequency: 2/100Hz Intensity: 5-10mA Duration: 20min	The acupuncture group did not differ from the control group in terms of functional improvements and other secondary outcomes
(Zhang et al., 2017)	A Randomized Clinical Trial Comparing the Effectiveness of Electroacupuncture versus Medium-Frequency Electrotherapy for Discogenic Sciatica	A Randomised clinical trial	2017	China	To investigate the short- and long-term effects of electroacupuncture (EA) compared with medium-frequency electrotherapy (MFE) on chronic discogenic sciatica	100 patients	Electroacupuncture group Medium frequency electrotherapy group	NRS ODI Patient Global Impression	Electroacupuncture: Needle size: (0.3 × 100 mm) Acupoints: DaChangShu, BL25 and bilateral JiaJi (Ex-B2) Depth: 1.5 inches Dilatational Wave Frequency: 50Hz Intensity: Tolerable Medium Frequency Electrotherapy: Electrode: 107mm x 72mm Intensity: maximum tolerable intensity	The results of this trial showed significant differences in the change in the leg pain NRS and ODI questionnaire scores in the EA group compared with those in the MFE group in the short-term treatment period and long-term follow-up

									Duration for both: 20 minutes, once daily, 5x a week for 2 weeks 3sessions a week for another 2 weeks	Effect of EA was superior to the effect of MFE in improving leg pain and dysfunction but was not superior to MFE in relieving low back pain and systemic symptoms. Long-term effect of EA was superior to that of MFE in improving low back pain
(Comachio et al., 2020)	Effectiveness of Manual and Electrical Acupuncture for Chronic Non-specific Low Back Pain: A Randomized Controlled Trial	Randomised Controlled Trial	2020	Brazil	To identify effectiveness of electroacupuncture (EA) and manual acupuncture (MA) on pain and disability in patients with chronic nonspecific low back	66 participants	Manual Acupuncture Electrical Acupuncture	NRS RMDQ McGill Pain questionnaire The Beck depression inventory SF-36	Manual acupuncture: 23 needles Needle size: 0.20mmx 15mm Depth: 0.5cm Duration: 40min Electroacupuncture: Duration: 30min manual EA and 10min EA Acupoints: BL23 and BL30 Intermittent wave Frequency: 10Hz Pulse width: 10mA Intensity: Comfortable level	EA and MA have similar effects in terms of reducing pain, disability, quality of life, global perceived effect, and depression in patients with chronic low back pain EA has a clinically relevant pain-relieving effect on certain forms of chronic pain but is not better than MA alone

(Yuanzhi & Yaochi, 2015)	Effect of electroacupuncture on muscle state and infrared thermogram changes in patients with acute lumbar muscle sprain	Randomised controlled Trial	2015	China	To observe the effect of electroacupuncture (EA) on force-displacement value (FDV) of muscle state and the temperature index of infrared thermogram in patients with acute lumbar muscle sprain	120 Patients	Electroacupuncture group Medication group (non-steroidal anti-inflammatory)	Force Displacement value	Electroacupuncture: Acupoints: Houxi (SI 3), Jiaji (EX-B2) and Ashi points Needle size: 0.30 mm × 40 mm Depth: 20-30mm Continuous Wave Frequency: 10-25Hz Intensity: 2mA Duration: 20min a day for 7 days	Increment of FDV increase in the EA group was larger than that in the medication group, suggesting that EA is more effective than medication in the improvement of acute lumbar muscle sprain The total efficacy rate after one course of treatment was 93.3 % in the EA group and 86.6 % in the medication group, with no significant difference in efficacy between the two groups
(Zhao et al., 2015)	The role of arginine vasopressin in electroacupuncture treatment of primary sciatica in human	Experimental	2015	China	To investigate the role of arginine vasopressin (AVP) in electroacupuncture in treating primary sciatica in human	77 Patients	Electroacupuncture Treatment Sham Treatment: same as EA treatment but not at acupoint and no EA	VAS	Electroacupuncture: Acupoints: ST36 Dense-disperse wave Frequency: 10 Hz / 20 Hz (1min each) Duration: 60 min Intensity: Patient comfort (10–15 mA)	AVP concentration of CSF, not plasma in primary sciatica patients was lower than that in health volunteers Electrical acupuncture of the bilateral “Zusanli” points (St. 36) for 60 min relieved the

										pain sensation in primary sciatica patients Positive correlation between the effect of electroacupuncture relieving the pain and the AVP level of CSF in the primary sciatica patients The central AVP, not peripheral AVP might take part in the progress of electroacupuncture relieving the pain sensation of primary sciatica

(Aval et al., 2016)	Effects of Electro-Acupuncture and Acupotomy Dissolution on mRNA Expression of Centre Pro-Opiomelanocortin (POMC) Detected by In Situ Hybridization in Rats with Non-Specific Low Back Pain	Experimental	2016	China	To determine the effects of electro-acupuncture and acupotomy dissolution on the mRNA expression of center Pro-opiomelanocortin (POMC) in rats with non-specific low back pain	42 rats	Normal Group (no intervention and no LBP stimulation) Model Group (no intervention) EA group Acupotomy group Except for the normal group, the other groups were treated from the 15th day	N/A	Electroacupuncture: Acupoints: GV-3 and left BL23 Frequency: 2 Hz and 100 Hz Dense-disperse wave Duration: 20min of each, there were six treatments in two consecutive weeks (days 8, 18, 20, 23, 25, 28).	POMC level in the EA and acupotomy groups increased significantly more than the normal and model groups No significant difference between the electro-acupuncture and acupotomy groups
(Lee, 2021)	Treating the Psoas Muscle Using Electroacupuncture	Case Study-descriptive	2021	N/A	This article outlines how the psoas can be effectively treated using electroacupuncture.	1 person	Electroacupuncture	N/A	Electroacupuncture: T12 to L5 on the left side along the Huatuojiaji M-BW-35 points and Inferior and medial to Biguan ST-31, close to the bone, insert a 75mm needle Depth: 0.5 to 1 cun Dense/Disperse wave Intensity: comfortable for patient Frequency: 6/2 Hz Duration: 15-20min	Patient could immediately stand up straight and walk with less pain

Appendix B Turnitin Report

Department of Physiotherapy

Faculty of Health Sciences, Department of Physiotherapy · Private Bag 3, Wits, 2050, South Africa
Tel: +27 11 717 73721/3702 · Fax : 27 86 5534 762 · E-mail: Veronica.Ntsiea@wits.ac.za · www.wits.ac.za

29 February 2024

The Chairperson
Graduate Studies Committee
University of the Witwatersrand
Faculty of Health Sciences

Dear Professor Papathanasopoulos

Re: Turnitin score of 18% for Ms Karishma Dahya's Research Report
MSc Physiotherapy: Student No. 855984

Ms Karishma Dahya is a MSc Physiotherapy student in our Department. She has just received her Turnitin score in preparation for submission of her research report for examination. I have read the detailed Turnitin report and can confirm that most of the areas that are highlighted in the document are not content related. It is mainly to do with names of the authors in articles reviewed, low back pain, electrotherapy and electro-acupunture terms which are commonly used throughout the studies reviewed and even in the discussion. There is no indication of plagiarism throughout the research report.

Regards

Associate Professor Veronica Ntsiea
Head of Department of Physiotherapy
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