The effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness associated with chronic lower back pain

By

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I, Ching-Hsuan Chen, do hereby declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary)

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DEDICATION

In family life, love is the gentle oil that soothes all friction, the steadfast bond drawing hearts closer with conviction, and the melody weaving harmony, soft and sweet, where each soul finds its rhythm, making life complete.

This study is dedicated to my parents, Yi-Lung Chen(dad) and Yuan-Ju Chen (mom), my brothers, Jen-Hao and Ching-Tung Chen, my wife Ting-Wen Chen, whose unwavering support and belief inspired me to complete this study

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endeavour is sincerely appreciated, and I am committed to ensuring that it yields valuable insights and contributes to the advancement of knowledge in the field.

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ABSTRACT

Background: Chronic lower back pain (CLBP) is one of the top ten causes of daily disability that affect large population globally. Musculoskeletal disorders account for 80% of lower back pain and in particular, hamstring tightness has been identified as one of the causative factors of chronic lower back pain.

Massage, needling and cupping therapy have been proven to be effective treatment options. However, these treatments are prohibited for patients with contraindications such as pregnancy, cancer, sunburn, rash, deep vein thrombosis and diabetes mellitus. Therefore, it is important to establish treatment options that can be administered to patients who present with low back pain due to hamstring tightness, but who also present with contraindications to established treatment options.

Techniques such as active release technique (ART) and muscle energy technique (MET) have been investigated in conditions like tension headache, chronic neck pain, tennis elbow, carpel tunnel syndrome, sciatic nerve pain and plantar fasciitis. However, these techniques have not been investigated in the treatment of chronic lower back pain caused by hamstring tightness.

Aim: This study aimed to identify the effectiveness of active release technique alone versus the combination of muscle energy technique and active release technique in the treatment of chronic lower back pain due to hamstring tightness.

Method: The proposed research study utilised a quantitative study design consisting of an experimental single blinded randomised and comparative clinical trial. The target population included participants between the ages of 18-55 years who reside in the eThekwini region of KwaZulu-Natal.

A total sample size of 40 patients underwent a randomised controlled trial and took place with 2 groups of 20 participants each. Group A, received active release technique alone in the treatment of hamstring tightness causing chronic lower back pain, and Group B, received the combination of active release treatment and muscle energy technique in the treatment hamstring tightness of chronic lower back pain. Each group received 2 interventions and the results from group A and group B were compared to identify the effectiveness from the outcome.

Throughout, a p-value of 0.05 was used to indicate significance levels. The analysis carried out using IMB SPSS Statistics 27 software.

Result: The findings of this study revealed that there was a significant difference between the group receiving ART alone compared to the combination of ART and MET.

Conclusion: In conclusion, this study revealed that the use of combination of ART and MET is more effective than the use of ART alone.

Key indexing terms: Manual therapy; active release technique; muscle energy technique; combination treatment mode; chronic lower back pain; hamstring tightness

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	Abbreviation
Chronic lower back	CLBP
Active release technique	ART
Muscle Energy Technique	MET
Range of Motion	ROM
Institutional Research Ethics Committee	IREC

CHAPTER ONE INTRODUCTION

1.1 Introduction

Chronic lower back (CLBP) pain refers to persistent or long-lasting discomfort, stiffness, or soreness in the lower back region (Ferreira *et al.* 2023). According to George *et al.* (2021) the term chronic implies that pain has been present for at least three months or more. Urits *et al.* (2019) state that similar to acute back pain, which may result from a specific injury or trauma, chronic lower back pain may persist over time and can be associated with various factors. These factors include underlying medical conditions, structural issues, or ongoing musculoskeletal problems (Reis and Macedo 2015; Kahere and Ginindza 2021).

Batool *et al.* (2019) and Bazzaz-Yamachi *et al.* (2021) state that CLBP which is identified as a top-ranking cause, and a significant contributor to daily disability, affects almost 25% of the global population (Schuttert *et al.* 2021). A study by Ferreira *et al.* (2023) found that almost 619 million people globally are affected by CLBP and Schafer *et al.* (2020) further estimate that by 2050, an estimated 843 million of the population will be affected by CLBP, as a result of the increase in the aging population and the lack of appropriate manual therapy.

Understanding the prominence of CLBP in the South African context is crucial for recognizing its substantial burden on individuals and society. Kahere *et al.* (2022) believe that CLBP can lead to a significant economic burden to a country and therefore state that it can cost approximately 78.78 billion Rands (South African) to treat patients with CLBP. A reason cited by Kahere and Ginindza (2020) for an increase CLBP is insufficient research, thus, leading to a lack of appropriate treatment outcomes in the medical healthcare system. Whilst there may be many contributing factors to CLBP (Batool *et al.* (2019), musculoskeletal disorders can be associated with strain in the musculature of the area and contribute 80% to the cause of CLBP (Pillet *et al.* 2020).

Musculoskeletal pain is defined as chronic pain arising from musculoskeletal structures (Bonanni *et al.* 2022). Musculoskeletal structure provides a crucial role in core stability to prevent muscular strain and minimize CLBP (Kim and Yim 2020). Furthermore, Dubon, Kotler and LaBella (2021) found that a weak core has a close association with a tight hamstring, which in turn has been closely associated with CLBP (Hori, Hasegawa and Takasaki 2021). Likewise, the Sadler *et al.* (2017) study reported that 95% of individuals with tight hamstring develop CLBP.

There are several established management options to treat hamstring tightness associated with CLBP (Hori, Hasegawa and Takasaki 2021). These include education in sport management and preventing over-exertion to the hamstring muscle (Vij *et al.* 2022), sub-occipital muscle inhibition (Jagtap and Mandale 2015), acupuncture, dry needling (Mortazavi, Zebardast and Mirzashahi 2015), cupping, spinal manipulation and sacroiliac manipulation (Wagener 2019; Parkes 2020), steroid injection (Vij *et al.* 2022), surgical treatment (Patel and Kinsella 2017; Vij *et al.* 2022). However, certain conditions such as cancer, sunburn, rash, deep vein thrombosis, and diabetes mellitus restrict patients from receiving treatments (Ansari *et al.* 2020; Schafer *et al.* 2020; Engman 2021). It is therefore crucial for the practitioner to identify treatment options for all patients who present and suffer from CLBP due to hamstring tightness.

Manual therapies, for example Active Release Technique (ART) and Muscle Energy Technique (MET) has been found to be effective in the treatment of CLBP and hamstring tightness (Michaeli 2020; Monteiro *et al.* 2021). Both ART and MET when used individually, have shown to reduce strain and tension to enhance muscle tissue elasticity (Gillani, Rehman and Masood (2020); Jain, Zore and Kumar (2020); Osama and Rehman (2020a). However, despite evidence that these treatments are effective, further studies need to be undertaken to investigate the effectiveness of ART and MET as a combined mode for treating CLBP (Kisilewicz, Urbaniak and Kawczyński 2018; Hagedorn 2020; Gangwar 2022).

1.2 Problem Statement

Several studies have shown that almost a quarter of the global population experience challenges with CLBP (Kahere and Ginindza 2021; Kahere *et al.* 2022; Ferreira *et al.* 2023). Research among the South African population revealed that almost 79 billion Rands were spent on treating patients with CLBP in 2022 (Kahere *et al.* 2022). Patients often suffer prolonged pain and discomfort, often leading to chronic stiffness and soreness in the lower back region (Ferreira *et al.* 2023). Despite patients struggling with CLBP, Urits *et al.* (2019) state that to date there are no established effective manual therapy to help patients relieve this discomfort and pain. This study therefore aimed to investigate the effectiveness of a single ART mode of treatment compared to a combined ART and MET for treating CLBP caused by hamstring tightness.

1.3 Research aim and objectives

1.3.1 Aim

This study aimed to investigate the effectiveness of the ART alone in comparison to a combination of the ART and MET in treating CLBP due to hamstring tightness.

1.3.2 Objectives

Objective One

To assess the effectiveness of the ART alone in treating CLBP caused by hamstring tightness in terms of subjective and objective measurements.

Objective Two

To assess the effectiveness of the combination of ART and MET in treating CLBP caused by hamstring tightness in terms of subjective and objective measurements.

Objective Three

To compare the results of objectives one and two.

1.4 Hypotheses

1.4.1 Null Hypothesis

No relationship exists between treating CLBP caused by hamstring tightness using ART alone in comparison to a combined mode of ART and MET together.

1.4.2 Alternate Hypothesis

The combination of ART and MET is more effective than ART alone in the treatment of CLBP caused by hamstring tightness.

1.5 Rationale

According to Kahere et al. (2022), CLBP is found to be an economic burden with estimated annual costs of 78,78 billion Rand in South Africa. Dubon, Kotler and LaBella (2021) and Hori et al. (2021) further identified several management options for treating hamstring tightness associated with CLBP. Urits et al. (2019) believe that there are appropriate identified manual therapies to assist patients to minimise or relieve their CLBP caused by hamstring tightness. Both ART and MET, when used individually, have been shown to decrease muscular strain and tension (Gillani, Rehman and Masood 2020; Osama 2023). However, Gangwar (2022) and Hagedorn (2020) stated that whilst most studies investigated the effectiveness of ART and MET alone for treating pain, more research is required to improve the effectiveness of a combined ART and MET treatment technique for patients with CLBP caused by hamstring tightness.

Despite research has been conducted on the effectiveness of ART and MET alone, the researcher in this study focused on assessing the effectiveness of ART alone in treating CLBP caused by hamstring tightness in terms of subjective and objective measurements. Furthermore, the researcher aimed to assess the effectiveness of the combination of ART and MET in treating CLBP caused by hamstring tightness in terms of subjective and objective measurements. Finally, the researcher aimed to compare the results of the above two objectives. The rationale for conducting this study because there were no research conducted with ART and MET as combination treatment for for CLBP caused by hamstring tightness. Schafer et al. (2020) state that some treatment options have been known to have a negative impact on patients with the following conditions: post-traumatic hip pain, pregnancy, cancer, sunburn, rash, deep vein thrombosis, and diabetes mellitus. Therefore, alternative treatment with minimal contraindication is required to treat these patients. For this reason, the researcher believes that there is a need for an investigation on the effectiveness of ART alone, and ART in combination with MET in the treatment of CLBP caused by hamstring tightness.

1.6 Summary

In this chapter, a comprehensive overview of the study was provided, including a concise introduction, the problem statement, and rationale. Furthermore, the aims and objectives of the study were outlined.

CHAPTER TWO LITERATURE REVIEW

2.1 Introduction

Lower back pain (LBP) is becoming a rapidly growing health condition affecting a number of people across various backgrounds and environments (Galliker *et al.* 2020; Wu *et al.* 2020; Chen *et al.* 2022). Overas *et al.* (2021) and Gilmore *et al.* (2020) agree that LBP is due to a combination of factors and can, if left untreated, persist and lead to a chronic condition. Chronic LBP extends over 12 weeks or more with the patient experiencing tremendous pain and suffering. In their global studies, Nielsen *et al.* (2021) found that CLBP was a significant cause of disability among woman and Bizzoca *et al.* (2023) and Dreyer *et al.* (2021) also found that CLBP was significantly more prevalent among females than males.

According to Chiarotto and Koes (2022) and Kahere *et al.* (2022) the pain can root from non-identifiable conditions such as muscle imbalance, nerve root pain, spinal pathologies like a tumour, infection, rheumatoid arthritis, osteoporosis, fracture, or inflammation. Koch and Hänsel (2019) further elaborate that the lower back can experience strain and stress due to either poor posture during long periods of sitting or poor posture in a standing position. Noonan and Brown (2021) and Saito *et al.* (2023) agreed, stating that incorrect anatomical posture can lead to a long period of low intensity pressure to the lumbar spine. This also concurs with Kim and Yim (2020), who stated that low-intensity pressure experienced on the lumbar spine could lead to the development of muscle tightness and pain. If left untreated, muscle spasm can occur due to reduced blood supply to the muscle fibres, depriving the oxygen, mineral and vitamins to the muscle (Urits *et al.* 2019; Popescu and Lee 2020).

Wang *et al.* (2020) state that patients suffering with CLBP struggle with sleep disorders, anxiety, depression, and concurrent musculoskeletal pain in other areas of the body. According to Kasher *et al.* (2022), Overas *et al.* (2021) and Overstreet *et al.* (2023), the presence of additional musculoskeletal pain in other regions can be linked to the onset of CLBP.

Musculoskeletal pain is acute or chronic pain that impacts muscles, ligaments, tendons, bones and nerves (Overas *et al.* 2021). Chronic LBP, neck pain, and pain associated with osteoarthritis and rheumatoid arthritis are the most common forms of musculoskeletal pain (El-Tallawy *et al.* 2021). Musculoskeletal pain can be differentiated from non-musculoskeletal pain as the former pain conditions are specifically related to musculature, whereas, non-musculoskeletal pain is related to conditions such as sleep problems, constipation/digestive conditions, menstrual pains (Goncalves *et al.* 2021). Urits *et al.* (2019) state that there is muscle involvement in CLBP. Tagliaferri *et al.* (2020) further highlight that an understanding of CLBP is essential for administering appropriate treatment, since the muscle tightness leads to imbalances in the lower back region of individuals, thus leading to CLBP. Khawar *et al.* (2022), found that 47% of athletes develop hamstring tightness due to frequently stressed in running, over-exertion, and even during long periods of sitting and walking. According to Sadler *et al.* (2017), 95% of individuals with tight hamstring develop chronic low back pain, thus, indicating a close relationship between hamstring tightness and CLBP . Overas et al. (2021) state that to treat the musculoskeletal pain as a result of CLBP diverse management approaches could be beneficial.

Khawar et al. (2022) found that effective treatment options included massage, needling, and cupping therapy. However, according to Ansari *et al.* (2020), these options can only be used in the absence of contraindications such as pregnancy, cancer, sunburn, rash, deep vein thrombosis, and diabetes mellitus (Schafer *et al.* 2020; Engman 2021). Therefore, it is important to explore treatment options that can be administered to patients who present with low back pain due to hamstring tightness and these aforementioned contraindications (George *et al.* 2021; Kahere *et al.* 2022).

According to Osama and Rehman (2020b) and Gaur, Kapoor and Phansopkar (2021a), the application of Active Release Techniques (ART) and Muscle Energy Techniques (MET) were found to be effective in reducing strain and tension, thus assisting with the improvement of muscle tissue elasticity. These techniques play a vital role in returning the normal function of both contractile and non-contractile muscle tissues (Gillani, Rehman and Masood 2020; Jain, Zore and Kumar 2020; Osama and Rehman 2020b). According to Gaur, Kapoor and Phansopkar (2021a), ART involves a hands-on approach that combines movement and pressure to assist with issues such as adhesions and tightness in muscles, tendons, ligaments, and fascia. Ahmed and Fouda (2022) further state that by accurately targeting the area of adhesions, ART helps to release tension, allowing for improved mobility and flexibility. Osama and Rehman (2020b) explain that MET involves the active participation of the patient in specific muscle contractions and stretches. Abd Elrazik Gad Elhak, Battesha and Samir (2021) reveal that this method is often utilised to address imbalances, improve joint mobility, and reduce muscle tightness. Gaur, Kapoor and Phansopkar (2021b) concur, adding that by engaging the patient with controlled movements, MET allows the re-establishment of muscle length and function, improving the ROM.

Gangwar (2022) and Gaur, Kapoor and Phansopkar (2021b) agree that both ART and MET techniques were proven to be effective in reducing existing strain and tension within muscles and improving the overall elasticity of muscle tissue. This assists in the restoration of normal function in both contractile muscles and non-contractile structures (Gillani, Rehman and Masood 2020; Jain, Zore and Kumar 2020; Osama and Rehman 2020b). However, the Thind (2019) study stated that there is limited research on the benefits of ART applied to hamstring-related pain and muscle length. Furthermore, the study of Khan, Patel and Limbani (2021), concluded that more combination management plans with active release techniques are needed; whilst Abaspour *et al.* (2020) agree that MET is normally used in combination with different manual techniques.

Although there is a high prevalence and significant social costs associated with CLBP, a large portion of cases appear to have an unknown cause due it the complex anatomy, degenerative changes and lack of clear diagnostic tool (Gellman 2020; Michie, Johnston and Carey 2020). This concurs with Lituiev *et al.* (2023) who stated that there are several factors, such as limited sensitivity of specialised tests commonly employed to evaluate CLBP, a notable occurrence of anatomical anomalies observed in diagnostic imaging, a lack of strong correlation between anatomical abnormalities and clinical symptoms, and the inability of clinical examinations to reliably predict rates of symptoms and disability (McCloy and Peck 2020; Popescu and Lee 2020).

2.2 Active Release Technique

Active release technique (ART),developed by Dr Michael Leahy, is a technique that introduces a repetitive injury cycle as a mechanism to add stiffness or tension to the tissue (Ravichandran *et al.* 2017; Kothawale and Rao 2018; Khan, Patel and Limbani 2021). Active release technique (ART) is a manual therapy that focus on relieving pain and tension by removing adhesion build up in tissues (Rehman *et al.* 2022; Naeem *et al.* 2023).

Figure 1 indicates the procedure of ART. With patient lying supine with hip passive flexed to 90-degree angle (label A), knee fully extended on the involved hamstring. Practitioner then isolate an adhesion point on hamstring (label B) and ask patient to actively flex the hamstring while holding on the adhesion (label C). For more detailed explanation, refer to Chapter 3, 3.9.

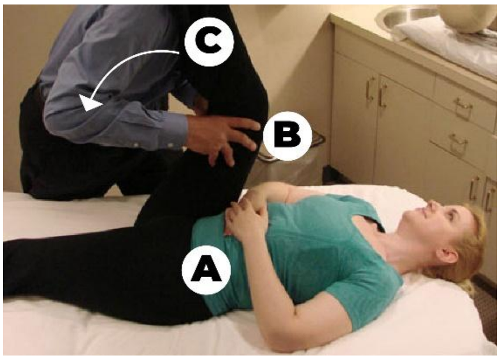


Figure 1 Procedure of active release technique (Leahy 2012)

Thacker *et al.* (2011) and Khan, Patel and Limbani (2021) state that ART is an approach practised by many medical professionals, including Chiropractors, Massage Therapists, Physiotherapists, Occupational Therapists, Kinesiologists, and Sports Physicians. Kothawale and Rao (2018) and Ahmed and Fouda (2022) found ART to assist with identifying specific restricted tissues and utilize many hand positions and soft tissue manipulation methods to allow the muscle fibres to return to their normal texture, tension, and length. Barnes and Rivera (2022) explain that an ART session act as both an assessment and therapeutic intervention. This concurs with Abd Elsadek *et al.* (2023) stating that the therapist employs physical hands-on techniques to assess the texture, tension, and mobility of muscles, fascia, tendons, ligaments, and nerves. Any abnormalities found in these tissues are attended by the application of precise direct tension in conjunction with specific movements performed by the patient (Kothawale and Rao 2018; Ahmed and Fouda 2022; Rehman *et al.* 2022; Abd Elsadek *et al.* 2023).

Kothawale and Rao (2018) state that ART stands out from other manual therapies due to its emphasis on patient involvement, where the "A" in ART represents the patient's active movement. Furthermore, Hagedorn (2020) place emphasis on the utilization of hands to assess the underlying soft tissue. This concurs with Joshi and Srivastava (2018) and Rehman *et al.* (2022) adding that ART assists with the movement of muscles, tendons, and ligaments, reducing the pressure on nerves and providing pain relief. Furthermore, George *et al.* (2006) found an increase in flexibility and ROM to the hamstring muscle immediately following ART treatment.

McHugh and Tyler (2019) agree that repetitive micro-injuries in a tight muscle contribute to the increase of friction and tension within the myofascial structures. Furthermore, Rehman *et al.* (2022) and Gangwar (2022) state that ART is unique as an advanced massage technique modified to release tension in muscles, tendons, and fascia.

Orejel Bustos *et al.* (2021) state when muscles and other soft tissues are over-exerted, many issues may include acute conditions like pulls, tears, muscle spasms, or contractures. Lalchhuanawma (2019) reveal that over-exerted soft tissue can lead to small tears resulting from repetitive motion, known as micro-trauma, where hypoxia, a lack of oxygen to the injured area, can occur. For this reason, Lalchhuanawma (2019) agree that ART is a beneficial treatment mode to relieve pain and discomfort for patients with CLBP caused by hamstring tightness. Hagedorn 2020; Gangwar 2022 state that over exertion to the body can lead to formation of dense scar tissue in the affected area, restricting the movement of healthy tissues. This concurs with Lalchhuanawma (2019) adding that the more scar tissue accumulates, the weaker the muscle, the higher the possibility of entrapped nerves, and tension on the tendons which can lead to inflammation or tendonitis. This cascade of events ultimately leads to reduced ROM, loss of strength, and the onset of pain (Phadke *et al.* 2016; Mackey and Kjaer 2017; Jain, Zore and Kumar 2020). In situations where a nerve is trapped, individuals may experience sensations like tingling, numbness, and weakness (Jacobson, Dengler and Moore 2020; Weiss 2020). On the contrary, Shah, Ghumatkar and Kumar (2021) state the disadvantage to the technique is that the procedure can sometimes be uncomfortable or even painful due to the break town of scar tissue. This concur with Kothawale and Rao (2018) stating it is not suitable for everyone as some may have underlying condition such as osteoporosis, advanced cancer, or open wound injuries.

Although Santos-Longhurst (2018) state the treatment procedure may bring discomfort, Kothawale and Rao (2018) reported that the effectiveness of the ART in a single treatment, showed improvement in the hamstring flexibility among a group of healthy, active male participants. To date, Jain, Zore and Kumar (2020) and Vaidya *et al.* (2021) both indicate ART to be effective in the reduction of pain and improve muscular flexibility within a short period of one month. However, Gangwar (2022) and Shah, Ghumatkar and Kumar (2021) add that further research is required to determine the effect of ART in long term treatment.

2.3 Muscle Energy Technique

Muscle Energy Technique (MET) is a manual therapy performed to lengthen muscles, enhance ROM, alleviate tightness and pain, improve circulation and lymphatic drainage, and prevent the formation of trigger points in the patient.

Figure 2 indicate the basic procedure to MET. With patient lying supine, hip passively flexed to 90 degree angle (label A), knee extended until barrier or moderate stretching sensation is felt. The patient then performs moderate isometric contraction of knee flexion against the practitioner’s shoulder (label B). For more detailed explanation, refer to Chapter 3, 3.9.

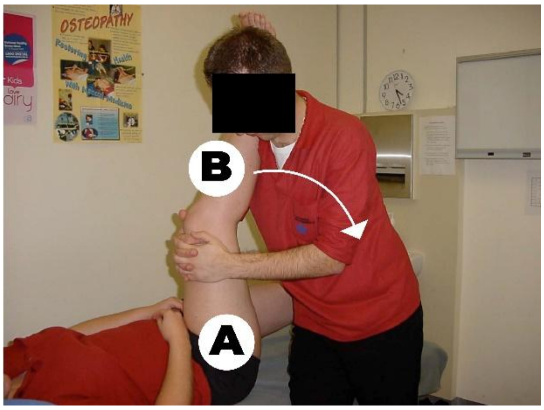


Figure 2 Muscle Energy Technique (Kostidis 2004)

Kedar and Malawade (2023) and (Osama 2023) further add this muscle-lengthening process utilizes the concepts of autogenic inhibition, a mechanism where a muscle relaxes its tension through signals generated within the muscle itself or reciprocal inhibition, where the stretching or contraction of one muscle leads to a decrease in the activity of the opposing muscle (Osama and Rehman 2020b; Siddiqui, Akhter and Baig 2022).

The technique is performed by initiating a contraction for seven seconds to induce a neurophysiological inhibitory effect on the muscle spindle, slowing down the brain signal to the muscle fibre, allowing the sensitivity and activity of muscle fibre to reset (Gaur, Kapoor and Phansopkar 2021a). Thomas *et al.* (2019) elaborate that the exact mechanism for the pain relief resulting from MET remains unclear, although it is proposed that MET affects joint proprioceptors and mechanoreceptors, influencing descending pathways and altering the motor response of the targeted joint (Wahyuddin *et al.* 2020; Waxenbaum and Lu 2020). However, Thomas *et al.* (2019) proposed another theory, stating that the reduction in pain and increased mobility is led from the alterations in the viscoelastic properties of soft tissue brought about by MET. Thomas *et al.* (2019) further emphasise that several researchers have proposed variety of methods for utilizing MET by modifying factors such as force, contraction duration, contraction directions, post-contraction length, and the stretch applied after contraction.

According to Deshmukh, Phansopkar and Kumar (2020), MET is considered effective in addressing pain and tenderness in CLBP patients, particularly in addressing hamstring tightness and improving knee joint ROM (Gaur, Kapoor and Phansopkar 2021a). Furthermore, Zaidi and Ahmed (2020) state that their study found the treatment of MET in lower back and lumbopelvic pain is significantly effective. However, Núñez-Cabaleiro and Leirós-Rodríguez (2022) and Aghayousefi *et al.* (2020) recommend that this technique be used with other manual techniques to provide better results.

Table 2.1 Comparison of ART and MET-indications and contradictions (Gaur, Kapoor and Phansopkar 2021a; Naeem et al. 2023)

	ART	MET
Definition	Soft tissue manipulation technique utilised to break down adhesions and scar tissue to restore normal function and range of motion.	Manual therapy technique consists of active contraction of muscles against a resistance to improve flexibility, range of motion and muscle function.
Approach	Primarily focus on soft tissue adhesions, scar tissue, and myofascial restrictions.	Primarily focus on improvement of muscle length, joint mobility and neuromuscular control through stretching and muscle contractions.
Indications	Used for many musculoskeletal conditions involving overuse injuries, muscle strains, and dysfunction	Used for addressing muscle tightness, joint restrictions, and neuromuscular dysfunction associated with musculoskeletal pain.
Contraindication	Acute inflammation, open wounds, deep vein thrombosis.	Acute fractures, open wounds, muscle strain or tear.
Techniques Used	Hands on placements on tissue adhesions combined with patient movement.	Patient actively contracts muscles in specific direction against resistance provided by therapist.

2.4 Effectiveness of ART and MET in treating chronic lower back

Barnes and Rivera (2022) state that ART is beneficial in assisting individuals within the athletic community, including both recreational and professional athletes. Bagherian *et al.* (2019) further highlight that ART helps increase ROM and reduction of pain, thus, improving the performance and reducing the risk of injury. Nam (2020) and Lee and Nam (2020) found that ART resulted in positive outcomes for patients with chronic pain where symptoms resembled muscular overuse syndrome, and individuals who have not found relief through conventional therapies. This is possible as the ART technique involves precise application of manual therapy by targeting scar tissue and adhesions which is often the root causes of pain and dysfunction (Risaldar *et al.* 2021; Tsai, Nödl and Galloway 2021). However, Kothawale and Rao (2018) state that ART can only be effective once the adhesions within the soft tissue is completely released. In the study by Vaidya *et al.* (2021), it was discovered that ART assisted in the reduction of lower back pain for patients. Barnes and Rivera (2022) and Cholewicki *et al.* (2019) suggest ART promotes the restoration of each individuals biomechanical structure, improving the overall movement and gait pattern, thus, helping to reduce CLBP. Rehman et al. (2022) adds that ART assists in the reduction of pressure on the nerves and provides pain alleviation. This concurs with Danazumi *et al.* (2021) and Shaikh *et al.* (2023) suggesting that the application of ART helps influence the nervous system by modulating pain perception and promoting more efficient neuromuscular coordination. Vaidya *et al.* (2021) state that ART has the potential to reduce muscle spasms and alleviate pain, providing relief from persistent and discomforting symptoms. Vaidya *et al.* (2021) further found that ART enhances the blood flow to the area of application, which in turn helps the delivery of oxygen and nutrients to the muscles, reducing the risk of muscle spasm and promoting muscular healing effect (Abd Elsadek *et al.* 2023).

Many studies have assessed various treatments aimed at enhancing flexibility and joint ROM (Barnes and Rivera 2022; Sulowska-Daszyk and Skiba 2022; Raza *et al.* 2023). These investigations have determined that both ART and MET are effective in improving joint flexibility (Hagedorn 2020; Chaitow and Franke 2023). However, there remains some speculation and debate regarding which intervention is the most effective for physical therapists to employ (Raza *et al.* 2023). Studies have utilised MET in patients experiencing acute and chronic low back pain (LBP), latent trigger points, cervical pain, and other musculoskeletal dysfunctions (Thomas *et al.* 2019; Sbardella *et al.* 2021; Raza *et al.* 2023). The Thomas *et al.* (2019) study that applied MET to the thoracic spine in asymptomatic subjects with a restricted and a non-restricted side, found that MET increased mobility only on the restricted side (Thomas *et al.* 2019).

Muscle energy technique involves the use of active isometric contraction to relax and lengthen muscles, placing a greater emphasis on lymphatic and venous drainage to enhance the ROM (Raza *et al.* 2023). Moreover, Santos *et al.* (2022) provide further insight into the positive impact of MET in alleviating acute and moderate chronic LBP through a study involving 822 participants, with no significant disability outcomes observed. This finding is supported by Dayanır *et al.* (2020) and Al Matif *et al.* (2023), whose studies to assess the effectiveness of MET on chronic lower back pain, reported a significant reduction in functional disability, improvement in lumbar spine ROM, and a decrease in pain intensity attributed to the technique. Furthermore, Al Matif *et al.*

(2023) established the effectiveness of MET in increasing facet flexion, spinal flexion, and spinal extension, demonstrating its efficacy in CLBP treatment. This concurs with the Deshmukh, Phansopkar and Kumar (2020) systematic review study on LBP that reported that enhancing the flexibility of muscles, tendons, and ligaments in the back contributes to increased ROM and aids in the functional movement of patients.

Nam (2020) and Osama (2023) found that ART and MET is more effective in improving pelvic tilt compared to the myofascial release technique in the improvement of CLBP. Ahmed *et al.* (2021) and Lee and Nam (2020) agree to the potential of ART and MET as a non-pharmacological and non-surgical intervention for treating chronic low back pain. Zemková and Zapletalová (2021) found that improving core muscular strength is crucial for supporting the lumbar spine, and both ART and MET play an effective role in this process by identifying and breaking down scar tissue and adhesions—the primary culprits behind pain, stiffness, weakness, and physical dysfunction associated with soft tissue injuries (Lee and Nam 2020; Gaur, Kapoor and Phansopkar 2021a; Raza *et al.* 2023). Furthermore, a recent study by Azuma and Someya (2020) on soccer players highlighted that the prophylactic use of stretching in healthy individuals or those with disabilities helps to prevent injuries, often believed to enhance performance. According to Gaur, Kapoor and Phansopkar (2021a) and Raza *et al.* (2023), ART and MET recover movement of all the soft tissues, relax entrapped nerves, blood vessels, and lymph, and restore the proper texture, elasticity, and functions of soft tissues. Abd Elsadek *et al.* (2023) and Raza *et al.* (2023) further suggest that ART and MET is effective in reducing pain levels and improving functionality in individuals with CLBP.

Healthcare professionals frequently employ stretching to increase joint motion in the care of patients with CLBP (Kim and Yim 2020; Shamsi *et al.* 2020). According to Gaur, Kapoor and Phansopkar (2021a) and Minnis (2018) their studies show that both technique ART and MET increases the flexibility and ROM of the hip, which in result decrease lower back pain. In a study conducted by Gaur, Kapoor and Phansopkar (2021a) all patients demonstrated significant improvements in pain, disability, and joint function outcomes, suggesting that ART and MET could be considered effective and safe techniques for managing CLBP.

2.5 Chronic lower back pain caused by hamstring tightness

The lower back, also known as the lumbar vertebrae of the body, supports most of the body's weight and act as the centre of body balance (Noonan and Brown 2021; Park and Srinivasan 2021). Lumbar vertebrae (usually 5 in total) occurring in the lower region of the spinal column together with their intervertebral discs, form a lordotic curve which provide support through the quality of shock absorption and cushioning effect between the spinal column (Yoshida *et al.* 2018; Frost, Camarero-Espinosa and Foster 2019). These supports take place continuously throughout the day (DeSai, Reddy and Agarwal 2018). The vertebrae are held in place by the ligaments and tendons attached to the muscles of the spinal column (Frost, Camarero-Espinosa and Foster 2019).

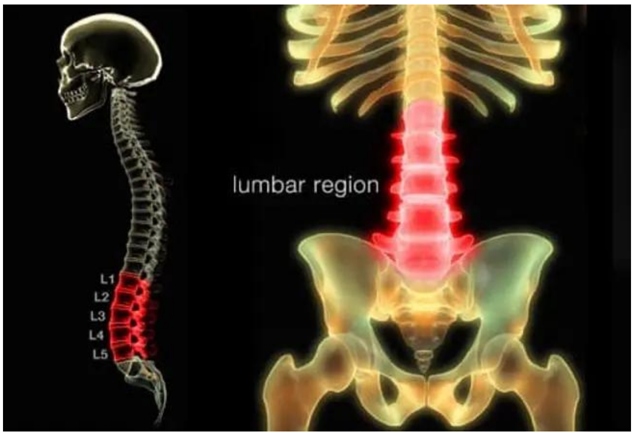


Figure 3 Lumbar Spine (Tyler Wheeler 2022)

Lower back pain, also known as non-specific low back pain or simple backache, refers to the existence of pain between the lower half of the body, ranging from below the ribs to the buttock (Zemková and Zapletalová 2021; Ferreira *et al.* 2023). According to Chiarotto and Koes (2022) and Kahere *et al.* (2022) the pain can root from non-identifiable conditions such as muscle imbalance, nerve root pain, spinal pathologies like a tumour, infection, rheumatoid arthritis, osteoporosis, fracture, or inflammation. Koch and Hänsel (2019) further elaborate that the lower back can experience strain and stress due to either poor posture during a long periods of sitting or poor posture in a standing position. Noonan and Brown (2021) and Saito *et al.* (2023) agree, stating that incorrect anatomical posture and age related degeneration can lead to a long period of low intensity pressure to the lumbar spine. This concurs with Kim and Yim (2020), as low-intensity pressure experienced on the lumbar spine could lead to the development of muscle tightness and pain. If left untreated, muscle spasm can occur due to reduced blood supply to the muscle fibres, depriving the oxygen, mineral and vitamins to the muscle (Urits *et al.* 2019; Popescu and Lee 2020).

Lower back pain is a complex health condition that manifests in various forms, each form indicating unique contributing factors (Urits *et al.* 2019; Popescu and Lee 2020). Kim and Yim (2020) state that among the multiple factors which may result in lower back pain, the common type includes muscular strain and tension. This concurs with McHugh and Tyler (2019) who added that muscle strain and tension develop from overexertion or improper movement, and this may also affect the supporting musculature and ligaments around the hip and lower limb. According to Urits *et al.* (2019), lower back pain is characterized by localized or referred pain, or tingling numbness in the lumbar region. Noonan and Brown (2021) stated that the lumbar spine, which is an important region of the human anatomy is prone to multiple stressors that contribute to lower back pain. If the condition is left unaddressed, lower back pain can progress from acute to chronic lower back pain (Ebadi *et al.* 2020; Hayden *et al.* 2021). Bonanni *et al.* (2022) and Urits *et al.* (2019) state the progression can take place due to unaddressed acute pain or inadequate treatment approach.

Chronic lower back pain (CLBP) is a complex health condition that lasts for more than 12 weeks (3 months) (Kato *et al.* 2019; Bonanni *et al.* 2022). Tagliaferri *et al.* (2020) and Urits *et al.* (2019) mention when compared to acute low back pain, CLBP is considered as a kind of “disorder” instead of potential adverse stimulus. CLBP affects more than half a billion of the population globally (Hurwitz *et al.* 2018). This results in poor quality of life, worsening of health status, emotional distress, daily disability, and social and economic impact (Traeger *et al.* 2019; Du *et al.* 2020).

According to Bhimani *et al.* (2020), tightness is experienced through the sensation of stiffness in the muscle. This tightness is typically the result of muscle overuse (Chan *et al.* 2019). Omodaka *et al.* (2019) further add that the correlation between muscle stiffness with low back pain, where long periods of tight muscle can result in muscle weakness of the lower back, leading to restriction of motion. Urits *et al.* (2019) and Van Dieën *et al.* (2019) agree that lower back pain may impair normal daily activity resulting in irregular and poorly coordinated movement patterns. Van Dieën *et al.* (2019) emphasise that poor muscle balance in the region of low back will affect unbalanced compressive force on the spine. This unbalanced compressive force further weakens the core stability strength, which adds the tension and strain to lower back pain (Kim and Yim 2020).

Hamstring tightness is the sensation of shortened muscles in the posterior aspect of the thigh (Kothawale and Rao 2018; Encarnación-Martínez *et al.* 2023). This limits the overall mobility of the thigh (Batool *et al.* 2019; Thind 2019). Batool *et al.* (2019) and Timmins *et al.* (2020) state that the common cause of tight hamstring include poor form of exercise, long periods of sitting and start and stop of movement. Allam *et al.* (2023) and Kim *et al.* (2021) agree that continuous repetitive movement and activities can lead to tight hamstring.

According to Cejudo, Centenera-Centenera and Santonja-Medina (2021), tight hamstring can lead to pelvic tilt, which is described as a forward tilt of the pelvis, creating an increased curvature in the lumbar spine, known as lumbar lordosis (Sadler *et al.* 2017; Allam *et al.* 2023). Cejudo, Centenera-Centenera and Santonja-Medina (2021) describe the connection to the pelvic tilt caused by hamstring tightness as due to the attachment of the muscle component. This is elaborated by Cejudo, Centenera-Centenera and Santonja-Medina (2021) and Timmins *et al.* (2020) explaining that biceps femoris (BF) (long head and short head), semitendinosus (ST) and semimembranosus (SM) muscles are attached to the ischial tuberosity, a direct connection to the pelvis (El-Hajj *et al.* 2020). Therefore, a tight or shortened hamstring often results in an increase in posterior pelvic tilt which decreases the lumbar curvature (Cejudo, Centenera-Centenera and Santonja-Medina 2021). As a result, increasing the stress load on the lower back region, leading to CLBP (Sadler *et al.* 2017; Nam 2020; Cejudo, Centenera-Centenera and Santonja-Medina 2021).

The study by Hemming *et al.* (2019) and Saito *et al.* (2023) show that individuals with LBP exhibit distinct muscle activation patterns compared to those without back pain. Van Dieën *et al.* (2019) and Park and Srinivasan (2021) further state that back pain can arise from the simultaneous activation of multiple muscles, including both agonist and antagonist muscles, especially in standing postures. This agrees with Wasser *et al.* (2020) who added that issues with the musculature around the hip can contribute to the spread of pain to the sacral regions, becoming a causative factor for CLBP. Furthermore, Kim and Yim (2020) and Noonan and Brown (2021) indicated that muscles in the lumbar spine can play a significant role as primary sources of both back and hip pain. Noonan and Brown (2021) emphasize that the increase of co-activation muscles around the lumbar spine increases lumbar spine loading. Tak *et al.* (2013) and Kahere and Ginindza (2021) agree that a change in the muscle activation pattern like this eventually causes LBP, leading to a change in pelvic tilt due to the increase in tightness of hip musculature.

Nam (2020) mentions increase in pelvic tilt for a long period can lead to CLBP. Kim and Yim (2020) further state that good stability in the lumbar spine and pelvis, it is important to maintain stability in the sacroiliac joint. This concurs with Encarnación-Martínez *et al.* (2023) and Zemková and Zapletalová (2021) who state that sacroiliac joint stability is maintained through the group of muscles such as multifidus, transversus abdominis, internal oblique and gluteus maximus. Dubon, Kotler and LaBella (2021) agree stating that weakness in these muscles can lead to decreased stability of the sacroiliac joint. This, as a result, adds extreme stress load to the hamstring as compensation, leading to overactivation of the hamstring (Kim and Yim 2020; Dubon, Kotler and LaBella 2021). Dubon, Kotler and LaBella (2021) put emphasis on the consequence to hamstring activation for stability compensation, as it further delays the utilisation of essential stabilising muscles.

A study by Wagener (2019) implemented stretching exercises for hamstring tightness and found an improvement in the reduction of CLBP and the ability to work more effectively. Another study by Fasuyi, Fabunmi and Adegoke (2017) found that improved flexibility in the hamstrings lessen the degree of pelvic tilt. Dubon, Kotler and LaBella (2021) agree adding that individuals with CLBP often have hamstring tightness. Bitenc-Jasiejko, Konior and Lietz-Kijak (2020) and Javadov, Ketenci and Aksoy (2021) state previous studies have proved the effectiveness of intervention plans to assist with the improvement of sacroiliac stability and muscles in the lower back. To further understand the connection between chronic lower back pain caused by hamstring tightness, it is important to investigate the effectiveness of these management options (Hori, Hasegawa and Takasaki 2021).

2.6 Treatment and management of Hamstring Tightness to minimise Chronic Lower Back Pain

Hamstring muscles also known as ischiocrural muscles, are found in the posterior compartment of the thigh (Timmins *et al.* 2020). The hamstring muscles consist of semitendinosus (ST), semimembranosus (SM), and biceps femoris (BF) long head and short head (Fasuyi, Fabunmi and Adegoke 2017). These components of the hamstring muscle receive vascular supply from the deep femoral artery, commonly known as the profunda femoris artery (Muscolino 2020; Timmins *et al.* 2020). The nerve innervation of hamstring muscle arises from the lumbosacral plexus, via the sciatic nerve (L3-S3), which bifurcates into common peroneal(fibular) nerve and tibial nerve at the level of the tibiofemoral joints (Timmins *et al.* 2020). The common peroneal branch of the sciatic nerve innervates the short head of the biceps femoris, whereas tibial branch innervates the semimembranosus, semitendinosus, and long head of biceps femoris muscles (Muscolino 2020). These components of the hamstring muscle function to induce flexion of the knee, extension of the thigh by the hip and rotation of the lower leg from side to side (Timmins *et al.* 2020). Common contributions to hamstring strain include not warming up properly before exercise, repetitive usage of the muscle, imbalance in musculature of the legs, or returning to activities too quickly after an injury (Khawar *et al.* 2022; Raza *et al.* 2023).

Figure 4 Components of Hamstring muscle (Muscolino 2020)

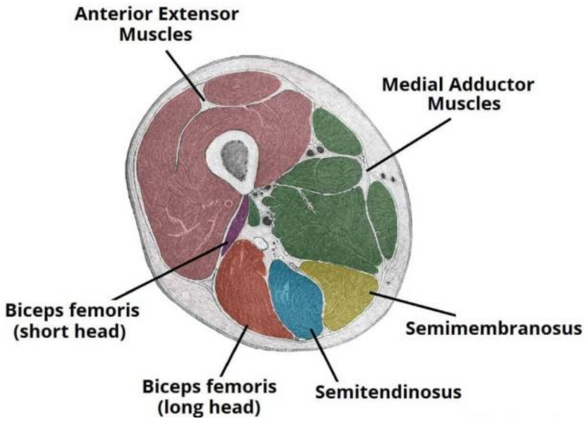


Figure 5 Cross Section of the thigh illustrating three components of the hamstring muscles (Jones 2024)

Muscle tightness is the reduction in the ability of a muscle or muscle groups to achieve the full ROM for a specific body part (Omodaka *et al.* 2019; Konrad *et al.* 2021). This tightness in muscle is due to the reduction in tissue quality, where musculature is semi-contracted continuously resulting in the inability to relax or lengthen (Alfuraih *et al.* 2019). Sareen and Prakash (2021) state that hamstring tightness does not only lead to a reduction in ROM but can also result in other musculoskeletal problems. Amir *et al.* (2022) and Gatti, Ledezma-Ramirez and Brennan (2023) further explain that muscle length tension relationship and the ability to absorb stress and shock wave is directly affected by the tightness of the muscle. As with the higher flexibility of the muscle, the stronger the myosin head attachment, allowing the eccentric contraction energy to be absorbed more effectively(Lange *et al.* 2020).

According to Rahman and Islam (2020), the degree of flexibility is an important component to maximise the function and performance of musculature. Thus, stretching is the most well-known approach to achieving muscular flexibility (Rahman and Islam 2020; Hori, Hasegawa and Takasaki 2021). The stretching techniques promote the stretching effect that helps to reduce the risk of muscular injury and also improves overall circulation, pain relief and ROM (Deshmukh 2019). Buttagat *et al.* (2020) and Capobianco, Mazzo and Enoka (2019) state that the two approaches to achieve this effect include: i) self-stretch through exercises such as stretching classes, yoga, pilates, or ii) external therapist assistance such as massage, muscle energy technique, ultrasound, proprioceptive neuromuscular facilitation stretch, active release technique, dry needling, cryotherapy (McAtee 2019; Bedford 2021). Although some techniques can be achieved individually, Zaidi *et al.* (2023) state that self-stretch is not as effective and efficient as a therapist applied techniques to achieve flexibility.

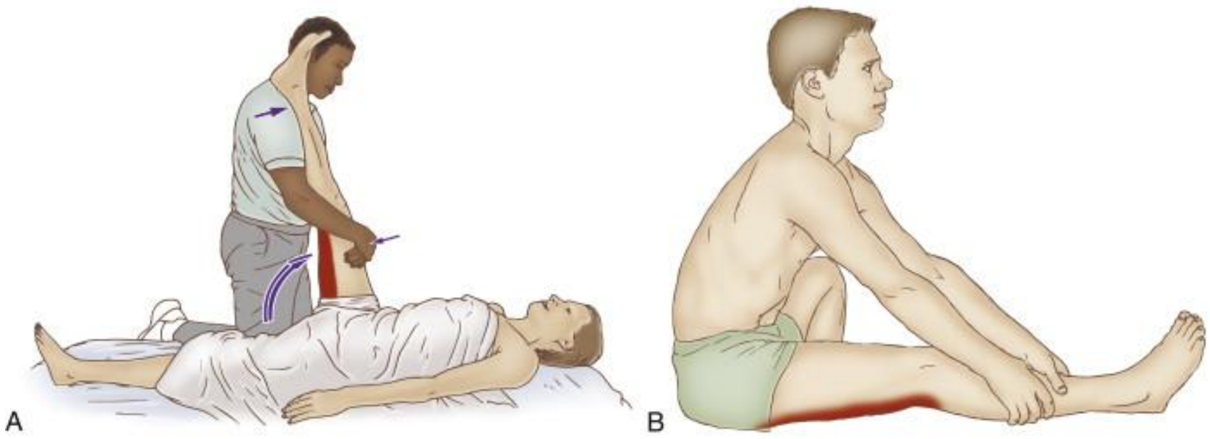


Figure A-Indicating Therapist Applied Stretch B-Indicating Self Stretch (Muscolino 2016)

Management plans should provide physiological and psychological improvements (Nikiphorou *et al.* 2021). Physiological improvements include stretching exercises such as static, dynamic and proprioceptive neuromuscular facilitation stretch to help restore flexibility and reduce tightness (Raza *et al.* 2023). Strengthening exercises improve muscle balance and alleviate tightness (Raza *et al.* 2023). Lastly, activity modification in sport or exercise avoids exacerbation of hamstring tightness and further promotes the recovery phase (Hayden *et al.* 2021). Psychological improvement includes relaxation techniques such as deep breathing exercises to prevent the progression of muscle tightness (Toussaint *et al.* 2021). Cognitive behavioural therapy to assist with negative thoughts and beliefs about the pain, promotes adaptable behaviors to avoid hamstring tightness (O'Sullivan *et al.* 2018). Positive social influence is recommended to provide emotional support and encouragement during the rehabilitation process for hamstring tightness (Fang, Fang and Fang 2022). Karpov *et al.* (2019) agree that factors such as physiological and psychological improvement help speed up the recovery phase from hamstring tightness. This concurs with Rimes, Smith and Bridge (2023), who stated that experiences such as anxiety, low self-esteem and depression can decrease the performance of the healing stage. In the study by Carter and Norman

(2023), positive reinforcement of self-talk, relaxation, and goal setting helped reduce the time of healing in athletes with hamstring tightness.

While many medications are commonly used to assist low back pain (Traeger *et al.* 2019), Lim *et al.* (2019a) state that this medication is not always as effective to assist with CLBP. Busse *et al.* (2021) further state that medication often provides symptomatic relief by masking pain, however, it does not address the underlying causes of CLBP such as structural abnormalities, muscle imbalance or poor posture. Anderson and Shaheed (2022) mention that the well-known medications used to relieve CLBP, are paracetamol and nonsteroidal anti-inflammatory drugs (NSAID). Freo *et al.* (2021) further add that these drugs, when used for long periods, may lead to the risk of toxicity in the body system. This concurs with Patel *et al.* (2019) who agreed that medication such as muscle relaxants can only provide short-term relief in the use of CLBP. Ultimately, medications may lead to adverse events, especially the medication types that are related to the central nervous system (Urits *et al.* 2019). These adverse events may or may not include sedation, drowsiness, headache, blurred vision, nausea, and vomiting (Chiappini *et al.* 2022).

Research has shown that there are many non-pharmacological therapies available to relieve CLBP (Lemieux *et al.* 2020). These include therapies such as cognitive behavioural therapy, exercise therapy, acupuncture, massage therapy, spinal manipulation and yoga (Leininger *et al.* 2023). Other interventions such as ultrasound, low-level laser therapy, interferential current and transcutaneous electrical nerve stimulation have been shown to have some degree of benefit to CLBP (Tantawy *et al.* 2019).

According to the International Association for the Study of Pain, chronic conditions are mostly managed rather than cured (Treede *et al.* 2019). Urits *et al.* (2019) state owing to the negative side effects of pharmaceutical interventions, the approach of self-management is considered more frequently to manage CLBP. Budhwani *et al.* (2018) and Svendsen *et al.* (2022) agree that self-management includes the ability for individuals to control and manage symptoms, physical and lifestyle changes, and seeking personal therapy. Despite the increased volume of treatment and management options, systematic reviews and randomized controlled trials on CLBP, no specific treatment plan can be advised for an effective outcome (Urits *et al.* 2019;

Tagliaferri *et al.* 2020). Therefore, Lim *et al.* (2019b) state that it is important for the healthcare professional to access and understand the up-to-date management plan. Buchbinder *et al.* (2020) further state that more evidence-based information is required to assist healthcare professionals in treatment decision-making.

Whilst Buchbinder *et al.* (2020) and Varsi *et al.* (2021) mention that self-management consideration is found beneficial to pain management. Stevans *et al.* (2021) reported that more than 32% of participants with low back pain had transitioned to CLBP. The reason is the constant increase in risk factors during daily living, these include smoking, obesity, and anxiety (Choi *et al.* 2021). To date, Du *et al.* (2020), Lim *et al.* (2019b) and Zhou, Salman and McGregor (2023) have concluded that the most effective approach to treat CLBP includes some degree of self-management plan with the incorporation of manual therapy.

Malfliet *et al.* (2019) state nonpharmacologic treatment approach is the most suitable option when approaching CLBP. Treatment options such as spinal manipulative therapy, behavioural therapy, exercise therapy, transcutaneous electric nerve stimulation, interferential currents, laser therapy and yoga are well evidenced to assist with CLBP (Malfliet *et al.* 2019; Zafereo 2020; Alrowayeh 2023). Owen *et al.* (2019) mentioned that a correct combination treatment technique in the treatment of CLBP provides a more effective and long lasting reduction of pain.

However, while these management options may be effective, there may be a portion of the population who will not be able to receive these treatments due to contraindications. This therefore, necessitates the exploration of alternative, safe therapies such as ART and MET, as a means to understand the treatment and management options for chronic lower back pain caused by hamstring tightness.

2.7 Outcome Measures

2.7.1 Active Knee Extension

The Active Knee Extension (AKE) test is a physical examination procedure used to assess the length of the hamstring muscle through the ROM of knee joint (Shamsi, Mirzaei and Khabiri 2019; Olivencia *et al.* 2020). The shorter the length of hamstring muscle, the tighter hamstring muscle is, decreasing the ROM of knee joint (Khan, Patel and Limbani 2021; Encarnación-Martínez *et al.* 2023). Lim (2021) and Shamsi, Mirzaei and Khabiri (2019) state that the test helps to evaluate the capability of active full knee extension to assess the degree of existing hamstring flexibility, joint ROM, and potential restrictions or pain in the knee joint. Ansari *et al.* (2020) and Shamsi, Mirzaei and Khabiri (2019) agree that AKE is often used to assess and diagnose conditions such as hamstring tightness, joint stiffness or ligament injuries affecting the knee. Furthermore, Niewiadomy *et al.* (2021) adds that the examination of AKE helps to rule out the degree of treatment outcome, the ability to return to normal, daily activity, and the prediction of susceptibility to future injury.

While Pesonen *et al.* (2021) and Rogers *et al.* (2020) acknowledged that other measuring techniques, such as straight leg raise were commonly used before, it was noted that this measuring method easily resulted in pelvic movement due to no stabilisation. This concurs with Crasto *et al.* (2020) who state that due to pelvic motion in straight leg raise, it is difficult to achieve hamstring isolation to obtain an accurate result. The straight leg raise involves the application of tension to the sciatic nerve, and is therefore a tool used for neurodynamic evaluation, as compared to the active knee extension test (Adnan *et al.* 2022; Pesonen 2023). Kothawale and Rao (2018) found that AKE in the use of ART on hamstring tightness is significantly effective. Furthermore, Olivencia *et al.* (2020) state that AKE is a test with good to excellent inter-rater and intra-rater reliability for the measurement of hamstring tightness.

According to Pesonen (2023), a universal goniometer is a tool used by AKE to measure the change in hamstring flexibility through the degree of knee angle. Dejaco *et al.* (2023) and Lind, Svensson and Harringe (2022) agree that the tool is used universally in clinical settings to measure ROM in joints. Shamsi, Mirzaei and Khabiri (2019) mention that the universal goniometer is a reliable tool for AKE test when used by a trained and experienced examiner. According to Mork *et al.* (2020), the study further demonstrated a positive correlation coefficient of >0.75 for measuring knee angle with a universal goniometer. Similarly, the study by Svensson, Lind and Löfgren Harringe (2019) concur with the statement of validity and reliability with a correlation coefficient of 0.998 for intra-rater reliability and 0.994 for inter-rater reliability upon measuring knee joint ROM amongst 20 participants. Further reliability was achieved by marking out the anatomical location before the intervention (Pérez-de la Cruz *et al.* 2021). A detailed discussion of AKE is in section 3.6.2.1.

2.7.2 Universal Algometer as a pain measuring instrument

The universal algometer, also known as dolorimeter, is a tool used to assess objective measurements by means of pressure pain threshold with the application of controlled pressure to a given physiological position (Melia *et al.* 2019). Caamaño-Barrios *et al.* (2019) defined pressure pain threshold as the initial sensation to the change of pain experienced. Kamińska, Dalewski and Sobolewska (2020) indicate that the tool can be utilised to rule out tender areas of the muscles and to assess the effect of treatment outcome on the musculature region.

Figure 6 Universal Algometer (De Heus *et al.* 2010)

Knapstad *et al.* (2018) and Jerez-Mayorga *et al.* (2020) agree to the accuracy of validity and reliability of the universal algometer. It was found that by having three consecutive measurements on the same site with 30-second intervals, a near-perfect measurement was recorded, demonstrating a positive correlation coefficient of 0.95. This concurs with Jerez-Mayorga *et al.* (2020) who stated that by having consistent pressure applied, the accuracy is drastically improved. Excellent validity and reliability was determined by Caamaño-Barrios *et al.* (2020) and Kinser, Sands and Stone (2009) when quantifying pain threshold. According to Caamaño-Barrios *et al.* (2020) and Reezigt *et al.* (2023), the universal algometer is shown to have high intra and inter-examiner reliability. Linde *et al.* (2018) and Reezigt *et al.* (2023) found a presence of validity and reliability with a universal algometer in the measurements for CLBP.

Saeedzadeh *et al.* (2023) found the universal algometer to be an effective measurement for ART. Aggarwal *et al.* (2024) and Girasol *et al.* (2018) who agreed thatthe set up and procedure was simple to achieve with a high consistancy of result. Mulla, Kulkarni and Kumar (2021) and Parab and Pattanshetty (2019) both found the tool to be effective in the measurement of the of pressure pain threshold immediately after the treatment of MET. Furthurmore, the study by Tan *et al.* (2023) showed positive reliable result with the use of universal algometer to demonstrate the level of pain in CLBP patients. The tool has been proven to be helpful in the assessments and presents good results with positive validity and reliability (Castien, Van Der Wouden and De Hertogh 2018), with very high ICC = 0.91; 95 CI 0.82, 0.97 and the p-value of (p = 0.0094) (Voogt *et al.* 2015; Waller *et al.* 2015; Castien, Van Der Wouden and De Hertogh 2018).

2.7.3 Numerical Pain Rating Scale

The Numerical Pain Rating Scale (NPRS) is a tool used to subjectively measure an individual's pain intensity (Shafshak and Elnemr 2021). In the study by Dhanavandhini, Alagesan and Buvanesh (2024) and Vaidya *et al.* (2021), NPRS was shown to be effective in the reflection of pain before and after the treatment of ART. Al Matif *et al.* (2023) and Abd Elsadek *et al.* (2023) concur, indicating that NPRS is simple and effective to capture an individual's pain response in both ART and MET on CLBP. The NPRS is found to be reliable and valid, and have been broadly validated in past studies, as it is simple for the patient to understand and engage with (Alghadir *et al.* 2018; Knapstad *et al.* 2018; Mehrad and Zangeneh 2019). Test-retest reliability of NPRS has been shown to vary from 0.73 to 0.92 indicating moderate to high reliability (Larsson *et al.* 2022). Similarly, the data obtained is easily interpretable, easily stored and meet the requirements for pain assessment (Karcioglu *et al.* 2018).

2.7.4 Central Sensitisation Inventory and Tampa Scale for Kinesiophobia

Central sensitization inventory is a 25-item measure designed to evaluate symptoms related to central sensitization and central sensitivity syndrome through the score of 0 to 100 (Cuesta-Vargas *et al.* 2020). According to Schuttert *et al.* (2021), central sensitization refers to the increase in amplification of neural signalling within the central nervous system, resulting in increased sensitivity to stimuli and an exaggerated response to pain. These 25 items consist of questions that relate to various symptoms commonly associated with central sensitization (Verbrugghe *et al.* 2023). The questions include sensitivity to pain, fatigue, sleep disturbances, cognitive difficulties, and emotional distress (Verbrugghe *et al.* 2023). Saitou *et al.* (2022) state that a significant score of equal 40 or more indicate the presence of central sensitisation. Central sensitization inventory is designed to identify individuals experiencing central sensitization and monitor changes in symptom severity over time (Cuesta-Vargas *et al.* 2020). This questionnaire is validated in many populations, including patients with fibromyalgia, chronic fatigue syndrome, temporomandibular disorder and other central sensitization related conditions(Bourke *et al.* 2021; dos Santos Proença *et al.* 2021).

According to Dupuis *et al.* (2023) and Eiger *et al.* (2023), tampa scale for kinesiophobia questionnaire consists of 17 items designed to assess attitudes and beliefs about physical activity and movement that can cause, exacerbate, to reinjury of pain. Mesaroli *et al.* (2023) explain that the fear of movement may commonly result in avoidance of physical activities which in turn can contribute to decreased physical functioning or chronic pain. This scale ranges from strongly disagree to strongly agree (Eiger *et al.* 2023). Ye *et al.* (2020) state a score with 37 or more indicate a significate to the fear of movement. Dupuis *et al.* (2023) state that validity has shown significant with at least $P<0.05$. According to Pontes-Silva *et al.* (2023), the tampa scale for kinesiophobia was also used to measure CLBP and it was found to be reliable.

2.8 Summary

In this chapter the study presented the relevant literature on the exploration of single ART technique vs the combination therapy of ART and MET on CLBP caused by hamstring tightness. A detailed discussion of the techniques performed in treating CLBP were presented. It is also explained the current available treatments for treating CLBP caused by hamstring tightness. The next chapter presents the research methodology used for this study.

CHAPTER THREE METHODOLOGY

3.1 Introduction

This chapter discusses the research methodology utilised in the current study. Topics covered includes the study design, the research tool and research procedures followed, the sampling process, ethical considerations and the statistical analysis methods used. The researcher briefly explains the rationale for the conducting this study. Since there is a lack of research conducted with ART and MET as combination treatment for CLBP caused by hamstring tightness the researcher explored this investigation at the Chiropractic Day Clinic (CDC) in the eThekwini municipality. Furthermore, research has found that CLBP is an economic burden with an estimated annual costs of 78,78 billion Rand in South Africa.

3.2 Study Design

This study used a quantitative research design consisting of an experimental single-blinded randomised and comparative clinical trial, to determine the effects of a single ART or combination mode of ART and MET in treating patients with CLBP caused by hamstring tightness.

According to Mehrad and Zangeneh (2019), a quantitative experimental study establishes the interconnection between the independent and dependent variable, the objectives being the independent; whilst the result being the dependent variable. A descriptive cross-sectional observational study was used to analyse the investigation.

3.3 Study Location

This study was conducted at the Durban University of Technology (DUT) Chiropractic Day Clinic (CDC) in the eThekwini municipality, once permission from Clinic Director (Appendix A) and the Research Director at DUT (Appendix B) was obtained to proceed with the study at the DUT CDC. The research investigation was registered on the clinical trial database website (https://pactr.samrc.ac.za), and the Institutional Research Ethics Committee (IREC) approval was subsequently submitted (Ethical Clearance number REC 157/23).

3.4 Study Population

The target population included participants between the ages of 18-55 years, who were residing in the eThekwini region of KwaZulu-Natal, and who experienced CLBP caused by hamstring tightness.

3.5.1 Participant Recruitment

Once the necessary permission was obtained, an advertisement (Appendix C) was placed around the campus (DUT Ritson, ML, Steve Biko, City Campus, Chiropractic Day Clinic (CDC) notice boards and on the DUT Pin Board (online). In addition, the advert was placed on free advertisement boards around local shops, supermarkets, sporting facilities and gymnasiums to attract potential participants for this study. Furthermore, participants were recruited through word of mouth and at sporting events.

3.5 Sampling

This study utilised a random sampling method to group participants into two groups.

3.5.1 Sample Selection

A screening procedure was conducted on all individuals who responded to the advertisements and screening questions (Table 2) were asked. The inclusion and exclusion criteria were explained to all participants prior to participating during the screening procedure (Table 2).

Table 3 Screening questions for potential participants

Questions asked during screening for potential participants	Required answers to participate
Are you willing to answer some questions?	Yes
Are you between the age of 18 – 55?	Yes
Have you experienced lower back pain for 3 months or more?	Yes
Do you experience lower back pain 3 to 4 days a week?	Yes

Participants who met the inclusion criteria were notified and arrangements were made for them to attend the CDC for their initial consultation. The research process was explained to each participant and participants were allowed to ask questions for clarification. The participant was then provided with an information letter (Appendix F) detailing the study and the contact information of the research team. Informed consent (Appendix G) was signed by each participant that agreed to voluntarily participate in the study.

To rule out central sensitisation and fear of movement, the Central Sensitisation Inventory and Tampa Scale for kinesiophobia was used (Appendix H)(See 2.10). Participants who indicated or showed illogical neuro-anatomical pain patterns (See 2.10), and fear of movement were excluded from the study. A full case history, physical examination of lumbar and hip region was completed (Appendix I). Participants were given an opportunity to ask clarity-seeking questions throughout the procedure. They were also informed that they could withdraw from the study at any time without providing an explanation.

3.5.1.1 Inclusion Criteria

A participant may be included if they are:

- between the ages of 18 to 55 years (verified through identification) due to the likelihood of experiencing lower back pain (Skovron 1992; Chowdhury *et al.* 2023). Furthermore, Wong, Karppinen and Samartzis (2017) state that there is an increase in risk factors of the older adulthood group (56 years and older), which may interfere with the accuracy of the study result;
- experiencing CLBP due to hamstring tightness (duration of 3 months or more);
- experiencing 3 to 4 days of pain a week;
- willing to read and sign the Informed Consent form and undergo a complete case history and physical examination; and
- willing to participate in 2 interventions/treatments.

3.5.1.2 Exclusion criteria

A participant may be excluded if they:

- disagree to sign the informed consent or refuse to undergo case history and/or physical examination;
- experienced lower back pain for less than 3 months;
- have received other treatment for chronic lower back pain within 2 months prior to the study;
- have undergone back surgery;
- have received previous cognitive exercise therapy for lower back pain within a week of the study; and
- displayed central sensitisation as per the central sensitisation inventory and tampa scale for kinesiophobia equal 40 or more.

3.5.2 Sample Size

Following consultation with a statistician and based on the power analysis calculation (Appendix J), a total sample size of 40 patients was deemed appropriate for this study (Hendry, 2022).

3.5.3 Sample Allocation

An envelope was filled with 40 slips of paper: 20 labelled “Group A” and 20 labelled “Group B”. When scheduling a visit for the participant, the envelope containing the group labels, was shaken thoroughly and with the staff member’s or receptionist’s eyes close, the folded slip of paper was drawn from the envelope and stored in a sealed envelope. This envelope was then only opened by the researcher at the first consultation. If the paper read “Group A”, ART was provided to the participant. If the paper read “Group B”, the combination of ART+MET was provided to the participant. Each participant had an equal opportunity of being in either Group A or B through the simple random sampling technique. The piece of paper was kept in a safe place to ensure principle of confidentiality.

3.6 Research Assistant

Two first year MHSc students (Appendix K) were recruited to assist with measurements of the study. The researcher followed the requirements as outlined in the CONSORT statement regarding the use of the research assistant (Hopewell *et al.* 2025). A training protocol and the research purpose was explained to the research assistants before the first intervention. To improve the algometer inter-reliability, a training procedure was provided to each research assistant (Pelfort *et al.* 2015; Middlebrook *et al.* 2020). This included the skill to apply the algometer device at a constant increase to pressure and angled 90 degrees to the flat surface until the participants responded with pain verbally. The assistants were taught to maintain constant pressure until the reading was taken. Three consecutive measurements were performed on each site, with 10 seconds of recovery time before repeated application. The assistants were also trained to accurately locate the site i.e. 2cm bilateral to vertebral L2 and L4, to capture the reading with the algometer. A competency test was performed on each research assistant after the completion of training. Five successive applications at a rate of 5Newtons/second was required to be competent (Middlebrook *et al.* 2020; Dicks 2022).

3.7 Outcome measures and instrumentation

3.7.1 Measurement

Two validated measuring tools, namely the Pressure Algometer (PA) and Universal Goniometer (UG) were used in this study.

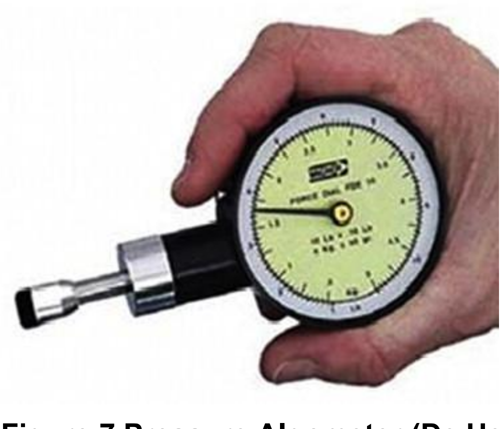


Figure 7 Pressure Algometer (De Heus *et al.* 2010)

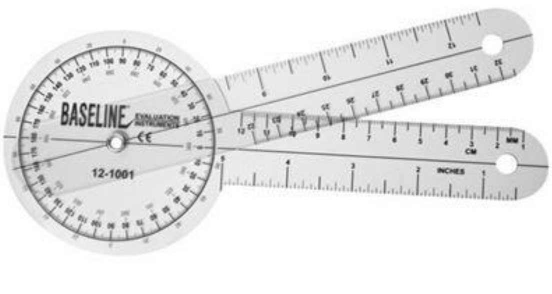


Figure 8 Universal Goniometer (Ruscoe 2021)

3.7.2 Numerical Pain Rating Scale (NPRS)

For this study, NPRS (Appendix L) was utilised to record the participant's pain rating. The patient rated their CLBP pain on a scale of 0 to 10, with 0 being no pain and 10 being the worst pain they had ever felt (Karcioglu *et al.* 2018; Young *et al.* 2019). A change of 3 points was regarded as a clinically significant difference (Dhanavandhini, Alagesan and Buvanesh 2024). The pain was measured immediately before and after the intervention along with the follow-up treatment.

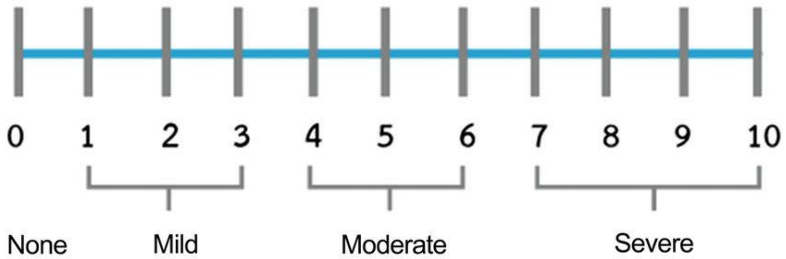


Figure 9 Numerical Pain Rating Scale (Wongsirichat 2017)

3.7.2.1 Active Knee Extension Test (AKE)

The Active Knee Extension Test (AKE) is a physical examination procedure commonly used to assess the ROM and flexibility of the knee joint (Shamsi, Mirzaei and Khabiri 2019; Olivencia *et al.* 2020). The test evaluates the ability to fully extend the knee actively, assessing factors such as muscle flexibility, joint ROM, and potential restrictions or pain in the knee joint (Lim 2021).

During the procedure, participants were positioned supine on a bed, allowing the leg not being tested to lie flat on the bed, knee extended. A strap/belt was placed over the mid-thigh of the non-tested leg to eliminate any elevation of the limb. An additional strap/belt was placed around the pelvis and bed in a neutral position during hamstring measurements. Once the uninvolved foot was in a neutral position and knee of the limb being examined was flexed at 90 degrees, the universal goniometer was used to measure the change in ROM (Pérez-de la Cruz *et al.* 2021). This was done by placing the universal goniometer over the lateral femoral condyle, 1 arm aligned along the thigh in line with the greater trochanter and the other arm aligned over the leg in the direction of the lateral malleolus.

The participants were then instructed to extend the knee until they feel a strong resistance and to hold that position for 2 to 3 seconds to allow the goniometric reading.

The results were recorded in terms of the degree to the angle of the knee extension movement, starting from the initial test position (knee flexed at 90 degree which correspond to the goniometric in 0 degree) (Khan, Patel and Limbani 2021).

The AKE readings were measured immediately before and after the intervention along with a follow up treatment.

Figure 10 Universal goniometer used for hamstring flexibility (Allam et al. 2023)

3.7.2.2 Universal Algometer

A pressure algometer is a tool used to assess the pain pressure threshold (Appendix N) with the application of controlled pressure to a given physiological position (Melia et al. 2019). During the procedure, participants were requested to lay prone for the lumbar measurements (Özdolap, Sarikaya and Köktürk 2014). Algometer readings were obtained immediately before and after the intervention at the first visit, as well as the follow up treatment. Each individual participant had 4 lumbar paravertebral points marked and evaluated (bilateral 2cm lateral to L2 and L4 spinous process) with the universal pressure algometer. The algometer gauge's reading was set to zero and the tip was positioned perpendicular to the designated location. Incremental pressure was then systematically applied at a rate of 1 kg/cm^2 per second. Participants were instructed to indicate the moment when the pressure sensation shifted to pain by saying "stop". Upon hearing this cue, pain pressure threshold reading was recorded and the applied pressure was reduced. Three consecutive measurements (in kg/cm^2) were performed on each site, with 10 seconds of recovery time allowed between repeated applications.

Figure 11 Image indicating the use of algometer on lower back (Bertoldo *et al.* 2021)

3.7.3 Subjective Measures

In the context of this research, subjective measures refer to the patient's individual perspectives on the severity of CLBP, specifically concerning pain and disability (Wettstein *et al.* 2019). These measures were elicited through the administration of the Numerical Rating Scale (NPRS).

3.7.4 Objective Measures

The objective measure involved direct observation of the severity of CLBP in patients using goniometer to assess hamstring tightness and a pressure algometer to measure Pressure Pain Threshold (PPT) (Aroke *et al.* 2020).

3.8 Measurement Frequency

The frequency measure was taken before the initial treatment protocol (Intervention). Thereafter measurements were obtained after the initial treatment protocol (intervention) . The next measurement were taken before the follow-up treatment protocol (intervention) and immediately after the follow-up treatment protocol (intervention) . The follow-up treatment protocol (intervention) took place 5 days after the initial treatment protocol (intervention).

3.9 Study Procedure

Once Institutional Research Ethics Committee approval and permission from relevant gatekeepers were received, the research proceeded the study. This study complied with the Protection of Personal Information Act (POPIA) ensuring that all personal data collected from the participants were handled lawfully, stored securely and used solely for the purpose of this research.

The research procedure was explained to each participant upon arrival for their initial consultation at the Chiropractic Day Clinic. A letter of information (Appendix F) and informed consent (Appendix G) was signed by the participant as an agreement to participate.

The central sensitisation inventory and tampa scale for kinesiophobia (Appendix H) were used as screening tools to rule out central sensitisation and fear of movement.

Participants with indications of illogical neuro-anatomical pain patterns, and fear of movement were excluded from the study. Participants were encouraged to ask questions for clarity and were informed that they were free to withdraw from the study at any point in time. A full case history, physical examination, lumbar and hip regional examination (Appendix E) was used to screen the patient before the treatment.

Participants who met the inclusion criteria were randomly allocated to one of the two intervention groups through the use of an envelope method that was controlled by the DUT clinic staff members or receptionist. The envelope method included piece of paper labelled Group A and Group B which were taken out from the hat by the clinic staff members or receptionist. The groups were: (A) ART alone, or (B) ART and MET. This gave each participant an equal chance of being placed in any of the groups, thus ensuring a random and concealed allocation of participants.

Following this, participants were asked to remove any accessories or clothing covering the lumbar region, and participants (both male and females) were provided with short pants and a gown. A baseline recording of the subjective and objective measurements were taken before the test.

Treatment was completed according to the allocated group. Group A received ART, and Group B received ART and MET. Subjective and objective measurements were then taken immediately before and after the first intervention. The next follow-up intervention was then discussed 3 days after the first intervention. The second set of subjective and objective measurements (pre and post treatment) were taken at the follow-up session.

3.10 Interventions

Prior to objective measurements, a regional examination of the lumbar spine and hip region was conducted with the goal to identify the side affected by chronic lower back pain and the tightness of the hamstring. This involved palpation, active and passive ROM, resisted isometric and orthopaedic tests to the paravertebral area around the lumbar region and posterior aspect of the thigh. Once the side of discomfort was identified, four points, 2cm apart bilaterally on L2 and L4, were marked for the research assistant to precisely locate the site for placing the algometer. Henna was employed as a marking instrument due to its durability, ensuring the marks would remain visible even with routine bathing for up to a week (Joshua *et al.* 2021). The subjective and objective finding was then measured before the intervention.

Group A: Active release technique alone

Active Release Technique was performed on both of the hamstring muscles as described by the method stated by George *et al.* (2006), Hagedorn (2020)and Gaur, Kapoor and Phansopkar (2021b). This method was applied as follows;

- the participant was asked to lay in the supine position with the testing knee fully extended and the hip flexed to the point of discomfort and the foot relaxed in plantar flexion. Whilst the non-tested leg was positioned with the hip and knee fully extend. The non-tested leg was supported with the use of belt strapped along the thigh to ensure full extension of the knee was achieved.
- the researcher then identified the most prominent myofascial trigger point on the hamstrings and locate the area. This was done with the examiner seated on the bed, supporting the tested leg with the shoulder.
- the participant was then then asked to flex the knee, contracting the hamstring to the maximum for 5 seconds. The examiner then pressed and held onto the myofascial trigger point of the hamstring muscle and asked the participant to fully extend the knee, contracting the antagonist (quadriceps) and agonist (hamstring) being resisted by the examiner for 15 seconds. The participant rested for 8-10 seconds.
- The procedure was repeated four times on a new set of trigger point (Hagedorn 2020; Gaur, Kapoor and Phansopkar 2021b).

The entire technique is re-applied according to the side that is not treated.

Group B: Combination of Active release technique and Muscle energy technique

The intervention process was the same as Group A for ART. However, in this group the additional technique of MET immediately followed the treatment of ART. Muscle energy technique was conducted on the hamstring muscle as follows:

- the participant had to lie supine on the bed with the same set up as ART.
- the tested hip was passively flexed with the knee extended until the participant reported a moderate stretching sensation, and the researcher sensed a tightness in the area.
- the participant then provided a moderate isometric contraction of knee flexion against the researcher's shoulder for 7-10 seconds.
- this was followed by a 2-3 seconds rest, after which, the leg was passively stretched to the new palpable barrier or tolerance to stretch.
- the participant was asked to hold this position for 30 seconds, and the leg was then moved back to the initial resting position on the bed for a short rest period of 8-10 second's. This was done to prevent an increase in blood pressure due to the manoeuvre and for decreasing compensatory muscle recruitment while the isometric contraction was taking place.
- the participant was guided to breathe normally during the resting period to avoid hip elevation. The procedure was then repeated two more times (Gaur, Kapoor and Phansopkar 2021b)

After the intervention was applied as per group designation, the research assistant took the measurement for subjective and objective findings.

3.11 Intervention Frequency

The study spanned one week (3 days) and comprised two consultations, ensuring a minimum one-day interval between each session to minimise extraneous variables. The maximum resting period allowed was one week (Wilks 2003; Jafari, Bahrpeyma and Togha 2017). To introduce blinding, the research assistant conducted objective measurements both before and after the intervention.

The consultation process was as follows:

3.12 Data Reduction and Analysis

3.12.1 Data Reduction

Subjective measurements:

The numeric pain rating scale was taken as a raw score out of 10. The data collected was transferred onto an Excel spreadsheet for each participant.

Objective measurements:

The mean for AKE and universal algometer values for the three repetitions were calculated for the pre-and post-test muscles. The results were transferred onto an Excel spreadsheet.

3.12.2 Data Analysis

Statistical data analysis for this study was achieved using the latest IBM SPSS 27 for Windows. Comparisons between groups were computed using software, with guidance from a statistician, through repeated measures ANOVA testing. The results were presented in the form of graphs and charts. The researcher followed the CONSORT guidelines in writing the results. The results were reported with a 95% confidence level and a p-value < 0.05 level was considered statistically significant.

The *descriptive statistics* help to summarise a set of data in this study(Mishra *et al.* 2019). Often in descriptive statistics the researcher breaks down the measures into central tendency (Kaliyadan and Kulkarni 2019). The measure of central tendency included the mean, median, and mode. This study used the frequencies in this study to describe the results. For *inferential statistics* the researcher made conclusions from the data examples, observational errors and sampling variation (Amrhein, Trafimow and Greenland 2019). The inferential statistics helped in making predictions and generalisation about the population of the study (Oh and Pyrczak 2023). In this study, two groups of the sample population were compared, those who received ART alone and the other received ART and MET combined.

To compare the data, the researcher used the two by two chi-square methods to identify the statistical significance significant. According to Sharpe (2019), the chi-square test can examine variations among two or more independent groups, even when dealing with moderately small to very large frequencies.

3.13 Validity and Reliability

According to Sürücü and Maslakci (2020), validity, in a quantitative study, pertains to how accurately a concept is measured. Both reliability and validity serve as criteria for assessing research quality. Reliability ensures consistency in results over time and the potential replication of the study findings using a similar methodology. To maintain high reliability and validity, a reflective stance was adopted, ensuring consistent equipment use and adherence to standardised measurement procedures throughout the study.

This study utilised standardised measurement tools, specifically the Active Knee Extension (AKE) and Universal Algometer. These instruments have undergone validation and are considered reliable for use in various health clinical trials. Both reliability and validity assess the effectiveness of a method, technique, or test in measuring a particular attribute. As the tools used in this study were previously validated and proven reliable Farooq et al. (2016) and Walton *et al.* (2011), there was no necessity for a pilot study to validate these instruments.

3.14 Ethical Consideration

The study began once full IREC approval (Appendix O) (Clearance number IREC157/23) and permission from the Chiropractic Day Clinic director and research director were attained (Appendix P and Appendix Q).

Confidentiality: To uphold confidentiality, participants' names were omitted from the datasheets, and each participant was assigned an alpha-numeric code to safeguard their identity. Only the researcher and the clinic receptionist had access to both the participant's name and the corresponding codes, ensuring confidentiality. The data collected will be securely stored in password-protected files and in locked cabinets at the CDC for a duration of five years. After this period, hard copies will be shredded, and soft copies will be permanently deleted.

All relevant permission to use the algometer and goniometer was obtained. The study upheld the principles of ethics, including autonomy, beneficence, justice, and non-maleficence (Vearrier and Henderson 2021).

Autonomy: Regarding autonomy, participants were provided with and completed an informed consent form (Appendix F). Participants were free to withdraw from the study at any point without facing any negative consequences. Participation in this study was voluntary, and there were no financial incentives or rewards given to participants.

Beneficence: The consideration of beneficence was given, as the study's outcomes could potentially influence and contribute to advancements in treatments or interventions for Chronic Low Back Pain (CLBP), ultimately benefiting both patients and the field of healthcare.

Justice: Justice was ensured by not excluding participants in this study based on factors such as race, gender, or occupation. All participants were treated with fairness with respect to safeguarding the welfare and rights of each individual.

Non-maleficence: Non-maleficence was observed to ensure that participants experienced no harm or, at the very least, the least possible harm in pursuit of a more beneficial outcome. Participants received only established interventions and safe treatments using effective tools, all of which are approved within the appropriate disciplines. The participants' choice to participate in, or abstain from the study was acknowledged and honoured, prioritising and respecting autonomy.

3.15 Summary

This chapter outlined the research methodology used in this study. In the next chapter data and findings are presented.

CHAPTER 4 RESULTS

4.1 Introduction

In the previous chapter, the study design and methodology were explained. In this chapter, the results are presented. The data is presented in tables, charts and graphs.

The analysis in this chapter includes the following:

- Demographic data such as gender and background variables such as the side of CLBP
- The treatment of the two identified groups, namely the ART and the combination techniques of ART and MET.
- The measurements taken before the intervention and immediately after the intervention on the first and second consultation, which was at least a three-day interval break after the first consultation. The measurements included the following;
  - The numerical pain rating scale;
  - The pain pressure threshold;
  - The range of motion to hamstring flexibility;
- Two treatment groups were compared by the use of chi-square test. The ANOVA test were used repeatedly to compare the outcomes over three time points within and between the treatment groups.

This study was based on the following hypotheses:

4.1.1 **Null Hypothesis (H_0)**

No relationship exists between treating CLBP caused by hamstring tightness using ART alone in comparison to a combined mode of ART and MET together.

4.1.2 **Alternative Hypothesis (H_1)**

The combination of ART and MET is more effective than ART alone in the treatment of CLBP caused by hamstring tightness.

4.2. RESULTS

4.2.1 Descriptive statistics

This section describes the descriptive statistics for gender. The mean, standard deviation, and p-value is presented in the findings.

4.2.1.1 Demographic variables

Demographics were compared between groups using two sample t-tests for continuous variables and chi square exact tests for categorical variables. Baseline outcomes were compared between age groups using one-way ANOVA, and between gender groups using t-tests.

a) Gender

Table 4 The comparison of baseline outcomes between gender

		Group A		Group B		p-value
		ART		ART+MET		
		Count	%	Count	%	
Gender	Male	11	55.0%	9	45.0%	0.527
	Female	9	45.0%	11	55.0%	
	Total	20	100.0%	20	100.0%	

In this study more, males participated than females. The table above show that 55% (n=11) males and 45% (n=9) females in group A, 45% (n=9) males and 55% (n=11) females in group B.

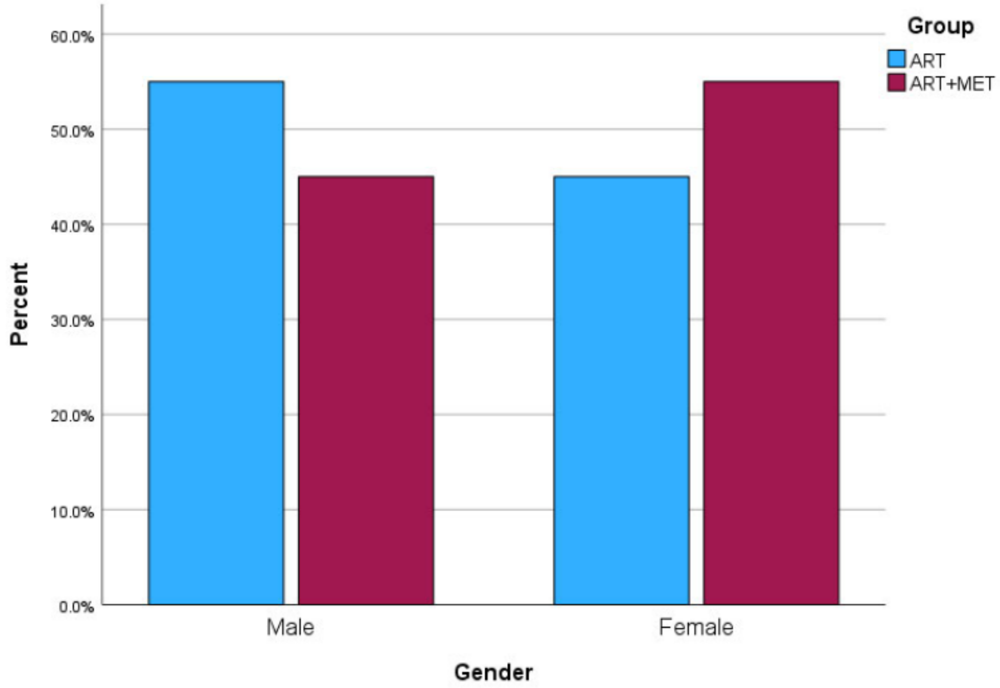


Figure 12 The comparison of baseline outcomes between gender

b) Age

Table 5 The relationship between the two groups to age

Group Statistics					
	Group	**N**	**Mean**	**Std. Deviation**	**p-value**
Group A	ART	20	28.25	9.078	0.938
Group B	ART+MET	20	28.00	11.169	

Table 3 presents the mean age group in the two groups. Group A received ART with the youngest participant being 18 years old and oldest being 49 years old, while Group B received ART+MET with the youngest participant being 18 years old and oldest being 55 years old. The mean for Group A was 28.25 with a SD of 9.078. For Group B the mean was 28.00 with a SD of 11.169. There was minimal difference recorded between the SD of both groups, thus no significant difference was found to exist between two groups prior to intervention.

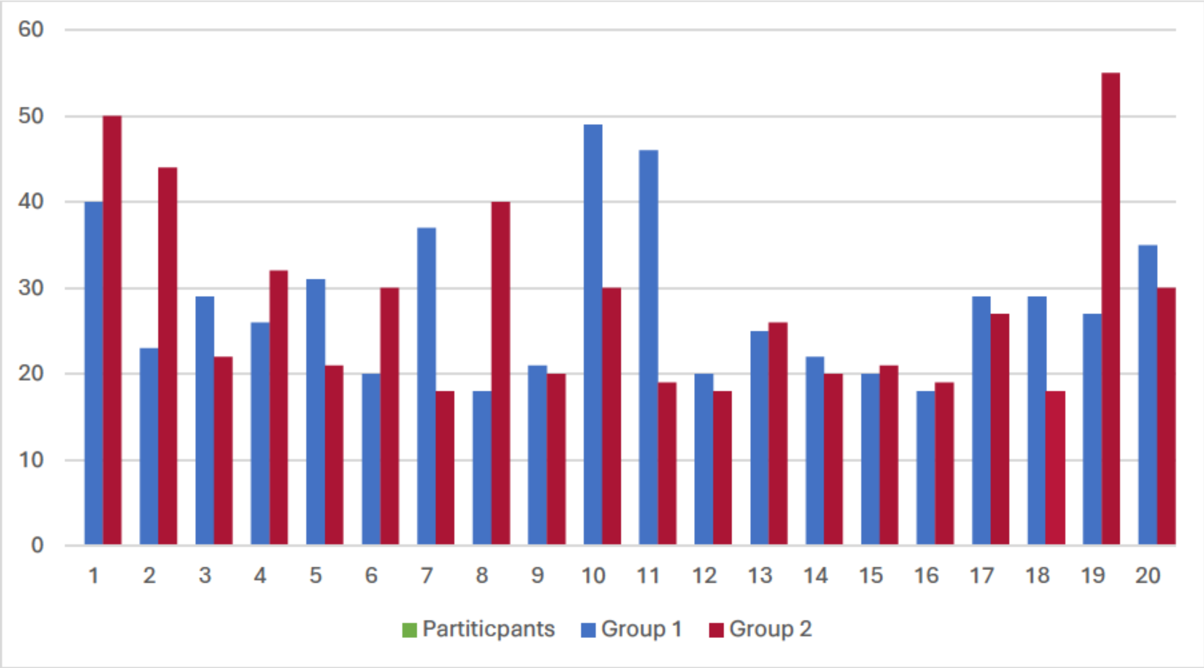


Figure 13 The relationship between the two groups to age

4.1.1.1 Side of Chronic Lower Back Pain

Table 6 The side of chronic lower back pain in each group

		GROUP A (ART)		GROUP B (ART+MET)		p-value
Side of chronic lower back pain	Bilateral	19	95.0%	11	55.0%	0.014
	Left	1	5.0%	6	30.0%	
	Right	0	0.0%	3	15.0%	
	Total	20	100.0%	20	100.0%	

In this study, the majority of participants (75%, n=30) presented with bilateral CLBP, of which 95% (n=19) were in Group A and 55% (n=11) were in Group B. Unilateral pain was present in 10 participants, with 70% (n=7) experiencing left-sided CLBP and 30% (n=3) experiencing right-sided CLBP. A p value of 0.014 indicates that there was a statistically significant difference in participant presentation in terms of the location of the CLBP. No participants presented with right CLBP in Group A.

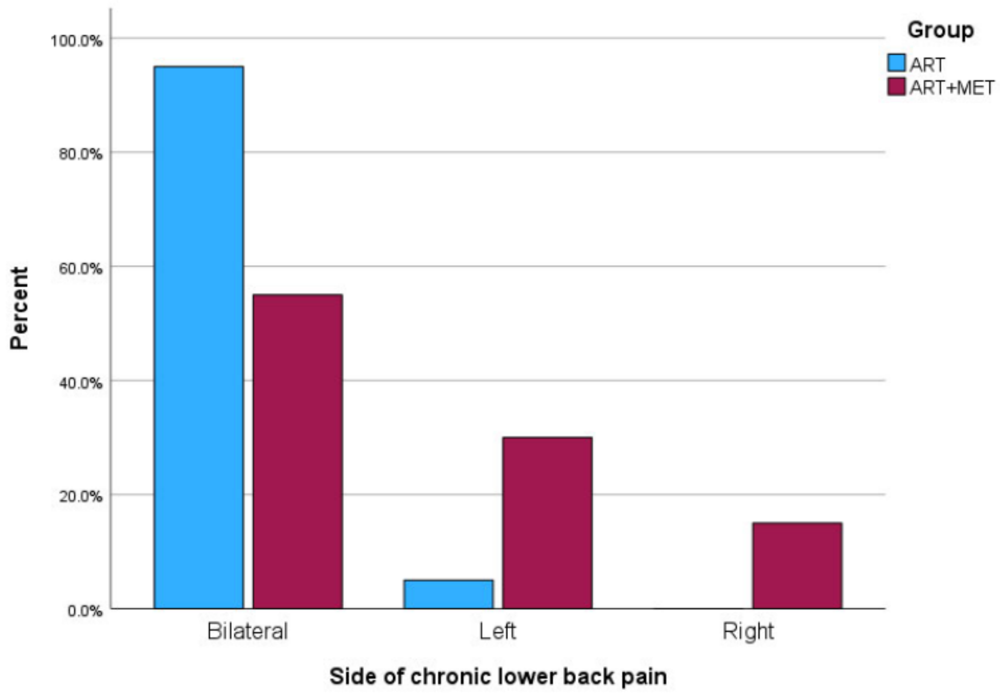


Figure 14 The side of chronic lower back pain in each group

4.2 Inferential Statistics

4.2.1 Results of Inferential Statistics

IBM SPSS version 29 was used to analyse the data and a p value <0.05 was considered as statistically significant. Chi-square tests were used to compare categorical variables between the three treatment groups. Repeated measures (before intervention one, after intervention one, before intervention two and after intervention two) ANOVA tests were used to compare outcomes over two-time points within and between treatment groups. Profile plots were used to show the direction and trend of treatment effects. Time effects were interpreted for the within-group effects, while interaction effects between time and treatment groups with significance <0.05 indicated significant between-group treatment effects.

4.2.1.1 Research Objectives

The research objective below are discussed as follows: i) To assess the effectiveness of ART alone in the treatment of CLBP caused by hamstring tightness; ii) To assess the effectiveness of the combination of ART and MET in the treatment of CLBP pain caused by hamstring tightness iii) To compare the results from objectives 1 and 2.

4.3 Objective 1: To assess the effectiveness of active release technique alone in the treatment of chronic lower back pain caused by hamstring tightness in terms of subjective and objective measurements.

4.3.1 Active Knee Extension

4.3.1.1 Left hamstring

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicated a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a clear decrease in the outcome measure across the four time points, with a mean from an initial 26 degree to 19.5 degree until full knee extension, suggesting a clinical significance in the reduction of left hamstring tightness. These results collectively indicate that ART alone significantly improves the condition of left hamstring tightness over time.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.895	48.338c	3.000	17.000	<0.001
	Wilks' Lambda	0.105	48.338c	3.000	17.000	<0.001
	Hotelling's Trace	8.530	48.338c	3.000	17.000	<0.001
	Roy's Largest Root	8.530	48.338c	3.000	17.000	<0.001

a. Group = ART
b. Design: Intercept
Within Subjects Design: time
c. Exact statistic

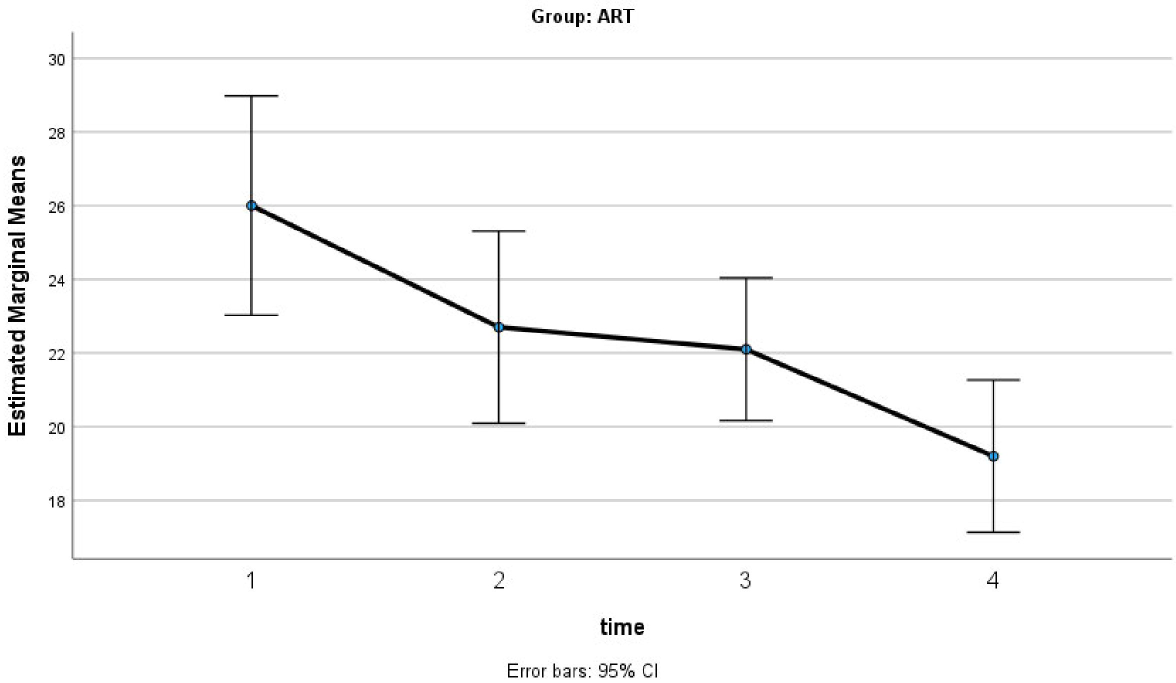


Figure 15 Result of ART treatment alone on the left hamstring

4.3.1.2 Right Hamstring

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a clear decrease in the outcome measure across the four time points, with a mean from an initial 25.5 degree to 20.5 degree until full knee extension, suggesting a clinical significance in the reduction of right hamstring tightness. These results collectively indicate that ART alone significantly improves the condition of right hamstring tightness over time. The plot shows the tightness was a decrease over time.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.860	34.923c	3.000	17.000	<0.001
	Wilks' Lambda	0.140	34.923c	3.000	17.000	<0.001
	Hotelling's Trace	6.163	34.923c	3.000	17.000	<0.001
	Roy's Largest Root	6.163	34.923c	3.000	17.000	<0.001

a. Group = ART
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

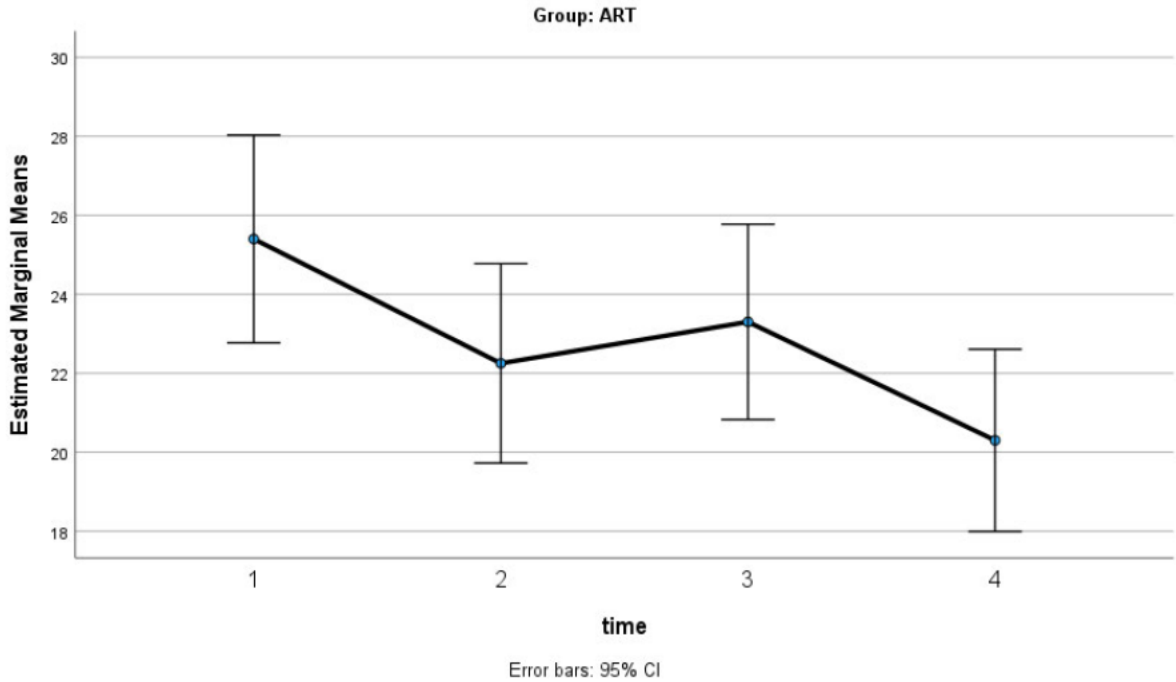


Figure 16 Result of ART treatment alone on the right hamstring

4.3.2 Universal Algometer

4.3.2.1 Left Lumbar Vertebra 2 (L2)

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.039$). The estimated marginal means plot demonstrated a minimal increase in the outcome measure across the Left L2, four time points, with a mean from an initial pain threshold of 4.5 kg/cm^2 to 4.9 kg/cm^2 . This suggests an increase in pressure pain threshold, indicating a clinical outcome of an increase in a patient's ability to tolerate pressure. These results collectively indicate that ART minimally increased the pain pressure threshold in the Left L2 region, thus reducing CLBP caused by hamstring tightness. Although the change to the Left L2 was minimal, it cannot be stated as being significant.

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.381	3.493c	3.000	17.000	0.039
	Wilks' Lambda	0.619	3.493c	3.000	17.000	0.039
	Hotelling's Trace	0.616	3.493c	3.000	17.000	0.039
	Roy's Largest Root	0.616	3.493c	3.000	17.000	0.039

a. Group = ART
b. Design: Intercept
Within Subjects Design: time
c. Exact statistic

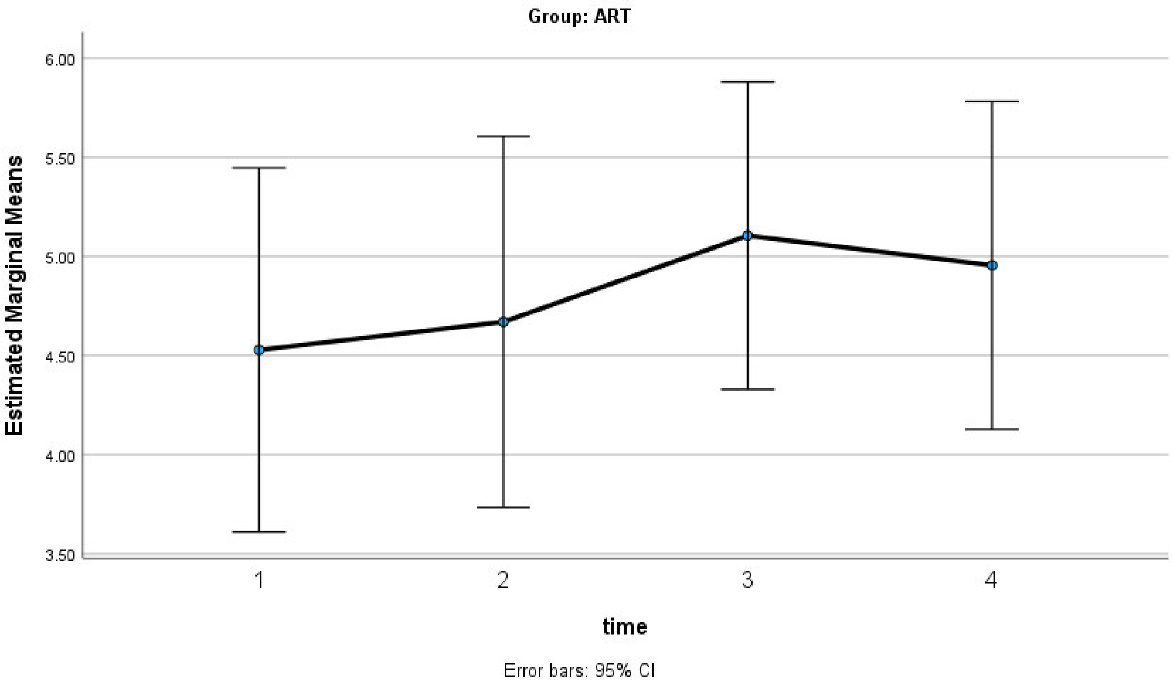


Figure 17 Pain threshold on the Left L2 – ART alone

4.3.2.2 Left Lumbar Vertebra 4(L4)

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a minimal difference in the outcome over time ($p < 0.402$). The estimated marginal means plot demonstrated a minimal increase in the outcome measure across the Left L4, four time points, with a mean from an initial pain threshold of 4.3 kg/cm^2 to 4.9 kg/cm^2. This suggests an increase in pressure pain threshold, indicating a clinical outcome of an increase in a patient's ability to tolerate pressure. These results collectively indicate that ART minimally increased the pain pressure threshold in the Left L4 region, thus reducing CLBP caused by hamstring tightness. Although the change to the Left L4 was minimal, it cannot be stated as being significant.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.154	1.034c	3.000	17.000	0.402
	Wilks' Lambda	0.846	1.034c	3.000	17.000	0.402
	Hotelling's Trace	0.183	1.034c	3.000	17.000	0.402
	Roy's Largest Root	0.183	1.034c	3.000	17.000	0.402

a. Group = ART
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

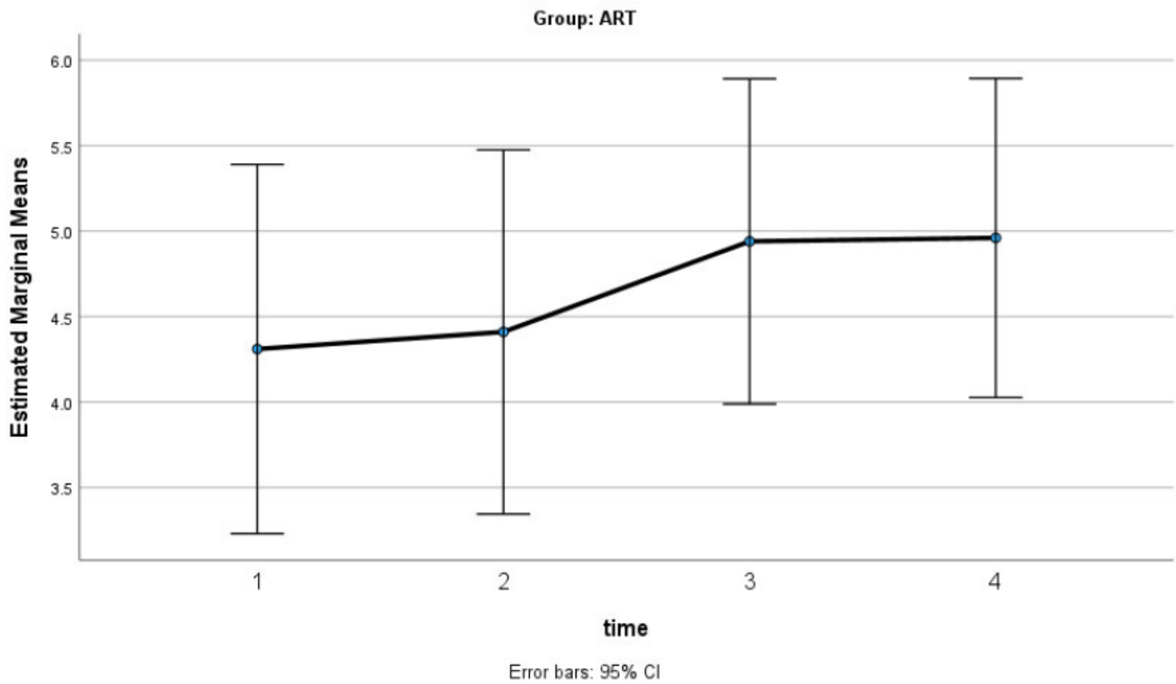


Figure 18 Pain threshold on the Left L4 – ART alone

4.3.2.3 Right Lumbar Vertebra 2 (L2)

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a minimal difference in the outcome over time ($p < 0.264$). The estimated marginal means plot demonstrated a minimal increase in the outcome measure across the Right L2, four time points, with a mean from an initial pain threshold of 4.3 kg/cm^2 to 4.8 kg/cm^2.This suggests an increase in pressure pain threshold, indicating a clinical outcome of an increase in a patient's ability to tolerate pressure. These results collectively indicate that ART minimally increased the pain pressure threshold in the Right L2 region, thus reducing CLBP caused by hamstring tightness. Although the change to the Right L2 was minimal, it cannot be stated as being significant.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.204	1.449c	3.000	17.000	0.264
	Wilks' Lambda	0.796	1.449c	3.000	17.000	0.264
	Hotelling's Trace	0.256	1.449c	3.000	17.000	0.264
	Roy's Largest Root	0.256	1.449c	3.000	17.000	0.264

a. Group = ART
b. Design: Intercept
Within Subjects Design: time
c. Exact statistic

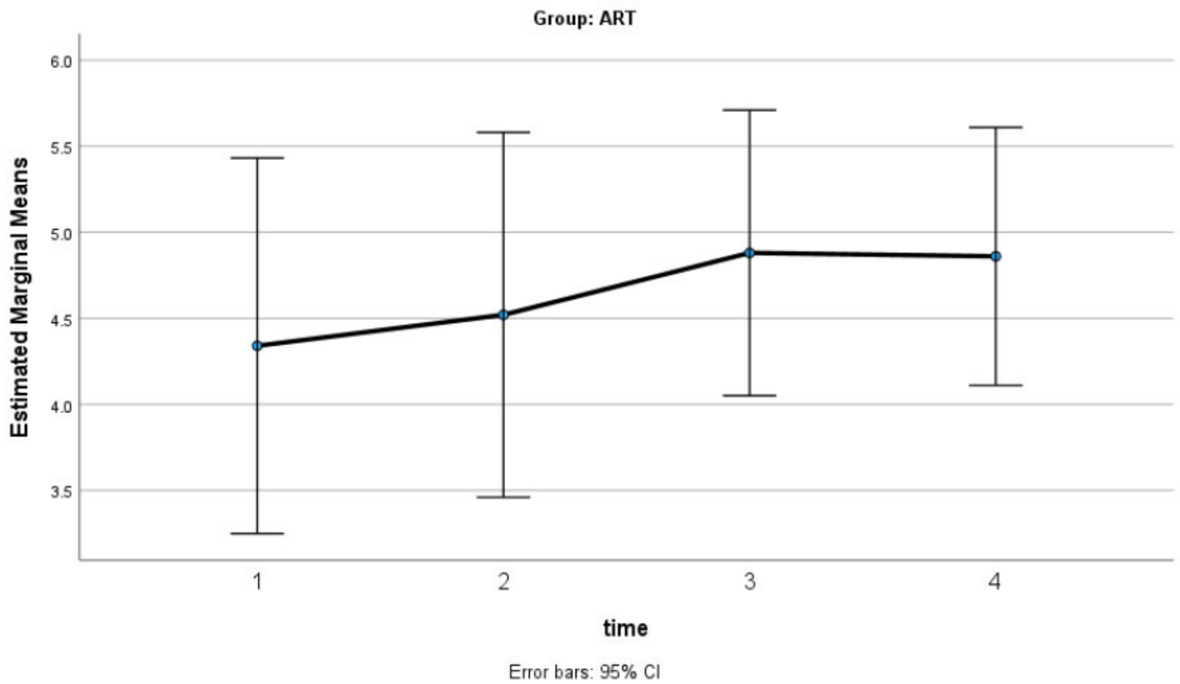


Figure 19 Pain threshold on the Right L2 – ART alone

4.3.2.4 Right Lumbar Vertebra 4(L4)

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a statistically significant difference in the outcome over time ($p < 0.009$). The estimated marginal means plot demonstrated a significant increase in the outcome measure across the Right L4, four time points, with a mean from an initial pain threshold of 4.2 kg/cm^2 to 5.0 kg/cm^2.This suggests an increase in pressure pain threshold, indicating a clinically significant increase in a patient's ability to tolerate pressure. These results collectively indicate that ART significantly increased the pressure pain threshold in the Right L4 region, thus reducing CLBP caused by hamstring tightness.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.482	5.277c	3.000	17.000	0.009
	Wilks' Lambda	0.518	5.277c	3.000	17.000	0.009
	Hotelling's Trace	0.931	5.277c	3.000	17.000	0.009
	Roy's Largest Root	0.931	5.277c	3.000	17.000	0.009

a. Group = ART
b. Design: Intercept
Within Subjects Design: time
c. Exact statistic

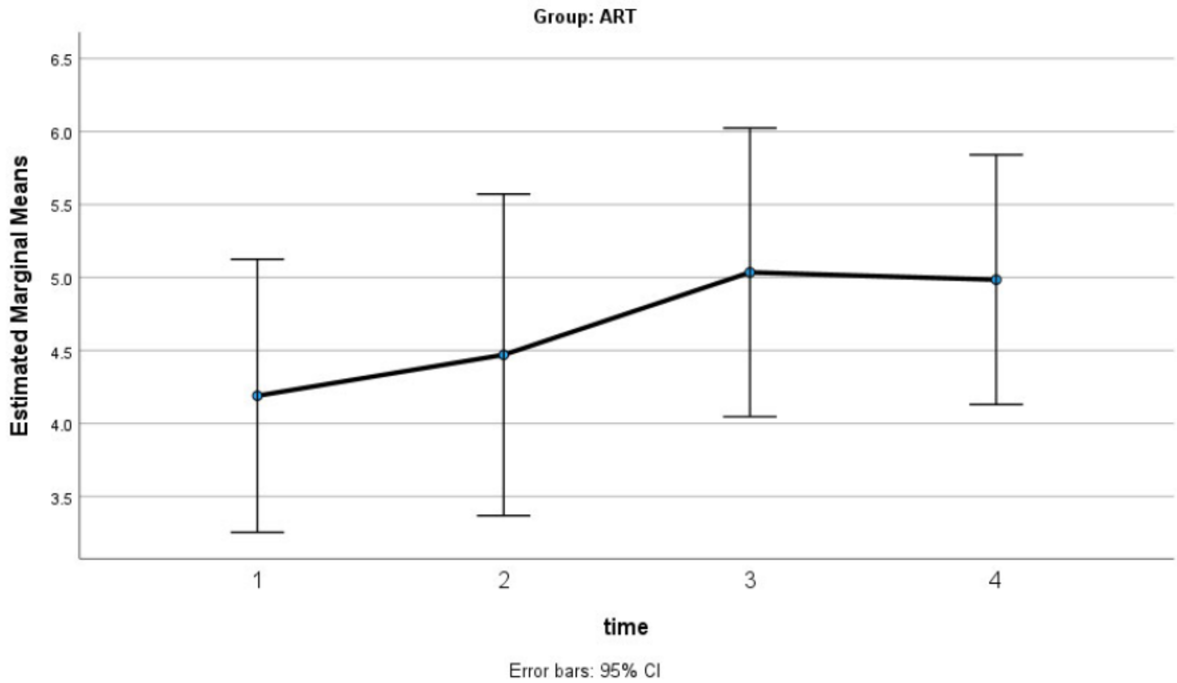


Figure 20 Pain threshold on the Right L4- ART alone

4.3.3 Numerical Pain Rating Scale

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a statistically significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a significant decrease in the outcome measure on the NPRS across the four time points. The mean decreased from an initial pain rating scale of 6.2 to 2.5, thus suggesting that the patient experienced a clinically significant decrease in CLBP caused by hamstring tightness.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.940	88.833c	3.000	17.000	<0.001
	Wilks' Lambda	0.060	88.833c	3.000	17.000	<0.001
	Hotelling's Trace	15.676	88.833c	3.000	17.000	<0.001
	Roy's Largest Root	15.676	88.833c	3.000	17.000	<0.001

a. Group = ART
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

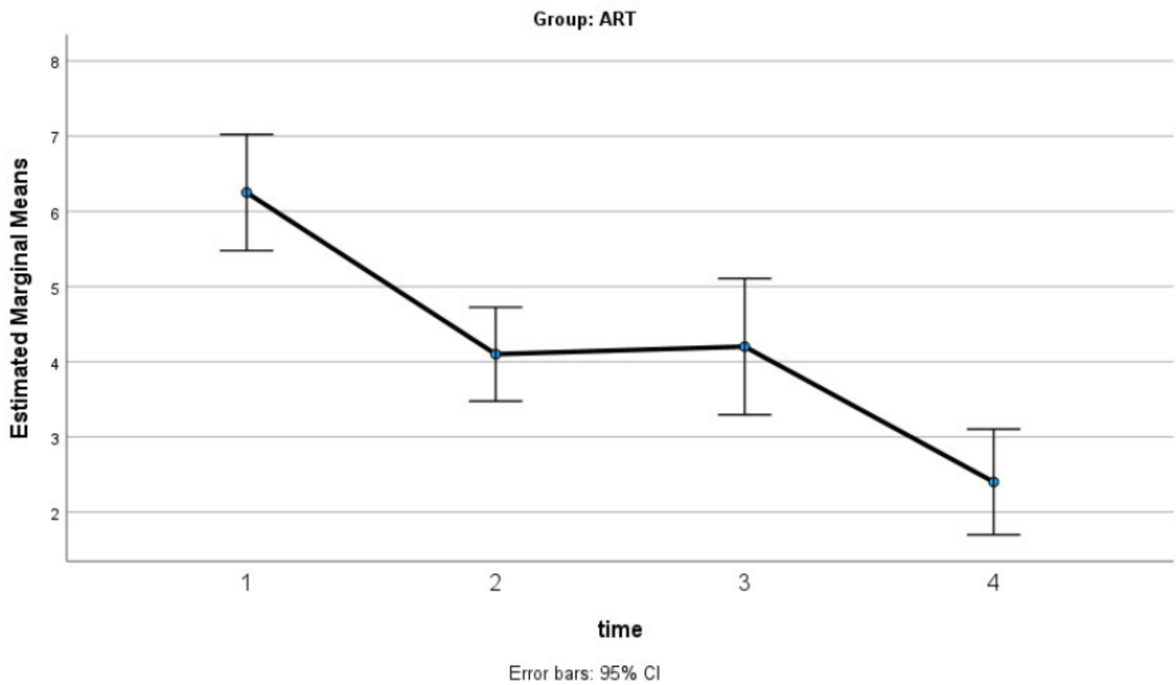


Figure 21 NPRS for ART alone

4.4 Objective 2: To assess the effectiveness of the combination of active release technique and muscle energy technique in the treatment of chronic lower back pain caused by hamstring tightness in terms of subjective and objective measurements.

4.4.1 Active Knee Extension

4.4.1.1 Left Hamstring

There was a statistically significant difference in this outcome over time in the ART+MET group ($p<0.001$). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a clear decrease in the outcome measure across the four time points, with a mean from an initial 29.5 degree to 14 degree until full knee extension, suggesting a clinical significance in the reduction of left hamstring tightness. These results collectively indicate that a combination of ART and MET significantly improved the condition of left hamstring tightness over time.

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.956	123.613c	3.000	17.000	<0.001
	Wilks' Lambda	0.044	123.613c	3.000	17.000	<0.001
	Hotelling's Trace	21.814	123.613c	3.000	17.000	<0.001
	Roy's Largest Root	21.814	123.613c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

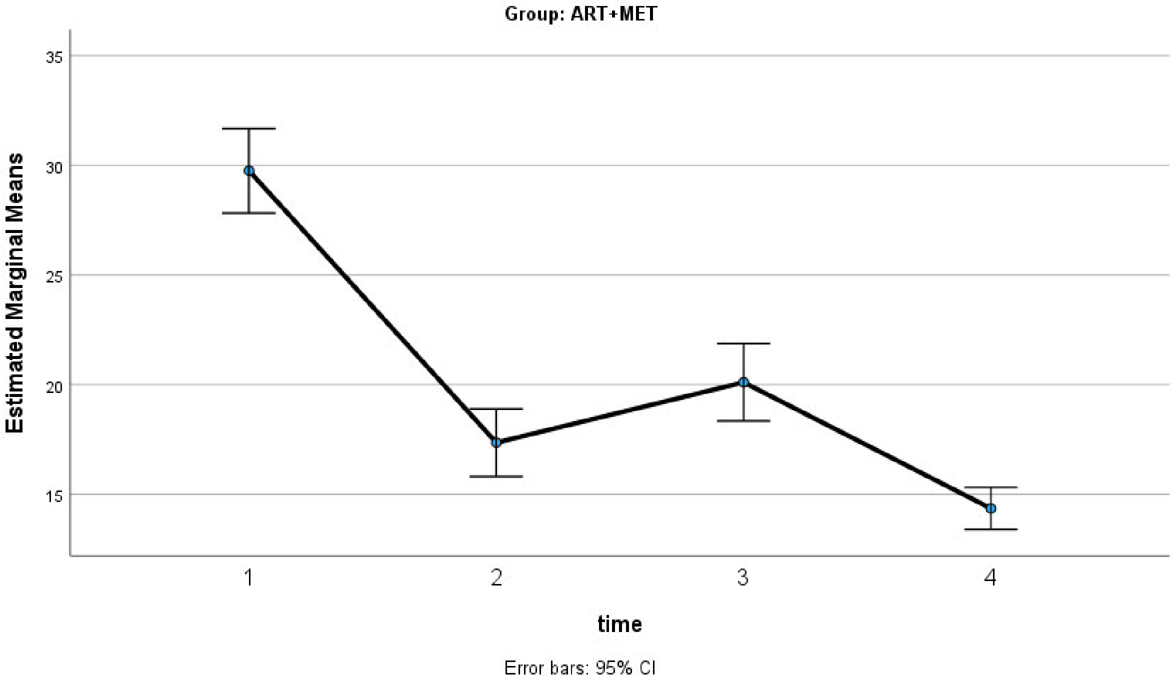


Figure 22 Result of the combination of ART and MET on the left hamstring

4.4.1.2 Right Hamstring

There was a statistically significant difference in this outcome over time in the ART+MET group (p<0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time (p < 0.001). The estimated marginal means plot demonstrated a clear decrease in the outcome measure across the four time points, with a mean from an initial 28 degree to 14 degree until full knee extension, suggesting a clinical significance in the reduction of left hamstring tightness. These results collectively indicate that a combination of ART and MET significantly improved the condition of right hamstring tightness over time.

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.898	49.937c	3.000	17.000	<0.001
	Wilks' Lambda	0.102	49.937c	3.000	17.000	<0.001
	Hotelling's Trace	8.812	49.937c	3.000	17.000	<0.001
	Roy's Largest Root	8.812	49.937c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
Within Subjects Design: time
c. Exact statistic

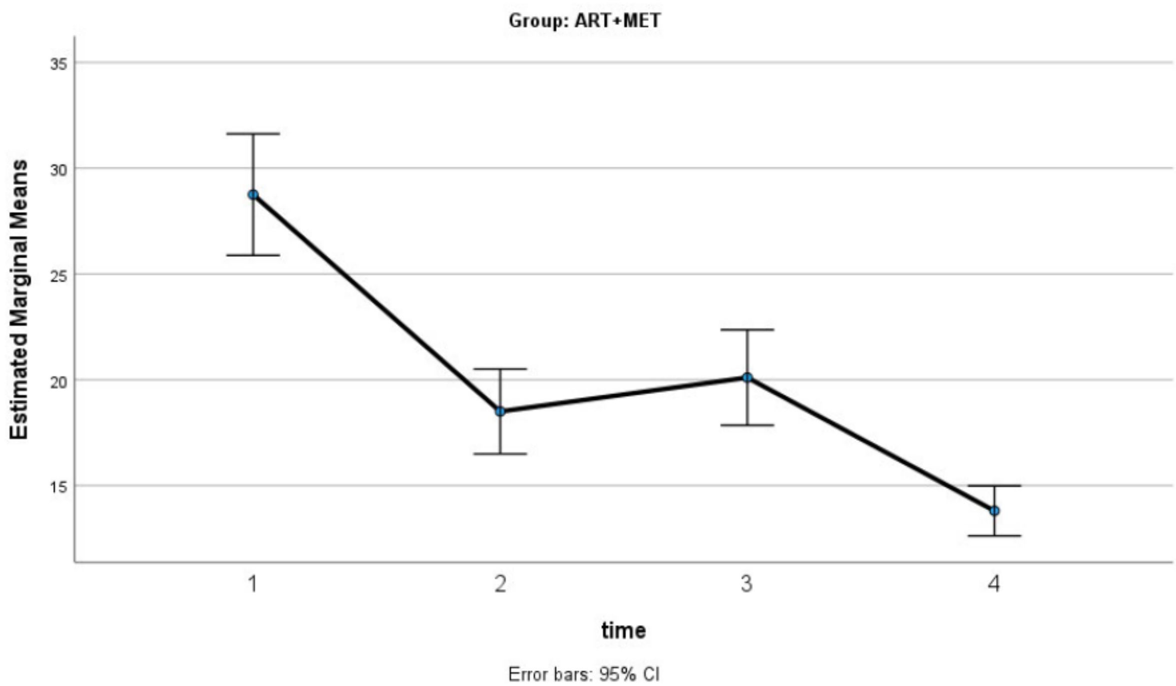


Figure 23 Result of the combination of ART and MET on the right hamstring

4.4.2 Universal Algometer

4.4.2.1 Left Lumbar Vertebra 2 (L2)

There was a statistically significant difference in this outcome over time in the ART+MET group (p=0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Left L2, four time points, with a mean from an initial pain threshold of 4 kg/cm^2 to 6.2 kg/cm^2 , suggesting an increase in pressure pain threshold, indicating a clinically significant increase in a patient's ability to tolerate pressure. These results collectively indicate that a combined ART and MET treatment increased the pressure pain threshold in the Left L2 region, thus reducing CLBP caused by hamstring tightness.

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.902	51.976c	3.000	17.000	<0.001
	Wilks' Lambda	0.098	51.976c	3.000	17.000	<0.001
	Hotelling's Trace	9.172	51.976c	3.000	17.000	<0.001
	Roy's Largest Root	9.172	51.976c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

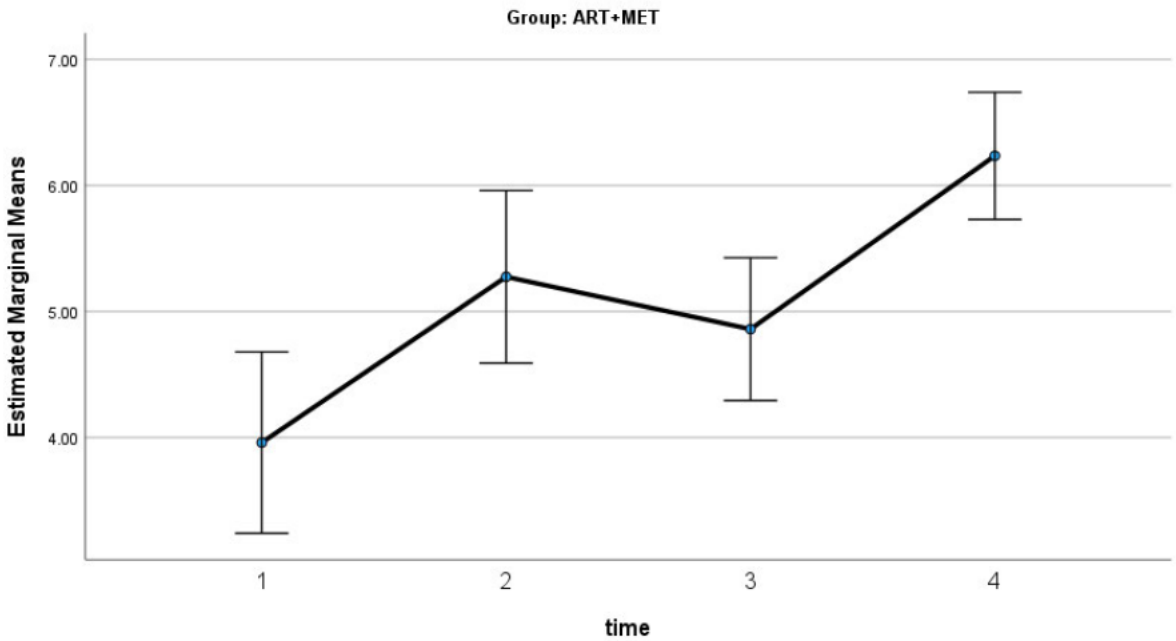


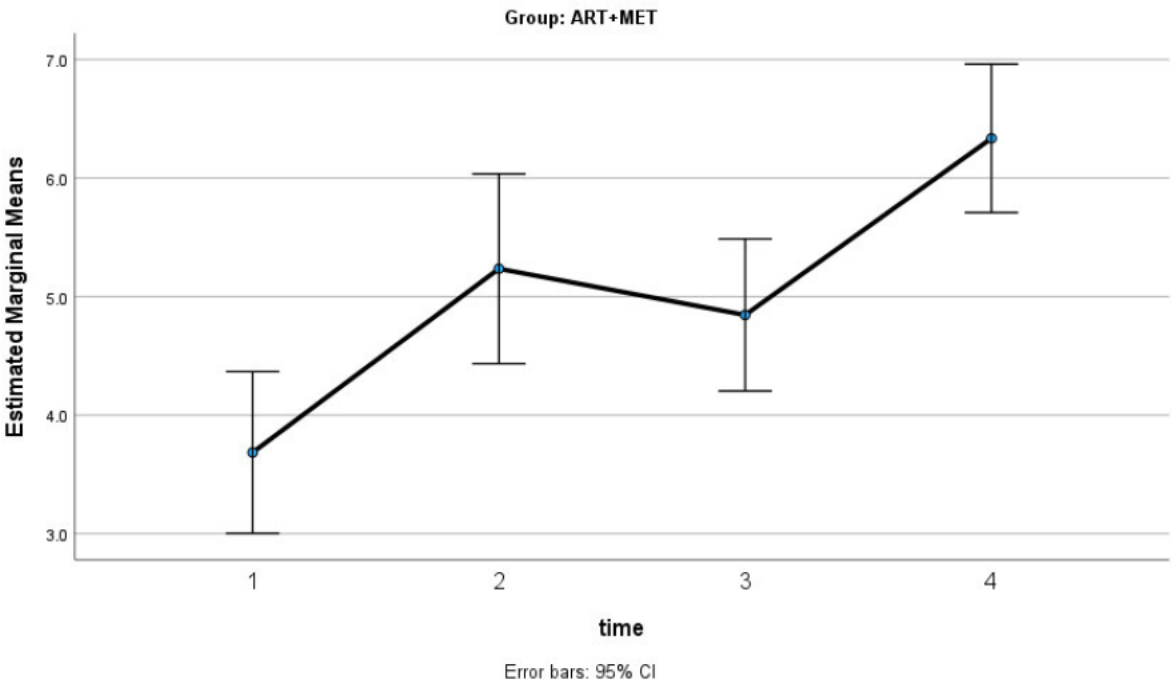
Figure 24 Pain threshold on the Left L2- Combination technique

4.4.2.2 Left Lumbar Vertebra 4 (L4)

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.898	49.941c	3.000	17.000	<0.001
	Wilks' Lambda	0.102	49.941c	3.000	17.000	<0.001
	Hotelling's Trace	8.813	49.941c	3.000	17.000	<0.001
	Roy's Largest Root	8.813	49.941c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic



[redacted]

There was a statistically significant difference in this outcome over time in the ART+MET group (p=0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Left L4, four time points, with a mean from an initial pain threshold of 3.7 kg/cm^2 to 6.2 kg/cm^2, suggesting an increase in pressure pain threshold, indicating a clinically significant increase in a patient's ability to tolerate pressure. These results collectively indicate that a combined ART and MET treatment increased the pressure pain threshold in the Left L4 region, thus reducing CLBP caused by hamstring tightness.

4.4.2.3 Right Lumbar Vertebra (L2)

There was a statistically significant difference in this outcome over time in the ART+MET group (p=0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Right L2, four time points, with a mean from an initial pain threshold of 3.9 kg/cm^2 to 6.2 kg/cm^2, suggesting an increase in pressure pain threshold, indicating a clinically significant increase in a patient's ability to tolerate pressure. These results collectively indicate that a combined ART and MET treatment increased the pressure pain threshold in the Right L2 region, thus reducing CLBP caused by hamstring tightness.

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.928	72.767c	3.000	17.000	<0.001
	Wilks' Lambda	0.072	72.767c	3.000	17.000	<0.001
	Hotelling's Trace	12.841	72.767c	3.000	17.000	<0.001
	Roy's Largest Root	12.841	72.767c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

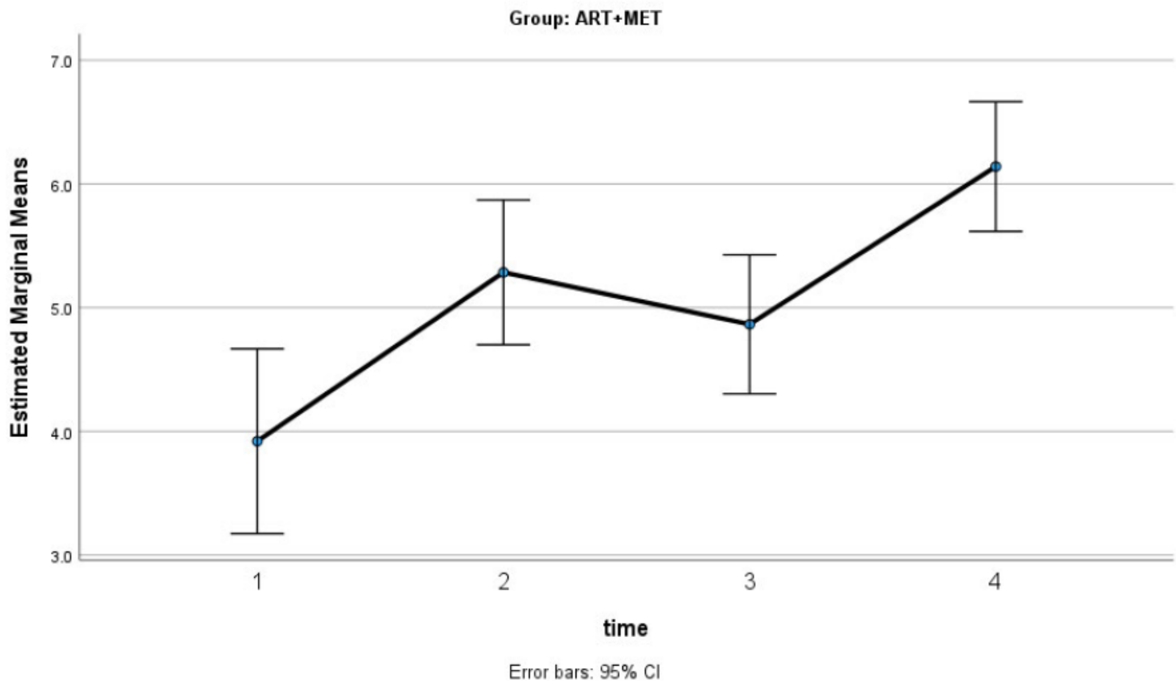


Figure 26 Pain threshold on the Right L2- Combination technique

4.4.2.4 Right Lumbar Vertebra 4 (L4)

There was a statistically significant difference in this outcome over time in the ART+MET group (p=0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Right L4, four time points, with a mean from an initial pain threshold of 4.2 kg/cm^2 to 6.5 kg/cm^2, suggesting an increase in pressure pain threshold, indicating a clinically significant increase in a patient's ability to tolerate pressure. These results collectively indicate that a combined ART and MET treatment increased the pressure pain threshold in the Right L4 region, thus reducing CLBP caused by hamstring tightness.

Multivariate Testsa,b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.876	39.983c	3.000	17.000	<0.001
	Wilks' Lambda	0.124	39.983c	3.000	17.000	<0.001
	Hotelling's Trace	7.056	39.983c	3.000	17.000	<0.001
	Roy's Largest Root	7.056	39.983c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
Within Subjects Design: time
c. Exact statistic

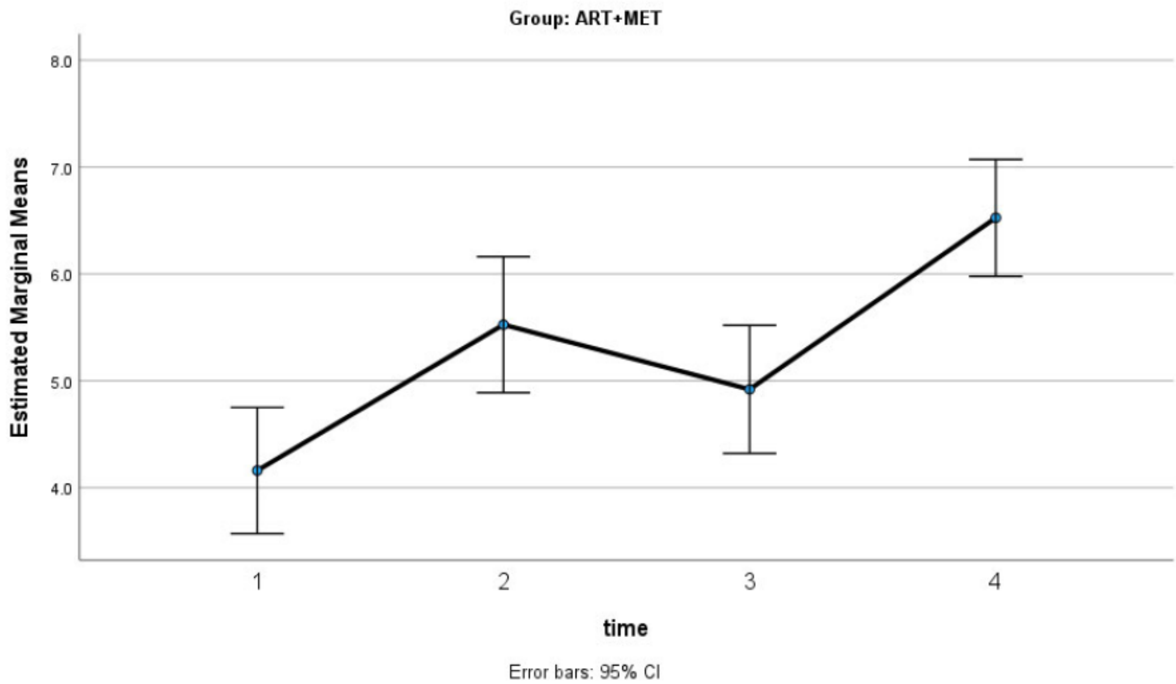


Figure 27 Pain threshold on the Right L4- Combination technique

4.4.3 Numerical Pain rating scale

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a statistically significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a significant decrease in the outcome measure on the NPRS across the four time points, with the mean from an initial pain rating scale of 4.8 to 0.5, suggesting that the patient experienced a clinically significant decrease in CLBP caused by hamstring tightness to near no pain.

Multivariate Testsa, b

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	0.940	89.044c	3.000	17.000	<0.001
	Wilks' Lambda	0.060	89.044c	3.000	17.000	<0.001
	Hotelling's Trace	15.714	89.044c	3.000	17.000	<0.001
	Roy's Largest Root	15.714	89.044c	3.000	17.000	<0.001

a. Group = ART+MET
b. Design: Intercept
 Within Subjects Design: time
c. Exact statistic

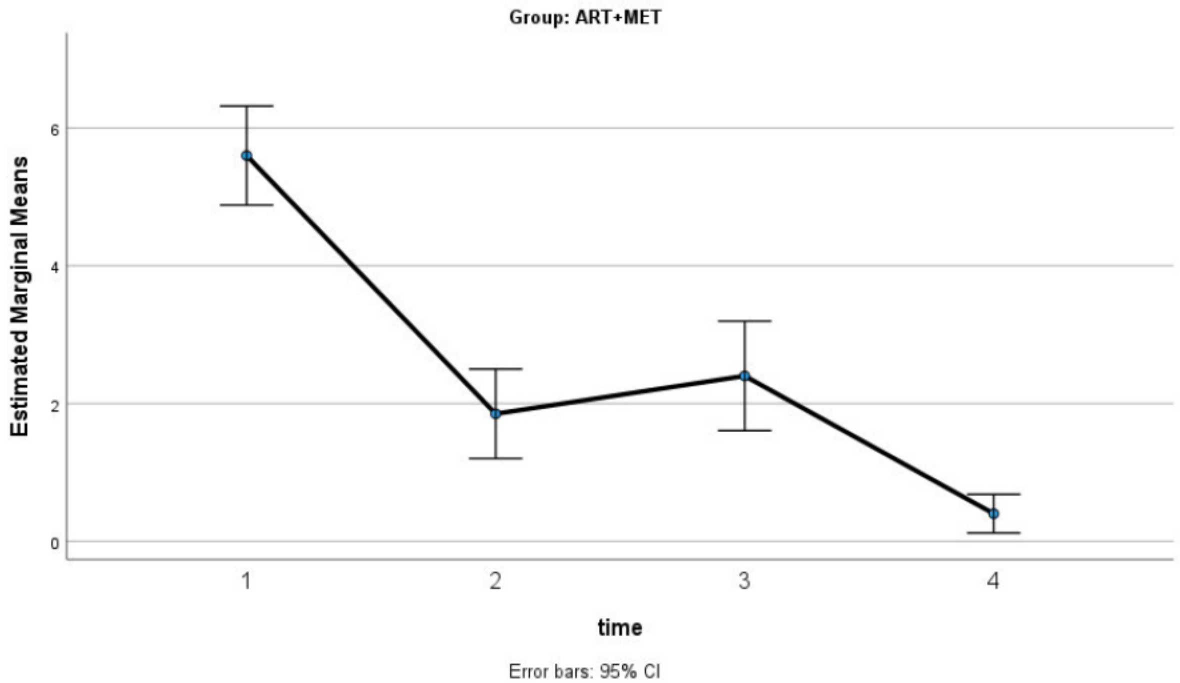


Figure 28 NPRS for the combination of ART and MET

4.5 Objective 3: To compare the results from objectives 1 and 2.

4.5.1 Active Knee Extension

4.5.1.1 Left hamstring

There was a statistically significant difference in this outcome over time in the ART group alone and ART+MET group ($p<0.001$). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$) for left hamstring. The estimated marginal means plot demonstrated a clear decrease at a faster rate over time than the ART alone compared to the ART+MET group, with a change of 6.5 degree in ART group alone compared to a change of 15.5 degree in ART+MET group, suggesting a greater clinically significant outcome in reducing left hamstring tightness with the combination technique of ART+MET treatment.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.807	50.090b	3.000	36.000	<0.001
	Wilks' Lambda	0.193	50.090b	3.000	36.000	<0.001
	Hotelling's Trace	4.174	50.090b	3.000	36.000	<0.001
	Roy's Largest Root	4.174	50.090b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

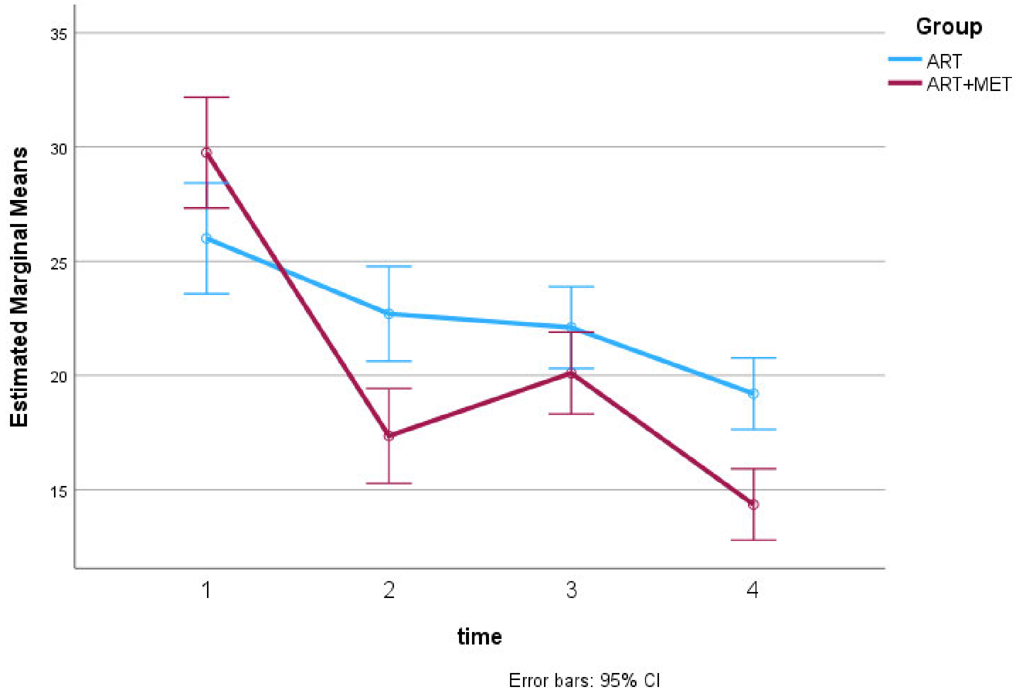


Figure 29 Comparison of ART alone vs ART+MET on left hamstring tightness

4.5.1.2 Right Hamstring

There was a statistically significant difference in this outcome over time in the ART group alone and ART+MET group ($p<0.001$). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$) for the right hamstring. The estimated marginal means plot demonstrated a clear decrease at a faster rate over time than the ART alone group compared to the ART+MET group, with a change of 5 degree in ART group alone compared to a change of 14 degree in ART+MET group, suggesting a greater clinically significant outcome in reducing right hamstring tightness with the combination technique of ART+MET treatment.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.625	19.971b	3.000	36.000	<0.001
	Wilks' Lambda	0.375	19.971b	3.000	36.000	<0.001
	Hotelling's Trace	1.664	19.971b	3.000	36.000	<0.001
	Roy's Largest Root	1.664	19.971b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

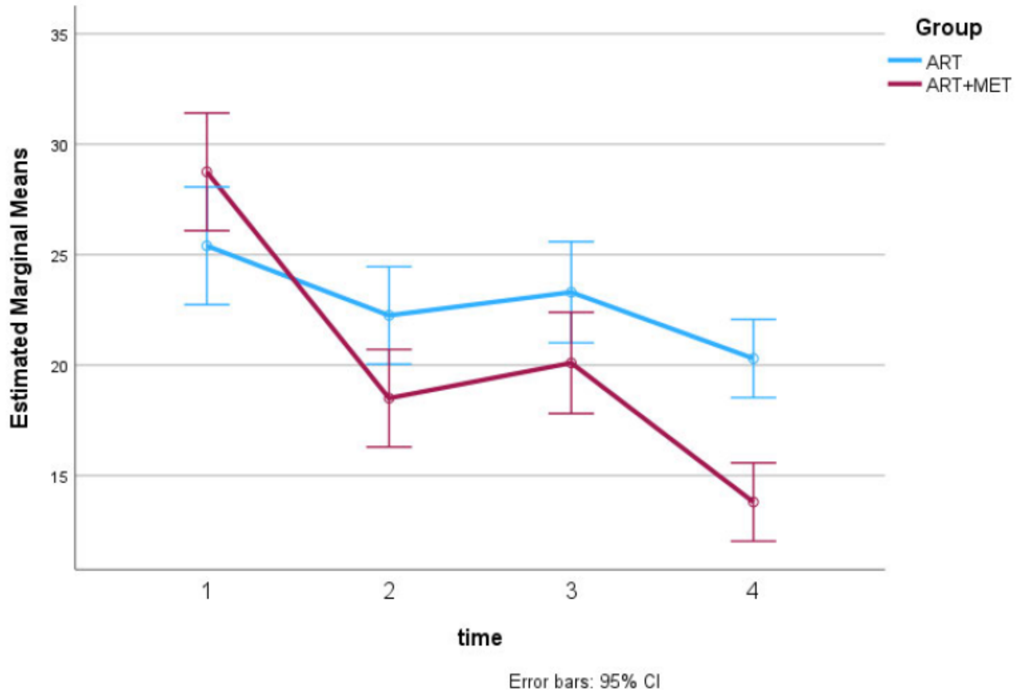


Figure 30 Comparison of ART alone vs ART+MET on right hamstring tightness

4.5.2 Universal Algometer

4.5.2.1 Left Lumbar Vertebra 2 (L2)

There was a statistically significant difference in this outcome over time in the ART alone and a combined ART+MET group ($p=0.001$). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Left L2 region, four time points, suggesting an increase in pressure pain threshold. Specifically, ART group alone showed a change of 0.4 kg/cm², whereas the ART+MET group demonstrated a change of 2.2 kg/cm². These results indicate that the combined ART and MET treatment led to a greater clinically significant increase in pressure pain threshold compared to ART alone in left L2 region.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.684	26.008b	3.000	36.000	<0.001
	Wilks' Lambda	0.316	26.008b	3.000	36.000	<0.001
	Hotelling's Trace	2.167	26.008b	3.000	36.000	<0.001
	Roy's Largest Root	2.167	26.008b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

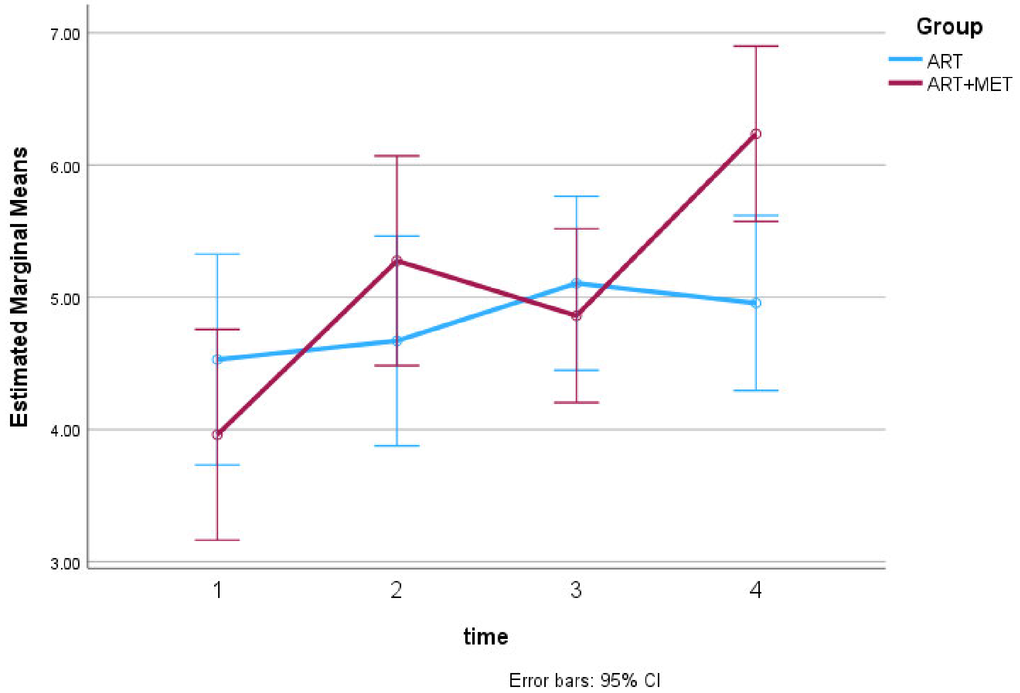


Figure 31 Comparison of Pain threshold on left L2 of ART alone vs ART+MET

4.5.2.2 Left Lumbar Vertebra 4(L4)

There was a statistically significant difference in this outcome over time in the ART alone and a combined ART+MET group (p=0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Left L4 region, four time points, suggesting an increase in pressure pain threshold. Specifically, ART group alone showed a change of 0.6 kg/cm², whereas the ART+MET group demonstrated a change of 2.5 kg/cm². These results indicate that the combined ART and MET treatment led to a greater clinically significant increase in pressure pain threshold compared to ART alone in left L4 region.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.668	24.094b	3.000	36.000	<0.001
	Wilks' Lambda	0.332	24.094b	3.000	36.000	<0.001
	Hotelling's Trace	2.008	24.094b	3.000	36.000	<0.001
	Roy's Largest Root	2.008	24.094b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

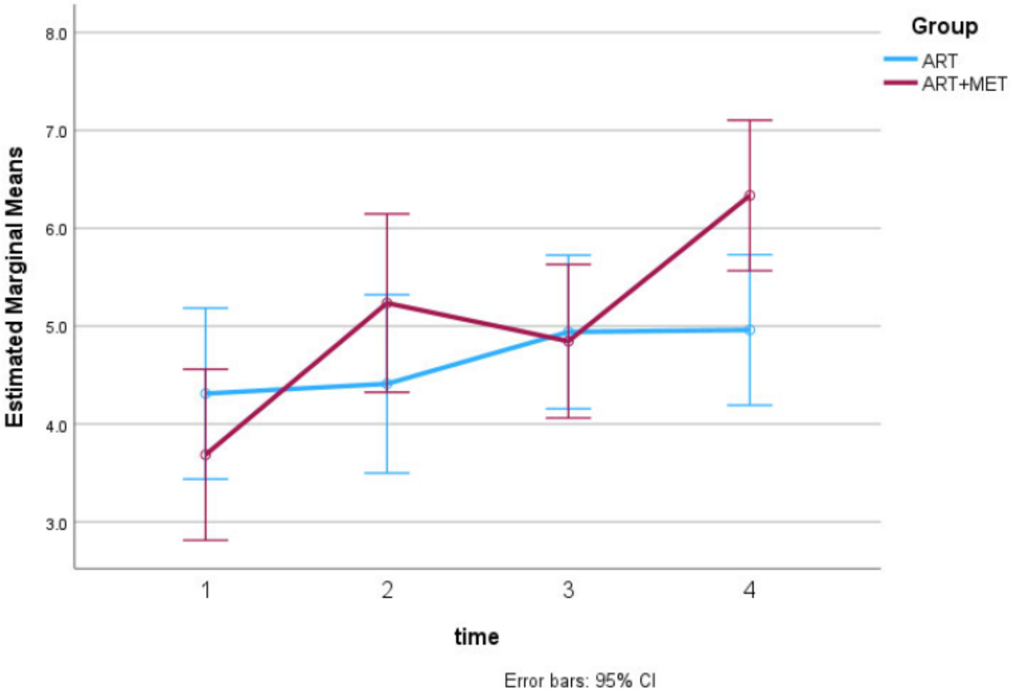


Figure 32 Comparison of Pain threshold on left L4 of ART alone vs ART+MET

4.5.2.3 Right Lumbar Vertebra 2(L2)

There was a statistically significant difference in this outcome over time in the ART alone and a combined ART+MET group ($p=0.001$). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Right L2 region, four time points, suggesting an increase in pressure pain threshold. Specifically, ART group alone showed a change of 0.5 kg/cm², whereas the ART+MET group demonstrated a change of 2.3 kg/cm². These results indicate that the combined ART and MET treatment led to a greater clinically significant increase in pressure pain threshold compared to ART alone in right L2 region.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.620	19.616b	3.000	36.000	<0.001
	Wilks' Lambda	0.380	19.616b	3.000	36.000	<0.001
	Hotelling's Trace	1.635	19.616b	3.000	36.000	<0.001
	Roy's Largest Root	1.635	19.616b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

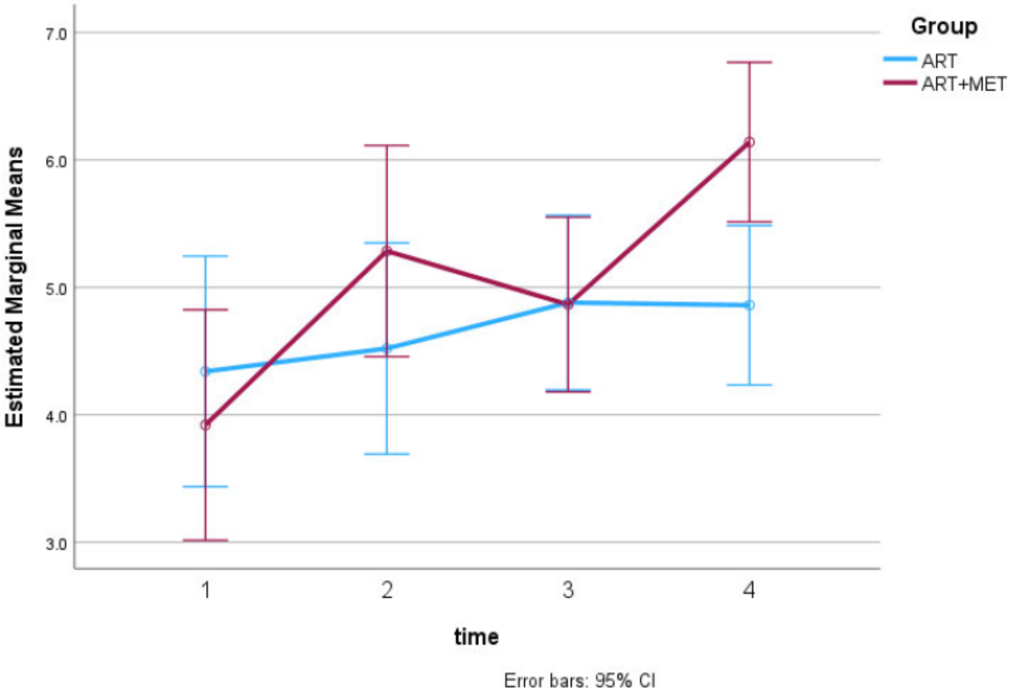


Figure 33 Comparison of Pain threshold on right L2 of ART alone vs ART+MET

4.5.2.4 Right Lumbar Vertebra 4 (L4)

There was a statistically significant difference in this outcome over time in the ART alone and a combined ART+MET group (p=0.001). The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a statistically significant increase in the outcome measure across the Right L4 region, four time points, suggesting an increase in pressure pain threshold. These results collectively indicate that a combined ART and MET treatment increased the pressure pain threshold significantly compared to ART alone in the Right L4 region. Specifically, ART group alone showed a change of 0.8 kg/cm², whereas the ART+MET group demonstrated a change of 2.3 kg/cm². These results indicate that the combined ART and MET treatment led to a greater clinically significant increase in pressure pain threshold compared to ART alone in right L4 region.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.630	20.466b	3.000	36.000	<0.001
	Wilks' Lambda	0.370	20.466b	3.000	36.000	<0.001
	Hotelling's Trace	1.705	20.466b	3.000	36.000	<0.001
	Roy's Largest Root	1.705	20.466b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

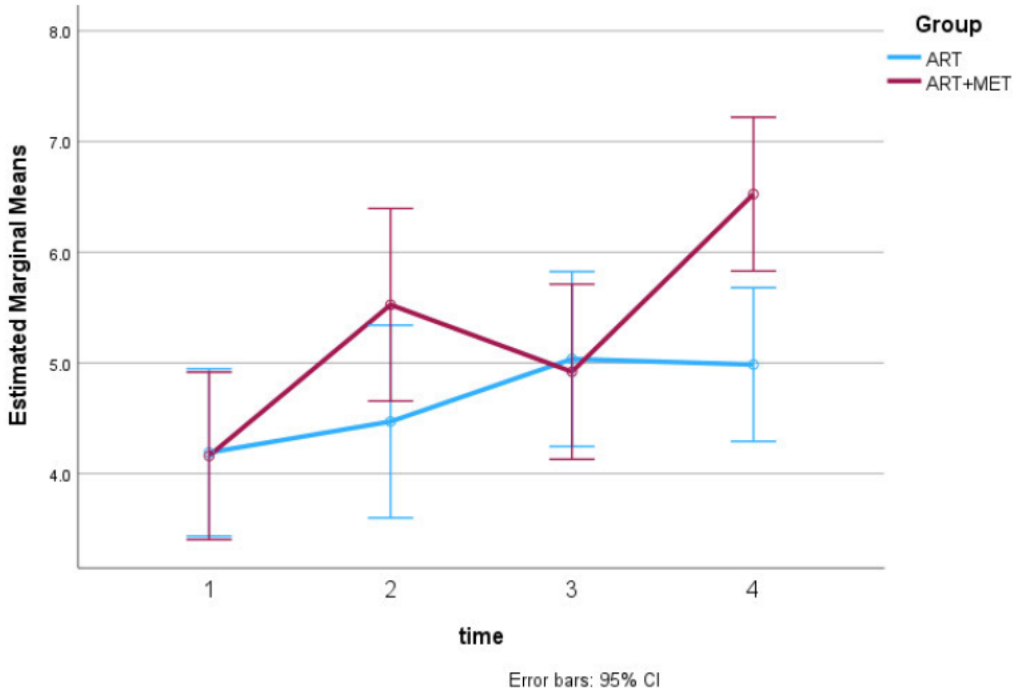


Figure 34 Comparison of Pain threshold on right L4 of ART alone vs ART+MET

4.5.3 Numerical Pain rating scale

The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root all indicate a statistically significant difference in the outcome over time ($p < 0.001$). The estimated marginal means plot demonstrated a significant decrease in the outcome measure on the NPRS across the four time points. There was a very statistically significant interaction between time and group for NPRS ($p<0.001$). Specifically, ART group alone showed a change in pain rating score of 3.7, whereas the ART+MET group demonstrated a change in pain rating score of 4.3. These results indicate that the combined ART and MET treatment led to a greater clinically significant decrease in pain rating scale compared to ART alone.

Multivariate Testsa

Effect		Value	F	Hypothesis df	Error df	Sig.
time * Group	Pillai's Trace	0.471	10.705b	3.000	36.000	<0.001
	Wilks' Lambda	0.529	10.705b	3.000	36.000	<0.001
	Hotelling's Trace	0.892	10.705b	3.000	36.000	<0.001
	Roy's Largest Root	0.892	10.705b	3.000	36.000	<0.001

a. Design: Intercept + Group
Within Subjects Design: time
b. Exact statistic

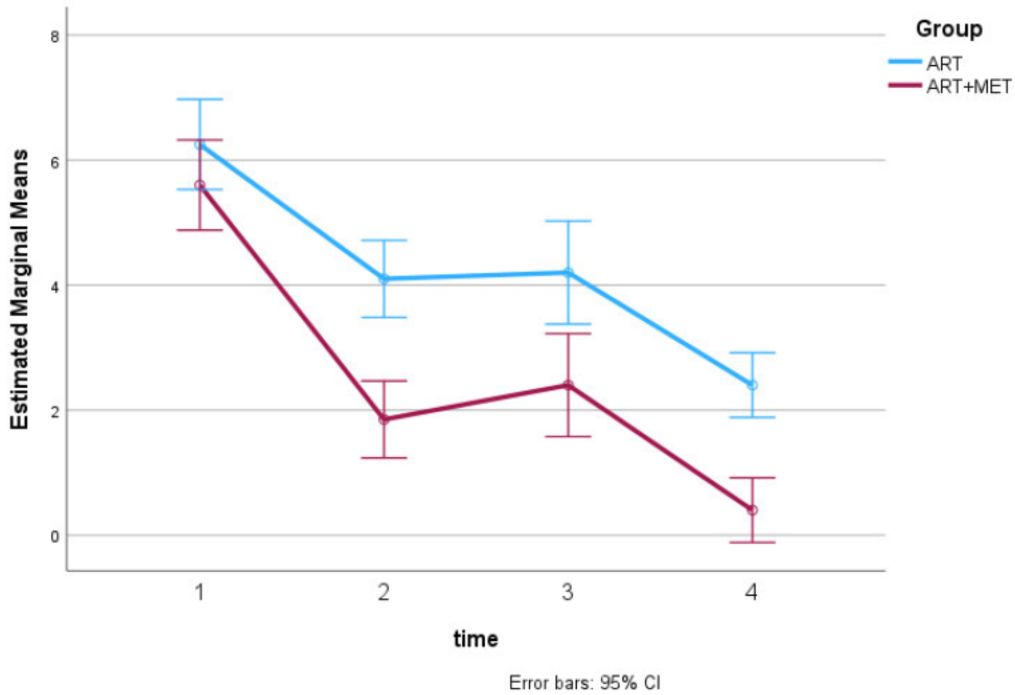


Figure 35 Comparison of NPRS of ART alone vs ART+MET

4.6 Summary and Conclusions

This chapter presented the findings of the study between the two groups of participants, Group A received ART and Group B received ART+MET. While both treatment groups recorded a statistically significant difference in the reduction of CLBP, Group B presented a greater statistically significant outcome in intervention one and intervention two. This is the same for clinically significant outcome as the combination group B indicated a greater effectiveness in treatment compared to Group A alone. Thus, a significantly higher reduction of CLBP caused by hamstring tightness was observed in treatment Group B as compared to treatment Group A. The next chapter presents the discussion of the findings.

CHAPTER 5 DISCUSSION

5.1 Introduction

This chapter discusses the results presented in Chapter 4 in the context of current literature. The statistical and clinical significance of the ART and a combination of ART and MET obtained from Group A and Group B is discussed in relation to possible theories. References are made to relevant sections in Chapter 2 and 4.

5.2 Demographic and Background Variable

5.2.1 Gender

Participants of both genders were included in this study. This study observed 55% (n=11) males and 45% (n=9) females participation rate in Group A, and a 45% (n=9) males and 55% (n=11) females participation rate in Group B. Both genders showed evidence of CLBP caused by hamstring tightness. This is comparable to the study by Nielsen *et al.* (2021), who conducted a gender-related variables for clinical and population research in U.S Institute of Medicine, and found that CLBP affects females more frequently than males. In addition, Nielsen *et al.* (2021) further stated that CLBP was a leading cause of disability among women globally. In this study, it was found that both males 50% (n=20) and females 50% (n=20) who participated in the clinical trial presented with CLBP caused by hamstring tightness.

5.2.2 Age

In this study, participants' age group ranged from ≥18 and ≤55 years. These results indicated that individuals who participated in the study between the age of 18years to 55years experiences CLBP caused by hamstring tightness due to poor posture, over exertion of the muscle, long hour of walking or sitting. The mean score for Group A was 28.25 years with a standard deviation of 9.078, while Group B had a mean score of 28.00years with a standard deviation of 11.169. The slight difference in standard deviations between the two groups indicates that there was no significant difference in variability prior to the intervention. Noonan and Brown (2021) and Saito *et al.* (2023) state that age related degeneration creates low intensity pressure experienced on the lumbar spine. This concurs with Kim and Yim (2020) who revealed that long periods of pressure on the lumbar spine causes the development of muscle tightness in the hamstrings and lower back, resulting in CLBP.

5.2.3 Background variables

The majority of participants in this study (95% (n=19) in Group A and 55% (n=11) in Group B) experienced CLBP caused by hamstring tightness bilaterally. In Group A 5%(n=1) experienced left CLBP; whilst Group B 30% (n=6) experienced left CLBP and 10% (n=2) experienced right CLBP. Rahimi *et al.* (2020) state that one of the leading cause of CLBP is due to different types of gait impairment such as short stride length, leg length discrepancy and rigid coordination between trunk segments as this creates an anatomical imbalance to the lumbar spine. McHugh and Tyler (2019) and Tagliaferri *et al.* (2020) concur stating that with an imbalance, unilateral pressure to the lumbar spine can affect negatively on the supportive musculature and ligaments, resulting in unilateral muscular strain and tension, forming unilateral lower back pain. Further causes are due to poor form of exercise, repetitive movements, long periods of sitting and stop of movement during exercise (Timmins *et al.* 2020; Kim *et al.* 2021). While unilateral CLBP was noted in this study, review of the studies conducted thus far did not elaborate on CLBP in terms of laterality (Gillani, Rehman and Masood 2020; Jain, Zore and Kumar 2020; Osama and Rehman 2020b).

5.3 Primary Data

5.3.1 Objective 1- Active Release Technique alone

5.3.1.1 Active Knee Extension – left and right

Active Knee Extension (AKE) test is a physical examination procedure used to examine the length of the hamstring muscle through the ROM of knee joint (Shamsi, Mirzaei and Khabiri 2019; Olivencia *et al.* 2020). The study aimed to test the hamstring tightness of the participants left and right hamstring using ART. Although Leahy (2024) state that ART is only effective once the adhesions within the soft tissue is completely released, Gaur, Kapoor and Phansopkar (2021a) state that ART is beneficial in reducing muscle pain and tightness. This study indicated that there was a statistically significant difference in the outcome reported over time on the left ($p<0.001$) and the right hamstring ($p<0.001$), with the clinically significant change of 6.5 degree after the intervention for left hamstring tightness and a change of 5 degree after the intervention for right hamstring tightness, indicating ART showed a positive treatment outcome. The finding of this study concurs with Gaur, Kapoor and Phansopkar (2021a), Khan, Patel and Limbani (2021) and Kothawale and Rao (2018) , as the studies compared the immediate and short term effective of ART on hamstring tightness with the result indicating that treatment technique helps in the improvement of hamstring tightness. While the technique ART is utilised in this study, beside the patient experience of post muscle soreness during the break down of adhesions, review of the studies conducted thus far does not reveal limitations that may propose risks in the reduction of CLBP caused by hamstring tightness (Gillani, Rehman and Masood 2020; Jain, Zore and Kumar 2020; Osama and Rehman 2020b).

5.3.1.2 Universal Algometer – left and right (L2 and L4)

The Universal Algometer was used to determine the pressure pain threshold of the left (L2 and L4) and right (L 2 and L4) side of the patients lower back.

The findings of this study revealed a statistically significant difference in the outcome for the left (L2) over time in the ART group ($p=0.039$). However, there was no change in the outcome over time for the right (L2) in the ART group ($p=0.264$).

While the findings showed that there was no change in the value over time in the ART group for the left (L4) (p=0.402), a statistically significant increase over time was observed in the right (L4) (p=0.009) in the ART group, with a clinical significant change of 0.4kg/cm^2 in Left (L2), 0.6 kg/cm^2 in Left (L4), 0.5 kg/cm^2 in Right (L2), 0.4 kg/cm^2 in Right (L4), suggesting a minor increase in pressure pain threshold, indicating a small positive clinical outcome from ART in the reduction of CLBP. This may be due to over active adhesion that may take time to break down due to possible lack of mechanical stimulation, reduced circulation to deliver nutrient to allow efficient healing, or increase collagen density due to prolonged existence of adhesion(Leahy 2024).

Although no significant clinical change was present over the period of two interventions, the study indicated a positive improvement in pressure pain threshold for CLBP caused by hamstring tightness. This is elaborated by Abd Elsadek *et al.* (2023) where the study compared the effect of ART vs myofascial release in the treatment of LBP found that 15 patients who received ART on gluteus medius and iliocostalis trigger points had an 82.93% improvement on pain pressure threshold over the period of 12 sessions, two sessions per week for one month.

To date, the latest literature consulted, declare that ART brings only short term relief to pain (Jain, Zore and Kumar 2020; Vaidya *et al.* 2021). Khan, Patel and Limbani (2021) and Thind (2019) state that more studies are required to identify long term benefits of ART applied to hamstring-related pain.

5.3.1.3 Numerical Pain Rating Scale

In a subjective interview with the patient, the patient is asked to rate the pain threshold out of a 10 point scale where 0 indicated no pain while 10 indicated server pain (Alghadir *et al.* 2018; Knapstad *et al.* 2018; Mehrad and Zangeneh 2019). Although Gangwar (2022) and Hagedorn (2020) state there is limited research in the effectiveness of ART to reduce pain (Hagedorn 2020; Gangwar 2022). The findings of this study revealed a significant decrease in pain over time in the ART group (p<0.001), with a significant change from an initial pain rating scale of 6.2 to 2.5, suggesting that the patient experienced a clinically significant decrease in CLBP caused by hamstring tightness.

The findings of this study concurs with Vaidya *et al.* (2021) as the study indicated ART directly utilised on lower back to be useful in the reduction of non-specific LBP on a 23 year old, returning her daily activities such as forward and backward bending, prolonged standing and relieve in long seated position, from an initial NPRS of 8 dropping down to 4 after receiving ART on lower back over the period of eight sessions. Abd Elsadek *et al.* (2023) also state that ART helps in reducing the pressure on the nerves, thus, reducing pain to the surrounding region.

Active Release Technique has the potential to reduce muscle spasms and minimise pain by improving blood to delivery adequate oxygen and nutrients and breaking down and reducing adhesion formation, thus providing immediate relief to patients with persistent CLBP (Vaidya *et al.* 2021). While NPRS was noted in this study, review of the studies conducted thus far did not reveal limitations that may propose risks on ART for CLBP (Alghadir *et al.* 2018; Knapstad *et al.* 2018; Mehrad and Zangeneh 2019; Gillani, Rehman and Masood 2020; Jain, Zore and Kumar 2020; Osama and Rehman 2020b).

5.3.2 Objective 2- Combination of Active Release Technique and Muscle Energy Technique

5.3.2.1 Active Knee Extension – left and right

In this study, hamstring tightness of the participants left and right hamstring was tested using combination of ART and MET. For the left hamstring, there was a statistically significant finding in the outcome over time ($p<0.001$) and the right also indicated a statistically significant decrease over time in the ART + MET group ($p<0.001$). A clinically significant change of 15.5 degree after the intervention for left hamstring tightness and a change of 14 degree after the intervention for right hamstring tightness, indicates that the combination ART+MET showed a significant improvement to the flexibility of left and right hamstring over time. This finding concurs with Gaur, Kapoor and Phansopkar (2021a) and Santos *et al.* (2022) that ART and MET individually both showed improvement in hamstring tightness and relieved the patient’s pain threshold. Furthermore, it was reported that this combination technique assisted with lymphatic and venous drainage to enhance the hamstring flexibility (Raza *et al.* 2023).

5.3.2.2 Universal Algometer – left and right (L2 and L4)

Pressure pain threshold was determined by using the universal algometer of the left (L2 and L4) and right (L2 and L4) side of the patient's lower back.

The findings of this study revealed that for both Left (L2) and Right (L2) there was a statistically significant increase over time in the ART+MET group ($p<0.001$). Similarly the findings showed that that there was a statistically significant increase over time in the ART+MET group ($p<0.001$) for both Left (L4) and Right (L4), with a clinical significant change of 02.2kg/cm^2 in Left (L2), 2.5 kg/cm^2 in Left (L4), 2.3 kg/cm^2 in Right (L2), 2.3 kg/cm^2 in Right (L4), suggesting a clinical significant increase in pressure pain threshold, indicating a significant outcome from the combination treatment of ART+MET in the reduction of CLBP.

Participants experienced mild discomfort during ART+MET treatment procedure as it involved breaking down scar tissues and adhesions as stated by Santos-Longhurst (2018). However, the study reveals a significant positive result, indicating the pressure pain threshold increased over time per treatment, thus resulting in an effective treatment outcome in reducing CLBP caused by hamstring tightness. This concurs with Lee and Nam (2020) and Gaur, Kapoor and Phansopkar (2021a) as the study found that the combination techinique of ART and MET significantly reduced patients' CLBP.Therefore, it can be stated that ART and MET help to improve lumbar ROM, decreasing functional disability and the reduction in pain intensity.

While the combination technique ART+MET is utilised in this study, beside experiencing mild discomfort during the procedure, review of the studies conducted thus far does not reveal limitations that may propose risks in the reduction of CLBP caused by hamstring tightness (Gillani, Rehman and Masood 2020; Jain, Zore and Kumar 2020; Osama and Rehman 2020b).

5.3.2.3 Numerical Pain Rating Scale

The study utilised Numerical Pain Rating Scale to determine the pain threshold of the patients. While Gangwar (2022), Hagedorn (2020) and Santos *et al.* (2022) state that there are little research done in ART and poor evidence that MET is effective in treating LBP, the findings of this study revealed a statistically significant decrease in pain over time ($p<0.001$), with a significant change from an initial pain rating scale of 4.2 to 0.5, suggesting that the patient experienced a clinical significant decrease in CLBP caused by hamstring tightness after the combination technique of ART+MET.

According to Abd Elsadek *et al.* (2023) and Raza *et al.* (2023) ART +MET are successful pain reduction treatment options. They also state that these treatment options help patients to improve their daily functionality. Al Matif *et al.* (2023) also concurs that this combination technique increases the movements of facet flexion, spinal flexion, and spinal extension to reduce CLBP.

5.3.3 Objective 3- Comparing of Objective 1 and 2

5.3.3.1 Active Knee Extension – left and right

In this study, the comparison of objectives 1 and 2 was analysed. Regarding the hamstring tightness, there was a statistically significant interaction between time and group for this outcome ($p<0.001$).The results of this study revealed that the combination treatment approach of ART+MET group was more effective in reducing CLBP caused by hamstring tightness. A similar finding was also revealed for the right hamstring ($p<0.001$). The profile plot shows that the combination ART + MET group decreased at a faster rate over time than the ART alone group, indicating a clin3ical significant change in flexibility of hamstring tightness to be more effectively with the combination technique, especially in the first intervention. According to Gaur, Kapoor and Phansopkar (2021a) and Minnis (2018) studies, the technique ART and MET individually was beneficial to patients by increasing their flexibility, ROM and decreasing lower back pain. Furthermore, the study by Gaur, Kapoor and Phansopkar (2021a) conducted 60 participants who received MET and ART individually for hamstring tightness, and both group proved that both ART and MET was effective in reducing hamstring tightness.

5.3.3.2 Universal Algometer – left and right (L2 and L4)

When comparing the pressure pain threshold of the combination of ART and MET for the Left (L2) and Left (L4), and Right (L2) and Right (L4), a statistically significant interaction was observed between time and treatment group for this outcome ($p<0.001$). The results indicate that the treatment combination approach of ART+MET group showed a more effective treatment outcome in reducing CLBP caused by hamstring tightness. The findings of this study revealed that the combination ART+MET group recorded a faster rate of increase over time than the ART alone group. Gaur, Kapoor and Phansopkar (2021a) and Minnis (2018) also found that ART+MET was an effective treatment mode for treating patients with CLBP caused by hamstring tightness. Their patients revealed immediate relief and less discomfort after treating their CLBP caused by hamstring tightness.

5.3.3.3 Numerical Pain Rating Scale

The findings of this study showed that there was a statistically significant interaction between time and group for NPRS ($p<0.001$). The combination ART +MET group reported decreased pain scores at a faster rate over time than the ART alone group. Thus it can be surmised that the combination treatment approach of ART+MET group was more effective in reducing CLBP caused by hamstring tightness. Gaur, Kapoor and Phansopkar (2021a) state that a combination of ART+MET has revealed that many patients experienced a decrease in the pressure pain threshold after receiving ART+MET combination.

5.4 Summary

This chapter presented a discussion of the findings. These findings were supported and where appropriate contrasted with relevant literature from Chapter 2. In the next chapter the summary, limitations, recommendations and conclusion of the study is presented.

CHAPTER 6 CONCLUSION, LIMITATION, AND RECOMMENDATIONS

6.1 Introduction

In this final chapter presents the conclusion, limitations and recommendations of the findings in this study.

6.2 Conclusion

The aim of this study was to identify the effectiveness of ART compared to a combination of ART+MET in the treatment of chronic lower backpain caused by hamstring tightness. For this study, forty (n=40) participants were recruited and were divided into two groups of twenty (20). Group A received ART alone while Group B received a combination ART+MET.

This study revealed that ART+MET combination treatment was significantly more effective in treating CLBP caused by hamstring tightness compared to ART alone treatment. In terms of the demographic and background variables there was a significant effect of the combination of ART+MET in relieving CLBP.

For all three objectives there was a significant difference in the outcome in these groups.

Objective One: To assess the effectiveness of ART in the treatment of CBLP cause by hamstring tightness

Objective measurements

Active knee extension

- Left hamstring: There was a statistically significant difference in this outcome over time in the ART group ($p<0.001$). The plot shows that this was a decrease over time.
- Right hamstring: There was a statistically significant difference in this outcome over time in the ART group ($p<0.001$). The plot shows that this was a decrease over time.

Pressure Algometer

- Left L2: There was a statistically significant difference in this outcome over time in the ART group ($p=0.039$). The plot shows that this was an increase over time.
- Left L4: There was no change in this value over time in the ART group ($p=0.402$).
- Right L2: There was no change in this outcome over time in the ART group ($p=0.264$).
- Right L4: The change increase over time was statistically significant in the ART group ($p=0.009$).

Subjective measurements

NPRS

- A statistically significant decrease in pain was noted over time in the ART group ($p<0.001$).

Objective Two: To assess the effectiveness of the combination of ART+MET in the treatment of CLBP caused by hamstring tightness.

Objective measurements

Active knee extension

- Left hamstring: The decrease over time in the combination ART and MET group was a statistically significant ($p<0.001$).
- Right hamstring: There was a statistically significant decrease over time in the ART + MET group ($p<0.001$).

Pressure Algometer

- Left L2: There was a statistically significant increase over time in the ART+MET group ($p<0.001$).
- Left L4: There was a statistically significant increase over time ($p<0.001$).
- Right L2: There was a statistically significant increase over time in this group ($p<0.001$)
- Right L4: There was a statistically significant increase over time in this group ($p<0.001$)

Subjective measurements

NPRS

- There was a statistically significant decrease in pain for this group over time ($p<0.001$)

Objective Three: **To compare the results of objective 1 and 2**

Objective measurements

Active knee extension

- Left hamstring: There was a very statistically significant interaction between time and group for this outcome ($p<0.001$). The profile plot shows that the combination ART +MET group decreased at a faster rate over time than the ART alone group, especially in the first intervention.
- Right hamstring: There was a very statistically significant interaction between time and group for this outcome ($p<0.001$). The profile plot shows that the combination ART +MET group decreased at a faster rate over time than the ART alone group, especially in the first intervention.

Pressure Algometer

- Left L2: There was a statistically significant interaction between time and treatment group for this outcome ($p<0.001$). The profile plot shows that the ART+MET group showed a faster rate of increase over time than the ART alone group.
- Left L4: There was a statistically significant interaction between time and treatment group for this outcome ($p<0.001$). The profile plot shows that the ART+MET group showed a faster rate of increase over time than the ART alone group.
- Right L2: There was a statistically significant interaction between time and treatment group for this outcome ($p<0.001$). The profile plot shows that the ART+MET group showed a faster rate of increase over time than the ART alone group.

- Right L4: There was a statistically significant interaction between time and treatment group for this outcome ($p<0.001$). The profile plot shows that the ART+MET group showed a faster rate of increase over time than the ART alone group

Subjective measurements

NPRS

- There was a statistically significant interaction between time and group for NPRS ($p<0.001$). The profile plot shows that the combination ART +MET group decreased their pain scores at a faster rate over time than the ART alone group.

6.3 Limitations

Some limitations were identified in this study.

- The sample size was (n=40). Although both groups received treatment, one group received ART and the other received ART+MET. A larger sample may yield different results.
- This was a quasi-experimental study using randomised control trial group. A different sampling technique other than random sampling could have been used.
- The timeframe between interventions in this study was three days apart which may be too soon to measure the long term effects of the treatment outcome.
- The use of the research assistants posed several challenges; in some instances, the measurements were incorrectly recorded by the assistants and the measurements had to be redone.

6.4 Recommendations

The following recommendation are made so aid further studies to improve the data obtained from this study and allow for a greater statistically significant result.

- Sample size: In this study the sample size was 40 participants divided into two groups. Although the results were statistically significant, a large sample size should be used so that generalisations could be made for a larger population.
- Study design: since this was quasi-experimental study using randomised sampling, the study recommends a true experimental study should be done using a different sampling technique. This will ascertain the impact of the intervention.
- Intervention timeframes: It is recommended that there is need to determine the long term effect of the intervention instead of only after a few days.
- Confounding Variables: Other factors that are not controlled for can influence the results (the period which patients return home), making it difficult to attribute outcomes solely to the intervention.

- The study as the likelihood of emphasising how tight hamstring can contribute to altered pelvic tilt and lumbar spine mechanic exacerbating CLBP.

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APPENDICES

Appendices A: Letter to the Clinic Director

2021/08/25

Dr. Desiree Varatharajullu.
Clinic Director: Chiropractic Day Clinic: Chiropractic
desireev@dut.ac.za

Request for Permission to Conduct Research

Dear Professor,

My name is Ching-Hsuan Chen, a MHSc Chiropractic student at the Durban University of Technology. For my Masters dissertation, the research I wish to conduct involves finding the effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness causing chronic lower back pain.

I am hereby seeking for your consent to conduct the research using DUT participants and staff.

I have attached for you copy of my proposal which includes the tools used in data collection and consent forms to be used in the research process. The approval letter received from the Institutional Research Ethics Committee (IREC) is also attached.

If you require any further information, please do not hesitate to contact me.
(084 326 3882 or kevinchen961208@gmail.com).

Thank you for your time and consideration.

Yours sincerely,

Ching-Hsuan Chen
Durban University of Technology

Appendices B: Letter of Permission to the Research Director

2022/08/30

Prof Napier
Director: Research and Postgraduate Support
Email: carinn@dut.ac.za

Request for Permission to Conduct Research

Dear Professor,

My name is Ching-Hsuan Chen, a MHSc Chiropractic student at the Durban University of Technology. For my Masters dissertation, the research I wish to conduct involves finding the effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness causing chronic lower back pain.

I am hereby seeking for your consent to conduct the research using DUT participants and staff.

I have attached for you copy of my proposal which includes the tools used in data collection and consent forms to be used in the research process. The approval letter received from the Institutional Research Ethics Committee (IREC) is also attached.

If you require any further information, please do not hesitate to contact me.
(084 326 3882 or kevinchen961208@gmail.com).

Thank you for your time and consideration.

Yours sincerely,

Ching-Hsuan Chen
Durban University of Technology

Appendices C: Advertisement

Appendices D: Permission to place advertisement

Letter requesting permission to place advertisements

Dear Sir/Madam

My name is Ching-Hsuan Chen, a chiropractic student doing Masters in Chiropractic at Durban University of Technology.

The research I wish to conduct for my Masters dissertation involves the effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness causing chronic lower back pain.

Brief Introduction and Purpose of the Study: Chronic lower back pain, is one of the top ten causes of daily disability, and is known to affect more than 80% of the population globally. This impacts the quality of life, work-related productivity. This study aims to investigate treatment regimens in the hope of improving the health and wellbeing of headache sufferers.

I hereby seek for your permission and consent to place an advertisement (attached below), on your premises/noticeboard for participant recruitment of participants for my study.

Your assistance in this matter is greatly appreciated.

If you agree to allow the placement of the advert, kindly complete the section below.

Statement for permission to place advertisements:

I..(Full name),ID number ...., have read this document in its entirety and understand its contents. Any questions have been answered and explained to me sufficiently by... I hereby grant permission for advertisements to be placed at.. (Full name of facility/location).

Name.............................

Signature....................... **Date...................**

Researcher's name.............................

Researcher's signature....................... **Date...................**

Witness' name...................................

Witness' signature.............................. **Date.................**

Appendices E: Telephonic Interview

Prospective participant name:
Participant age:
Date: Time:

Questions asked during screening for potential participants	Required answers to participate	Actual Answer
Are you willing to answer some questions?	Yes	
Are you between the age of 18 – 55?	Yes	
Have you experienced lower back pain for 3 months or more?	Yes	
Do you experience lower back pain 3 to 4 days a week?	Yes	

Researcher signature:

Witness signature:

Appendices F: Letter of Information

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) - LETTER OF INFORMATION

Dear participant,
Thank you for taking the time to read this letter and for considering participating in this research study.
Title of the research study:
The effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness causing chronic lower back pain.

Principal investigator/s/ researcher:
Full names and surname : Ching-Hsuan Chen (kevinchen961208@gmail.com)
Qualifications : Bachelors of Health Science in Chiropractic

Co-investigator/s/ supervisor/s:
Full names and surname : Dr Fazila Ally (fazilaa@dut.ac.za)
Qualifications : PhD: Anatomy (UKZN)
Full names and surname : Dr Cleo Prince (cleop@dut.ac.za)
Qualifications :MTech: Chiropractor

Brief introduction and purpose of the study:
Chronic lower back pain, is one of the top ten causes of daily disability, and is known to affect more than 80% of the population globally. Though there may be many contributions to chronic lower back pain, such as age, gender, type of occupation and life habits, there is an overall utilisation of body mechanics from body parts, abnormal posture, height, weight and emotional strain which all lead to musculoskeletal disorder and chronic lower back pain. This condition can lead to a great economic burden as estimated costs to treat chronic low back pain has been found to be extremely high in South Africa, with an estimated annual cost of 78,78 billion Rand annually.

Musculoskeletal disorders contribute 80% to the cause of chronic low back pain, and musculoskeletal disorders can be associated with strain in the musculature of the area. In the case of chronic low back pain, hamstring tightness has been identified to be one of the causes to low back pain, however, if left untreated, the development to chronic low back pain will arise. A suggested reason could be that the hamstring, which is made of biceps femoris long and short head, with semi-tendinosis and semi-membranous, attaches close to the ischial tuberosity, a direct relation to the pelvis, therefore, when the hamstring is tight or shortened, it commonly increases the posterior pelvic tilt that reduces the lordotic curve, increasing the loads experienced in the chronic lower back which develops into low back pain.

Treatment options that have been established and proven to be effective are massage, needling and cupping therapy, however, these options can only be used in the absence of contraindications such as pregnancy, cancer, sunburn, rash, deep vein thrombosis and diabetes mellitus. Thus, it is important to establish treatment options that can be administered to patients who present with low back pain due to hamstring tightness and these aforementioned contraindications.

Inclusion Criteria
A participant may be included if they are:
between the ages of 18 to 55years
experiencing Chronic Lower Back Pain (duration of 3 months or more)
experiencing 3 to 4 pain days a week

willing to read and sign the Informed Consent form and undergo a complete case history and physical examination.
willing to participate for 2 interventions/treatments

Exclusion criteria
A participant may be excluded if they:
do not wish to sign the informed consent form or refuse to undergo case history and physical examination
have lower back pain that is less than the duration of 3 months
have received other treatment for Chronic lower back pain within 2 months prior to the study
have undergone back surgery
have received previous cognitive exercise therapy for lower back pain within a week of the study
screened with central sensitization inventory and tampa scale for kinesiophobia

Outline of the procedures:
Participants of the study will be approached directly by the researcher. A letter of information and informed consent will be signed before participation in the study can commence. The participant will then be required to complete a once-off questionnaire which will take approximately twenty (10) minutes. The questionnaire is an adaptation of the Dutch Musculoskeletal Questionnaire (Hildebrandt *et al*., 2001) and consists of a series of questions and statements regarding LBP experienced by the participant. All the groups will receive 2 treatments. You will be treated two times in a one-week period.The results of this study will provide key information to the effectiveness from the interventions.

Risks or discomforts to the participant:
This research study is a clinical trial study which target trigger points that may result in slight discomfort during the procedure.

Benefits:
If these treatment options are found to be effective, this may add to the management regimen of chronic lower back pain, which may lead to reduced management time period, a decrease in the number of required visits, and lower the medical costs for the patient.

Withdrawal from the study:
You may withdraw from the research study at any given time without penalty/ consequence.

Remuneration:
You will not receive any form of remuneration for your participation in this research study.

Costs of the study:
You will not be liable for any financial contribution/s towards this research study.

Confidentiality:
The information provided by you will be treated as highly confidential and will remain anonymous at all times. You will not be required to include your name or any identifiable details when completing the questionnaire. Data records may be inspected for data analysis by relevant Ethics Committees.

Persons to contact in the event of any problems or queries:
You may contact the researcher, Mr. C. Chen (084 326 3882) or the study supervisors, Dr. F. Ally (031-373 2389/082 703 0006), or the study collaborator, Dr C. Prince (cleop@dut.ac.za) . You may also contact the Institutional Research Ethics administrator on 031-373 2900.
Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031- 373 2382 or dvctip@dut.ac.za.
Yours faithfully,
Mr. C. Chen
Principal researcher

Isithathiselo F: incwadi yolwazi

IKOMIDI LWEZIMILO ZOCWANINGO LWESIKHUNGO (IREC) – INCWADI YOLWAZI

Mhlanganyeli othandekayo

Ngiyabonga ngokuthatha isikhathi sokufunda lencwadi kanye nokucabanga ukubamba iqhaza kulolu ncwaningo.

Isihloko socwaningo:

Ukusebenza kahle kobuchwepheshe be “active release” ihamba yodwa kanye nobuchwepheshe be “active release” ihlanganiswe nobuchwepheshe bamandla emisipha ekwelashweni kokuqina kwemisipha yangemuva emathangeni okubangela ubuhlungu obungapheli beqolo langezansi.

Umcwaningi oyinhloko:

Amagama aphelele : Ching-Hsuan Chen (kevinchen961208@gmail.com)

Iziqu : Bachelors of Health Science in Chiropractic

Ababambisene nomcwaningi:

Amagama aphelele : Dr Fazila Ally (fazilaa@dut.ac.za)

Iziqu : PhD: Anatomy (UKZN)

Amagama aphelele : Dr Cleo Prince (cleop@dut.ac.za)
Iziqu : Mtech: Chiropractor

Isingeniso esifushane kanye nenjongo yocwaningo

Ubuhlungu obungapheli beqolo langezansi bungenye yezimbangela ezihamba phambili zokukhubazeka kwansuku zonke futhi buthinta abantu abangaphezulu kwephesenti eliyishumi nesishagalombili (80%) emhlabeni jikelele. Nanxa kungase kube kuningi okunomthelela ebuhlungwini obungapheli beqolo langezansi okufana neminyaka, ubulili, uhlobo lomsebenzi kanye nemikhuba yokuphila. Kukhona ukusetshenziswa jikelele kwemishini yomuzimba evela ezingxenyeni zomzimba, ukuma okungavamile, ubude, isisindo kanye nokucindezeleka ngokomoya okuholela ezinkingeni zamathambo nemisipha kanye nobuhlungu obungapheli beqolo langezansi. Lesimo singaholela emthwalweni omkhulu kwezomnotho njengoba izindleko ezilinganisiwe zokulapha ubuhlungu obungapheli beqolo zitholakale ziphezulu kakhulu eNingizimu Afrika, ngesilinganiso sezigidi ezingu 78,78 zamarandi ngonyaka.

Izinkinga zamathambo nemisipha zifaka u80% ezimbangeleni zobuhlungu obungapheli beqolo elingezansi kanti lezizinkinga zingahlotshaniswa nezinkinga zemisipha endaweni. Esimweni sobuhlungu obungapheli beqolo langezansi, ukuqina kwemisipha yangemuva emathangeni bukhonjwe njengenye yezimbangela zobuhlungu obungapheli beqolo langezansi nokho kodwa uma kushiywe kungalashwa lokuqina kwemisipha kube sekuholela ebuhlungwini obungapheli beqolo langezansi. Isizathu esiphakamisiwe kungaba ukuthi imisipha yangemuva emathangeni eyakhiwe ikhanda elide nelifushane le “biceps femoris”, i “semi-tendinosus” kanye ne “Semi-membranosus” kunamathela eduze kwe kwengxenye ephansi yokhalo. Lokhu kunobudlelwane obuqondile nokhalo ngakho ke uma imisipha yangemuva emathangeni iqinile noma ifinyele, ngokuvamile kwandisa ukutsheka kwengxenye engemuva yokhalo. lokhu kunciphisa ijika le lodosisi kwandise isisindo semithwalo ethwalwa iqolo ngemuva bese kuthuthukela ebuhlungwini beqolo langezansi.

Izindlela zokulapha eziye zasungulwa futhi zafakazelwa ukuthi ziyasebenza ezifana nemasaji, ukufaka izinaliti emisipheni kanye nohlobo lokwelapha olwaziwa ngokuthi ikhaphingi. Nokho ke, lezi zinhlobo zingasetshenziswa kuphela uma kungekho okuvimbayo okufana nokukhulelwa, umdlavuza, ukushiswa ilanga, amashashaza, amahlwili asemithanjeni ejulile kanye nesifo sikashukela. Ngakho ke, kubalulekile ukusungula ezinye izindlela zokwelapha ezingase zinikezwe iziguli ezethula ubuhlungu beqolo langezansi obudalwa ukuqina kwemisipha yangemuva emathangeni.

Indlela yokufakwa ocwaningweni

Umhlanganyeli angase afakwe uma:
Ephakathi kweminyaka eyi-18 kuya kwengama-55

Uzwa Ubuhlungu Obungapheli Beqolo (isikhathi esiyizinyanga ezi-3 noma ngaphezulu)

Babe nezinsuku ezintathu kuya kwezine zobuhlungu ngeviki.

Ezimisele ukufunda nokusayina ifomu lemvume enolwazi futhi enze umlando ophelele kanye nokuhlolwa ngokomzimba.

Ezimisele ukubamba iqhaza ekwelashweni okubili.

Indlela yokukhishwa ocwaningweni
Umhlanganyeli angase akhishwe uma:
Engeni esigabeni sobudala.

Engafisi ukusayina ifomu lemvume enolwazi noma enqaba ukwenza umlando nokuhlolwa ngokomzimba**.**

Esebenzisa imithi eqeda ukuvuvuka noma ephumuza imisipha, kumele babe nezinsuku ezintathu bengayisebenzisi lemithi ngaphambi kokuba bangene ocwaningweni.

Ethola ezinye izinhlobo zokulashwa kobuhlungu obungapheli beqolo elisezansi phakathi nesikhathi sezinyanga ezimbili.

Sebeke bahlinzwa eqolo.

I-kinesiophobia ihlolwe nge-central sensitization kanye neskali se-tampa

Uhlaka lwezinqubo:

Abazobamba iqhaza kulolucwaningo bazothintwa umncwaningi ngqo. Incwadi yolwazi kanye nefomu lemvume enolwazi kuzosayinwa ngaphambi kokuba ukubamba iqhaza ocwaningweni kuqale. Obambe iqhaza kuzodingeka ukuba agcwalise kanye uhlu lwemibuzo oluzobe luthatha isikhathi esilinganiselwe emizuzwini eyishumi. Uhlu lwemibuzo lususelwe ohlwini lemibuzo ye “Dutch musculoskeletal” (Hildebrandt *et al.*, 2001) futhi iqukethe uchungechunge lwemibuzo nezitatimende ezimayelana nobuhlungu beqolo elisezansi. Wonke amaqembu azothola ukwelashwa kabili, lapho lokulashwa kabili kuzokwenziwa evikini elilodwa. Imiphumela yocwaningo izohlinzeka ngolwazi olubalulekile mayelana nokusebenza kahle okuvela kuloluhlobo lokwelashwa.

Ubungozi noma ukungakhululeki okungahle kuvelele obambe iqhaza:

Lolucwaningo lunguhlobo lwesivivinyo esiphathelene nokubhekwa nokwelashwa kwamafindo asemisipheni okungase kubangele ukungakhululeki okuncane ngesikhathi senqubo.

Izinzuzo:

Uma lezizinhlobo zokwelapha zitholakala zisebenza kahle, lokhu kungase kwengeze ohlelweni lokwelapha ubuhlungu obungapheli beqolo elisezansi, okungaholela ekunciphiseni isikhathi esidingekayo ekwelapheni, kuphinde kunciphe inani elidingekayo lokuvakasha ukuze kwelashwe ubuhlungu kanye nokunciphisa izindleko zosizo lwempilo yeziguli.

Ukuhoxa ocwaningweni:

Ungahoxa ocwaningweni nganoma yisiphi isikhathi ngaphandle kwesijeziso.

Iholo:

Alikho iholo noma inkokhelo ozoyithola ngokubamba kwakho iqhaza kulolucwaningo.

Izindleko zocwaningo:

Angeke ube nesibopho sanoma yimiphi iminikelo yezezimali kulolu cwaningo.

Imfihlo:

Ulwazi olunikezwe nguwe luzophathwa njengoluyimfihlo enkulu futhi luyohlala lungaziwa ngaso sonke iskhathi. Ngeke kudingeke ukuba ufake igama lakho nanoma yimiphi imininingwane ehlonzile uma ugcwalisa uhlu lwemibuzo. Amarekhodi olwazi angase ahlolwe ngamakomidi okuziphatha afanelekile ukuze kuhlaziywe ulwazi.

Abantu ongabathinta uma kuba nezinkinga noma nemibuzo:

Ungathinta umcwaningi, uMnumzane Chen (084 326 3882) noma ababambisene nomcwaningi, udokotela F. Ally (031- 373 2389/082 703 0006), okanye udokotela C. Prince (cleop@dut.ac.za). Noma ungathinta umqondisi wezimiso zocwanungo lwesikhung kulenombolo 031-373 2900.

Izikhalazo zingabikwa ku DVC: TIP, Prof F. Otieno on 031- 373 2382 or dvctip@dut.ac.za.

Ozithabayo

Mnumzane C. Chen

Umcwaningi oyinhloko

Appendices G: IREC Consent Letter

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC) – CONSENT LETTER

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Mr. Ching-Hsuan Chen, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _________________.

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth and initials will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

Full Name of Participant **Date** **Time** **Signature**

I, Mr. Ching-Hsuan Chen, herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the proposed research study.

Full Name of Researcher **Date** **Signature**

Full Name of Witness (If applicable) **Date** **Signature**

Incwadi yokuvuma yakwa IREC

IKOMIDI LWEZIMILO ZOCWANINGO LWESIKHUNGO (IREC) – INCWADI YOKUVUMA

Isitatimende sesivumelwano sokubamba iqhaza ocwaningweni:
Ngiyaqinisekisa ukuthi ngaziswe umcwaningi, uMnumzane Ching-Hsuan Chen mayelana nesimo, ukuziphatha, izinzuzo kanye nobungozi balolucwaningo – inombolo yemvume yezimiso zocwaningo ________________.
Ngiphinde ngaluthola, ngalufunda futhi ngaluqonda ulwazi olubhalwe ngenhla (incwadi yombambi qhaza yolwazi) olumayelana nocwaningo.
Ngiyazi ukuthi imiphumela yocwaningo, ehlanganisa nemininingwane ebucayi emayelana nobulili bami, ubudala, usuku lokuzalwa kanye neziqalo zami kuzocutshungulwa ngokungaziwa kube umbiko wocwaningo.
Ngokubheka izidingo zocwaningo, ngiyavuma ukuthi ulwazi oluqoqwe phakathi nalolu cwaningo lungacutshungulwa ohlelweni lwekhompuyutha ngumcwaningi.
Ngingakwazi, nganoma yisiphi isikhathi, ngaphandle kokubandlulula, ngihoxise imvume yami nokubamba iqhaza ocwaningweni.
Ngibe nethuba elanele lokubuza imibuzo futhi (ngokuzithandela) ngazitshela ukuthi ngikulungele ukuhlanganyela ocwaningweni.
Ngiyaqonda ukuthi okutholakele okusha okubalulekile okuvezwe phakathi nalolu cwaningo okungase kuhlobane nokubamba kwami iqhaza kuzokwenziwa nami ngikuthole.

________________ __________ ________ ________________

Amagama agcwele **usuku** **isikhathi** **isiginesha omhlanganyeli**

Mina Mnumzane Ching-Hsuan Chen, ngiyaqinisekisa ukuthi umhlanganyeli ongenhla waziswe ngokugcwele mayelana nesimo, ukuziphatha kanye nobungozi bocwaningo oluhlongozwayo.

________________ __________ ___________________

Amagama agcwele **omcwaningi** **usuku** **isiginesha**

________________ __________ ___________________

Igama Eligcwele likafakazi (Uma likhona) **usuku** **isiginesha**

Appendices H: Tampa Scale for Kinesiophobia

(Rayner 2019)

Name: ____________________

Date: ____________________

	Strongly disagree	Disagree	Agree	Strongly agree
1. I'm afraid that I might injure myself if I exercise	1	2	3	4
2. If I were to try overcome it, my pain would increase	1	2	3	4
3. My body is telling me I have something dangerously wrong	1	2	3	4
4. My pain would probably be relieved if I were to exercise	4	3	2	1
5. People aren't taking my medical condition seriously enough	1	2	3	4
6. My accident has put my body at risk for rest of my life	1	2	3	4
7. Pain always means I have injured my body	1	2	3	4
8. Just because something aggravates my pain does not mean it is dangerous	4	3	2	1
9. I am afraid that I might injure myself accidently	1	2	3	4
10. Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening	1	2	3	4
11. I wouldn't have this much pain if there weren't something potentially dangerous going on in my body	1	2	3	4
12. Although my condition is painful, I would be better off if I were physically active	4	3	2	1
13. Pain lets me know when to stop exercising so that I don't injure myself	1	2	3	4
14. It's really not safe for a person with condition like mine to be physically active	1	2	3	4
15. I can't do all the things normal people do because it's too easy for me to get injured	1	2	3	4
16. Even though something is causing me a lot of pain, I don't think it's actually dangerous	4	3	2	1
17. No one should have to exercise when he/she is in pain	1	2	3	4

Central Sensitization Inventory: Part A
(Neblett 2018)
Name: ____________________
Date: ____________________

	Never	Rarely	Sometimes	Often	Always
1. I feel tired and unrefreshed when I wake from sleeping.	0	1	2	3	4
2. My muscles feel stiff and achy.	0	1	2	3	4
3. I have anxiety attacks.	0	1	2	3	4
4. I grind or clench my teeth.	0	1	2	3	4
5. I have problems with diarrhea and/or constipation.	0	1	2	3	4
6. I need help in performing my daily activities.	0	1	2	3	4
7. I am sensitive to bright lights.	0	1	2	3	4
8. I get tired very easily when I am physicaly active.	0	1	2	3	4
9. I feel pain all over my body	0	1	2	3	4
10. I have headaches	0	1	2	3	4
11. I feel discomfort in my bladder and/or burning when I urinate	0	1	2	3	4
12. I do not sleep well.	0	1	2	3	4
13. I have difficulty concentrating.	0	1	2	3	4
14. I have skin problems such as dryness, itchiness, or rashes.	0	1	2	3	4
15. Stress makes my physical symptoms get worse.	0	1	2	3	4
16. I feel sad or depressed.	0	1	2	3	4
17. I have low energy.	0	1	2	3	4
18. I have muscle tension in my neck and shoulders.	0	1	2	3	4
19. I have pain in my jaw.	0	1	2	3	4
20. Certain smells, such as perfumes, make me feel dizzy and nauseated.	0	1	2	3	4
21. I have to urinate frequently.	0	1	2	3	4
22. My legs feel uncomfortable and restless when I am trying to go to sleep at night.	0	1	2	3	4
23. I have difficulty remembering things	0	1	2	3	4
24. I have suffered trauma as a child.	0	1	2	3	4
25. I have pain in my pelvic area.	0	1	2	3	4
	Total:				

Central Sensitization Inventory: Part B

Name: ____________________

Date: ____________________

Have you been diagnosed by a doctor with any of the following disorders?

Please check the box to the right for each diagnosis and write the year of the diagnosis.

		NO	Yes	Year Diagnosed
1	Restless Leg Syndrome			
2	Chronic Fatique Syndrome			
3	Fibromyalgia			
4	Temporomandibular Joint Disorder (TMJ)			
5	Migraine or tension headaches			
6	Irritable Bowel Syndrome			
7	Multiple Chemical Sensitivities			
8	Neck Injry (including whiplash)			
9	Anxiety or Panix Attacks			
10	Depression			

Appendices I: Case History

DEPARTMENT OF CHIROPRACTIC

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: Date:

File #: Age:

Gender: Occupation:

Student: Signature

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:

Previous: Current:

X-Ray Studies:

Previous: Current:

Clinical Path. lab:

Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

Conditions met in Visit No:	Signed into PTT:	Date:

Case Summary signed off:	Date:

Student's Case History:

1. **Source of History:**

2. **Chief Complaint: (patient's own words):**

3. **Present Illness:**

	Complaint 1(principle complaint)	**Complaint 2 (additional or secondary complaint)**
Location Onset : Initial: Recent: Cause: Duration Frequency Pain (Character) Progression Aggravating Factors Relieving Factors Associated S & S Previous Occurrences Past Treatment Outcome:		

4. **Other Complaints:**

5. **Past Medical History:**

General Health Status

Childhood Illnesses

Adult Illnesses

Psychiatric Illnesses

Accidents/Injuries

Surgery

Hospitalizations

6. Current health status and life-style:

Allergies

Immunizations

Screening Tests incl. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

Current Medication
Analgesics/week:
Other (please list):

Tobacco Alcohol Social Drugs

7. Immediate Family Medical History:

Age of all family members
Health of all family members
Cause of Death of any family members

	Noted	Family member		Noted	Family member
Alcoholism			Headaches		
Anaemia			Heart Disease		
Arthritis			Kidney Disease		
CA			Mental Illness		
DM			Stroke		
Drug Addiction			Thyroid Disease		
Epilepsy			TB		
Other (list)					

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

9. Review of Systems (please highlight with an asterisk those areas that are a problem for the patient and require further investigation)

- General: ____

Weight Change		Weight Gain		Weight Loss		Weakness		Fatigue		Fever	

- Skin: ____

Rashes		Lumps		Sores		Itching		Dryness		Colour Change		Hair/Nail Changes	

- Head: ____

HA		Head Injury		Dizziness		Light-headedness	

- Eyes: ____

Blurred/D bl Vision		Glasses/Lenses		Pain		Redness		Excessi ve		Cataracts		Spots/Specks		Glaucom a	

- Ears: ____

Hearing		Tinnitus		Vertigo		Earaches		Infection		Discharge		Hearing Aids	

- Nose/Sinuses: _____

Fq Colds		Nasal Stuffiness		Discharge		Itching		Hay fever		Nosebleeds		Sinus Prob	

- Mouth/Throat: _____

Teeth/Gum Condition		Bleeding Gums		Dentures		Sore Tongue		Dry Mouth		Sore Throats		Hoarsenes s	

- Neck: ____

Lumps		Lymphadenopathy		Goitre		Stiffness	

- Breasts: ____

Lumps		Pain/Discomfort		Discharge		Self-Examination?	

- Respiratory: _____

Cough		Sputum		Haemoptysis		Dyspnoea		Wheezing		Asthma		Infections		Last X-Ray	

- Cardiac: ____

Che st		Hypertensio n		Palpitations		Murmurs		Dyspnoea		Orthopnoe a		Oedem a		ECG/Cardi ac Test?	

- GIT: ____

Trouble Swallowing		Heartburn		Appetite		Nausea		Vomiting		Regurgitation		Indigestion	
Rectal Bleeding		Black Tarry		Haemorrhoids		Constipation		Diarrhoe a		Abdominal Pain		Food Intolerance	
Bowel Mvts		Colour/Size Stool?		Change in Bowel Habits		Excessive Belching/Gas		Jaundic e		Liver/Gallbladder Issues			

- Urinary: _____

Fq Urination		Polyuria		Nocturia		Burning/Pain?		Haematuria		Infections	
Urgency		Hesitancy		Dribbling		Incontinence		Stones			

- Genital: _______

  Male: _

Hernias		Discharge		Sores		Testicular Pain		Hx of STD	
Sexual Preference		Libido		Satisfaction		Condoms		Exposure to HIV	

Female: _____

Menstruation:		Age Began		Regularity		Duration		Amt of Bleeding	
Bleeding between Periods		Bleeding after Sex		Dysmenorrhea		PMS		Last Menstruation?	

Menopause:		Symptoms		Postmenopausal Bleeding	

Vagina:	Itching		Discharge		Sores		Lumps		STD's and Tx	

Pregnancies:	NU		Type of Delivery		Abortions		Spontaneous/Induced		Complications	
	Dyspareunia		Birth Control		Sexual Preference		Libido		Satisfaction	

- Vascular: _____

Intermittent Claudication		Leg Cramps		V.V.		Hx of Thrombosis	

- Musculoskeletal: ______

Muscle/Joint Pain		Swelling		Redness		Limited Motion		Stiffness	

- Neurological: _____

Fainting		Blackouts		Seizures		Weakness		Paralysis	
Numbness		Tingling P & N		Tremors		Involuntary Mvts			

- Haematological: ______

Anaemia		Easy Bruising/Bleeding		Past Transfusions		Reaction to them?	

- Endocrine: _____

Thyroid:	Heat/Cold Intolerance		Excessive Sweating	
Diabetes:	Excessive Thirst/Hunger		Polyuria	

- Psychiatric: _____

Nervousness		Tension		Depression		Memory	

DUT DURBAN UNIVERSITY OF TECHNOLOGY — DEPARTMENT OF CHIROPRACTIC

PHYSICAL EXAMINATION: SENIOR

Patient Name: ______________________ **File no:** __________ **Date:** ________

Student: **Signature:**

VITALS:

Pulse rate:				Respiratory rate:	
Blood pressure:	R	L		Medication if hypertensive:	
Temperature:				Height:	
Weight:	Any recent change?	Y / N	If Yes: How much gain/loss		Over what period

GENERAL EXAMINATION:

General Impression		
Skin		
Jaundice		
Pallor		
Clubbing		
Cyanosis (Central/Peripheral)		
Oedema		
Lymph nodes	Head and neck	
	Axillary	
	Epitrochlear	
	Inguinal	
Pulses		
Urinalysis		

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature:**

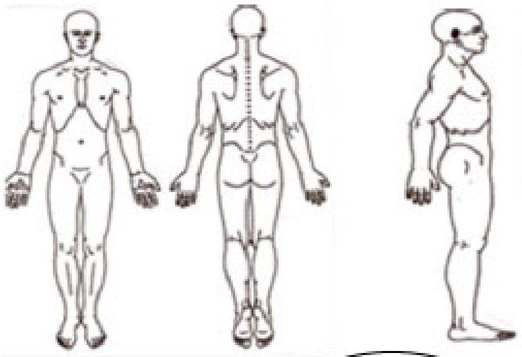
DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC

REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Patient:________________________ File#:______________ Date:__________

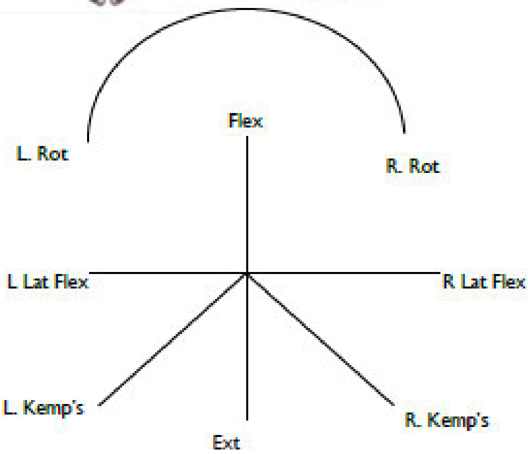
Student:________________________ Clinician:________________________



STANDING:
Posture type:
Scoliosis/antalgia
Body type
Kyphosis
Skin/Scar
Discolouration
Minor's Sign
Muscle tone
Spinous Percussion
Schober's Test (6cm)
Bony and Soft Tissue Contours

GAIT:
Normal walking
Toe walking Heel
Walking Half
squat

ROM:
Forward Flexion = 40-60° (15 cm from floor)
Extension = 20-35°
L/R Rotation = 3-18°
L/R Lateral Flexion = 15-20°



Which movement reproduces the pain or is the worst?
- Location of pain
- Supported Adams: Relief? (SI)
- Aggravates? (disc, muscle strain)

SUPINE:
Observe abdomen (hair, skin, nails)
Palpate abdomen\groin
Pulses - abdominal
 - lower extremity
Abdominal reflexes

		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
SLR	**L**										
	R										

	L	**R**
Bowstring		
Sciatic notch		
Circumference (thigh and calf)		
Leg length: actual -		
apparent -		
Patrick FABERE: pos\neg – location of pain?		
Gaenslen's Test		
Gluteus max stretch		
Piriformis test (hypertonicity?)		
Thomas test: hip \ psoas \ rectus femoris?		
Psoas Test		

SITTING:
Spinous Percussion
Valsalva
Lhermitte

		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
TRIPOD SI, +, ++											
	L										
	R										

SLUMP 7 TEST	L										
	R										

LATERAL RECUMBENT:	**L**	**R**
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:	**L**	**R**
Gluteal skyline		
Skin rolling		
Iliac crest compression		
Facet joint challenge		
SI tenderness		
SI compression		
Erichson's		
Pheasant's		

MF tp's	**Latent**	**Active**	**Radiation**
QL			
Paraspinal			
Glut Max			
Glut Med			
Glut Min			
Piriformis			
Hamstring			
TFL			
Iliopsoas			
Rectus Abdominis			
Ext/Int Oblique muscles			

NON ORGANIC SIGNS:
Pin point pain
Trunk rotation
Flip Test
Ankle dorsiflexion test
Axial compression
Burn's Bench test
Hoover's test
Repeat Pin point test

NEUROLOGICAL EXAMINATION

Fasciculations						
Plantar reflex						
level	Tender?	Dermatomes		DTR		
		L	R		L	R
T12				Patellar		
L1				Achilles		
L2						
L3				Proprioception		
L4						
L5						
S1						
S2						
S3						

MYOTOMES

Action	Muscles	Levels	L	R	
Lateral Flexion spine	Muscle QL				
Hip flexion	Psoas, Rectus femoris				5+ Full strength
Hip extension	Hamstring, glutes				4+ Weakness
Hip internal rotation	Glutmed, min, TFL, adductors				3+ Weak against grav
Hip external rotation	Gluteus max, Piriformis				2+ Weak w\o gravity
Hip abduction	TFL, Glut med and minimus				1+ Fascic w\o gross movt
Hip adduction	Adductors				0 No movement
Knee flexion	Hamstring,				
Knee extension	Quad				W - wasting
Ankle plantarflexion	Gastrocnemius, soleus				
Ankle dorsiflexion					
Inversion					
Eversion					
Great toe extensor					

MOTION PALPATION AND JOINT PLAY	L	R
Lumbar Spine		
Sacroiliac Joint		

FUNCTIONAL TESTS:

	L	R
Hip extension test		
Hip abduction test		
Supine DNS sagittal stabilisation		
Prone DNS sagittal stabilisation		
Other DNS assessments		
Breathing pattern		
Sit up		
Other functional test e.g. squat, lunge		

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC

HIP REGIONAL EXAMINATION

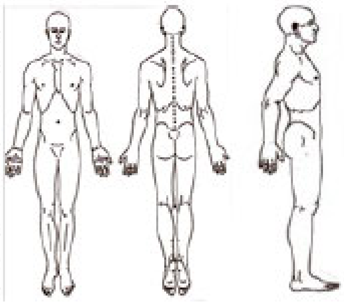
Patient:________________________ File no:__________ Date: __________

Student:________________________ Signature: __________

Clinician:________________________ Signature: __________

OBSERVATION

Gait	
Posture type	
Weight-bearing symmetry	
Balance and proprioception: Stork-standing test)/Berg balance	
Bony / soft tissue contours: Buttock contour	
Hip flexion contracture	
Lumbar lordosis	
Scoliosis	
Skin	
Swelling	



PALPATION

• Anterior aspect			Right	Left
1.	Iliac crests			
2.	Greater trochanter			
3.	Pubic symphysis and tubercle			
4.	Femoral head			
5.	Femoral triangle	Femoral artery		
		Lymph nodes		
6.	ASIS's			
7.	Inguinal ligament			
8.	Inguinal hernia			
9.	Muscles -	Quadriceps		
		Adductors		
		Abductors		
		Psoas		
• Posterior aspect			**Right**	**Left**
1.	Iliac crests posteriorly			
2.	Ischial tuberosity			
3.	Muscles	Piriformis		
		Gluteals		
		Hamstrings		
4.	PSIS's			
5.	Sciatic notch			
6.	SI joints			
7.	Lumbar Spine			
8.	Sacrum + coccyx			

REFLEXES	Right	Left
Patella		
Achilles		

DERMATOMES *(indicate deficits by level and location)*

Level		
Location		

		Right	Left
ACTIVE MOVEMENTS *(note rom and pain)*		**Right**	**Left**
1.	Flexion (110-120°)		
2.	Extension (10-15°)		
3.	Adduction (30°)		
4.	Abduction (30-50°)		
5.	Medial rotation (30-40°)		
6.	Lateral rotation (40-60°)		
PASSIVE MOVEMENTS *(note end-feel, rom and pain)*		**Right**	**Left**
1.	Flexion (tissue stretch or approximation)		
2.	Extension (tissue stretch)		
3.	Adduction (tissue stretch or approximation)		
4.	Abduction (tissue stretch)		
5.	Medial rotation (tissue stretch)		
6.	Lateral rotation (tissue stretch)		
RESISTED ISOMETRIC MOVEMENTS *(note strength and pain)*		**Right**	**Left**
1.	Hip Flexion		
2.	Hip Extension		
3.	Adduction		
4.	Abduction		
5.	Medial rotation		
6.	Lateral rotation		
7.	Knee flexion		
8.	Knee extension		
JOINT PLAY MOVEMENTS		**Right**	**Left**
1.	Caudal glide (long axis traction superior – inferior)		
2.	Compression @ 90° (inferior – superior)		
3.	Medial ➢ lateral @ 180°/ @ 90°		
4.	Lateral ➢ medial @ 180°/ @ 90°		
5.	Internal rotation		
6.	External rotation		
7.	Anterior ➢ posterior		
8.	Posterior ➢ anterior		
9.	Quadrant (scouring) test		
SPECIAL TESTS		**Right**	**Left**
1.	Patrick FABER Test		
2.	Quadrant scouring Test		
3.	Trendelenberg's Test		
4.	Anterior labral tear (FADDIR) test		
5.	Craig's Test		
6.	Leg Length – Actual		
	Leg Length – Apparent		
7.	Sign of the Buttock		
8.	90-90 SLR		
9.	Gaenslen's Test		
10.	Thomas Test (hip flexion contracture)		
11.	Rectus Femoris Contracture Test		
12.	Iliopsoas contracture Test		
13.	Ely's Test (rectus femoris hypertonicity)		
14.	Ober's Test (ITB contracture)		
15.	Noble Compression Test (ITB Friction Syndrome)		
16.	Piriformis Test		
17.	Hamstrings – Hamstring Contracture Test		
	Hamstrings – Tripod Test		
FUNCTIONAL TESTS		**Right**	**Left**
1.	Hip abduction test		
2.	Hip extension test		
3.	Hip flexion test / active straight raise		
4.	Squat		
5.	Overhead squat		
6.	Single leg bridge		
7.	Lunge		

Page 2 of 2

Patient Name: ***File number:*** ***Page:***

Date: ***Visit:*** ***Student:***

Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Student Rating*** ***A:***

Least 0 1 2 3 4 5 6 7 8 9 10 Worst

0: ***P:***

E:

Special attention to: ***Next appointment:***

EBCC References:

Date: ***Visit:*** ***Student:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Student Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: ***P:***

E:

Special attention to: ***Next appointment:***

EBCC References:

Appendices J: Statistician Sample Size Calculation

In order to do sample size calculations for the study, it was necessary to have statistics (specifically the standard deviations) as scored in prior studies that used the same protocol as what you suggest.

Khan, Patel and Limbani (2021)'s study used the same intervention treatments concerning hamstring tightness. Thus this paper was used for the relevant info needed.

In your study you intend the following:

2 groups   Group A = ART and   Group B = ART + MET

Khan, Patel and Limbani (2021) had 2 groups. However, these were slightly different.

Group A = ART and   Group B = MET

Group A is the same and thus we can do calculations based on this treatment.

Group B is not the same. Therefore only MET was used within the statistical equation. There is no paper that previously applies MET and ART on the same patients.

Group A:

Statistics I have from previous study. These are AKE statistics.

Group/ Treatment	**PRE**		**POST**		**Pooled SD**	**Sample size needed for the group in order to detect the following changes in degree**			
	mean	**SD**	**mean**	**SD**		**7**	**8**	**9**	**10**
ART	42.4	11.078	75.633	12.933	12.041	24	18	15	12
MET	51.833	8.094	81.2	10.838	9.565	15	12	9	8

Choose in between the number 20

In terms of calculations based on the **pain rating**:

Divya Prasanna (2011) presented pain ratings scale for MET. I will give these – they will not be useful and are also redundant since we look at the calculations giving MAXIMUM sample size.

Group/ Treatment	**PRE**		**POST**		**SD_{Δ}**	**Sample size needed for the group in order to detect the following changes (E)**			
	mean	**SD**	**mean**	**SD**		**2**	**3**	**4**	**5**
MET	5.87	1.0601	1.47	1.0601	.8281	2	1	1	1

It is correct practice to use the largest of all sample sizes calculated. So, in this case you would use those from the red shaded row.

The formula used:

I used the following formula to determine sample size for a paired sample t-test (pre and post) in which alpha = .05 and power = 80%. These figures are generally accepted as standard to use.

$n = \quad (Z_{\alpha/2} + Z_{1-\beta})^2 / (E / S_\Delta)^2$

$Z_{\alpha/2} = 1.96$

$Z_{1-\beta} = 0.8416$

E = change to detect (pre to post)

S_Δ = Standard deviation of the change pre to post

Appendices K: Research Assistant

Statement of Agreement in the Participation of the Research Study as a Research Assistant:

I ….……………........................., ID number……………………………………………… voluntarily agree to participate in this study: "**The effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness causing chronic lower back pain**.", as a research assistant.

I will ensure that I maintain confidentiality with regards to the research data that is collected.

Research assistant's name (print) ………………………………………………………………….

Research assistant's signature: ………………………………… Date: ……………………………………

Researcher's name (print)……………………………… Signature: ……………………………………….
Date: ……………………………………

Witness name (print)………………………………………Signature………………………………………
Date: …………………………………

Appendices L: Numerical Pain Rating Scale (NPS-11)

Patient name:

Date:

File number:

Visit :

Before intervention

In the line below, which indicates the pain you experience **at its worst,** please indicate the number between 0 and 10. A zero being the least pain or no pain at all, and ten being the worst pain.

Please circle only one number.

0 1 2 3 4 5 6 7 8 9 10

Key

Rating	Pain Level
0	no pain
1-3	Mild (annoying, nagging and interfering with activities of daily living)
4-6	Moderate (significantly interferes with activities of daily living)
7-10	Severe (unable to perform activities of daily living or disabling)

After intervention

In the line below, which indicates the pain you experience **at its worst,** please indicate the number between 0 and 10. A zero being the least pain or no pain at all, and ten being the worst pain.

Please circle only one number.

0 1 2 3 4 5 6 7 8 9 10

Key

Rating	Pain Level
0	no pain
1-3	Mild (annoying, nagging and interfering with activities of daily living)
4-6	Moderate (significantly interferes with activities of daily living)
7-10	Severe (unable to perform activities of daily living or disabling)

Appendices M: Active Knee Extension test

Patient name:

Date:

File number:

Participants will be positioned supine on a bed, allowing the leg not being tested lay flat on the bed, knee extended. A strap/belt will be placed over the mid-thigh of the non-tested leg to eliminate any elevation of the limb. An additional strap/belt will be placed around the pelvis and bed in a neutral position during hamstring measurements. With the foot in neutral position and knee flexed at 90 degree. A universal goniometer will be placed over the lateral femoral condyle, 1 arm aligned along the thigh in line with the greater trochanter and the other arm aligned over the leg in the direction of the lateral malleolus.

The participants will then be instructed to extend the knee until they feel a strong resistance and will hold the position for 2 to 3 seconds to allow the goniometric reading. The results will be recorded in terms of the degree to the angle of the knee extension movement, starting from the initial test position (knee flexed at 90 degree which correspond to the goniometric in 0 degree) (Khan, Patel and Limbani 2021).

	Intervention 1		Intervention 2	
	Before treatment	After treatment	Before treatment	After treatment
Change in degree to Left hamstring				
Change in degree to Right hamstring				

Appendices N: Universal Algometer Reading

Patient name:

Date:

File number:

Universal pressure algometer will be used to measure pressure pain threshold with a stimulation surface area of 1cm^2. Three consecutive measurements will be performed on each site, with 10 seconds of recovery time allowed between repeated applications. During the measurements, the participants will be asked to say “yes” when the initial pain is experienced

2cm bilateral L2 and L4

	Intervention 1			Intervention 2		
	M1	M2	M3	M1	M2	M3
Left L2 kg/cm^2						
Right L2 kg/cm^2						
Left L4 kg/cm^2						
Right L4 kg/cm^2						

Appendices O: IREC Approval

DUT
Durban University of Technology

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

10 October 2023

Mr C-H Chen
113 Jan Smuts Avenue
Winston Park
Gillits
3610

Dear Mr Chen

The effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness associated with chronic lower back pain
Ethical Clearance number IREC 157/23

The DUT-Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letters.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the DUT-IREC according to the DUT-IREC Standard Operating Procedures (SOP's).

Please note that any deviations from the approved proposal require the approval of the DUT-IREC as outlined in the DUT-IREC SOP's.

It is compulsory for a student or researcher to apply for recertification on an annual basis. The failure to do so will result in withdrawal of ethics clearance. It is the responsibility of the researcher and the supervisor to apply for recertification.

Please note that you are required to submit a Notification of Completion of Study form together with an abstract to the DUT-IREC office on completion of your study.

Yours Sincerely

Prof J K Adam
Chairperson: DUT-IREC

Appendices P: Approval from the Clinic Director

MEMORANDUM

To : Prof Adam
Chair: IREC

From : Dr Desiree Varatharajullu
Head of Department: Chiropractic; Clinic Director: Chiropractic Day Clinic

Date : 06.09.2023

Re : Request for permission to use the Chiropractic Day Clinic for research purposes

Permission is hereby granted to:

Mr Kevin Chen (Student Number: 21710944)

Research title: "The effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness associated with chronic lower back pain."

Mr Chen, is requested to submit a copy of his FRC/IREC approved proposal along with proof of his MHSc: Chiropractic registration to the Clinic Administrator/s before he starts with his research in order that any special procedures with regards to his research can be implemented prior to the commencement of him seeing patients.

Thank you for your time.

Head of Department: Chiropractic; Clinic Director: Chiropractic Day Clinic: Chiropractic

Cc: Mrs Linda Twiggs: Chiropractic Day Clinic
Dr F. Ally Supervisor
Dr C. Prince: Co-supervisor

Appendices Q: Approval from the Reserach Director

18 September 2023

Mr Ching-Hsuan Chen
c/o Department of Chiropractic
Faculty of Health Sciences
Durban University of Technology

Dear Mr Chen

PERMISSION TO CONDUCT RESEARCH AT THE DUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research and Innovation Committee (IRIC) has granted **Gatekeeper Permission** for you to conduct your research "The effectiveness of active release technique and the combination of active release technique and muscle energy technique in the treatment of hamstring tightness associated with chronic lower back pain" at the Durban University of Technology. **Kindly note that this letter must be issued to the IREC for approval before you commence data collection**.

The DUT may impose any other condition it deems appropriate in the circumstances having regard to nature and extent of access to and use of information requested.

Upon completion of your research project, you are requested to share the summary of your key research findings.

Kind regards.
Yours sincerely

DR V GOVENDER
ACTING-DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT DIRECTORATE

Appendices R: Ethics Certificate