THE EFFECT OF PILATES REFORMER-BASED EXERCISES COMPARED TO PILATES MAT-BASED EXERCISES ON GENERAL LOWER BACK PAIN AND FUNCTION IN INDIVIDUALS SUFFERING FROM NON-SPECIFIC LOWER BACK PAIN

MINI-DISSERTATION

By

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This study would not have been possible without the involvement and contribution of a number of individuals.

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ABSTRACT

Background: Chronic non-specific lower back pain is a debilitating musculoskeletal ailment affecting approximately 85% of adults worldwide who will, at some point in their lifetime, experience lower back pain. Approximately 40% of individuals with acute lower back pain progress into a state of chronic pain over time (Lim, Poh, Low, & Wong, 2011). Pilates has been increasingly utilised in the treatment of individuals with lower back pain. Although previously characterised as an intensive and rigorous exercise modality, Pilates has, over the years, been modified to allow diverse age groups to use it as a rehabilitative tool. **Aims**: The study aims to compare Pilates Reformer-based exercises to Pilates mat-based exercises in its effectiveness in alleviating pain and movement disability in individuals afflicted with chronic non-specific lower back pain. **Methods:** Twenty-nine participants with chronic non-specific lower back pain, aged between 25 and 60 years old, were randomly assigned to one of the six-week interventions, being either reformer-based or mat-based. During the first consultation, the following assessments were completed: anthropometry measurements, flexibility, mobility, stability, pain, and disability ratings. Following the six-week interventions, all measurements will be repeated. **Results**: At baseline testing, both the Pilates mat-based group (50%) and the Pilates reformer-based group (53.3%) showed similar outcomes when assessing disability based on their Roland-Morris Disability Questionnaire (RMDQ) scores however, there was no statistically significant difference. (p = 0.858). 85.7% of the Pilates mat-based group hada high NPRS score at baseline compared to 66.7% of the Pilates reformer-based group. A Fishers exact test was conducted to determine the differences in proportions between the two groups, p = 0.858. There was a greater distribution of individuals with good stability in the Pilates reformer-based group (66.7%) compared to the Pilates mat-based group (28.6%) at baseline. This result was based on their performance in the Trendelenburg test and the bridge with leg extension test (BwLE), (p = 0.04). The statistical analysis revealed no significant associations

between pain and disability ratings. ($p > 0.05$) However, there was a moderately strong significant association between the intervention group stability. ($\varphi = 0.381$, $p = 0.04$) Repeated measures ANOVA showed no significant changes over time ($p = 0.088$) or a group x time interaction ($p = 0.487$) for mobility that was measured using the Sit-and-Reach outcome variable. However, the Pilates reformer-based group showed a significant improvement in mobility, as measured by the active Straight-leg-raise test (ASLR) ($p = 0.033$), compared to the Pilates mat-based group, which did not show significant improvement in ASLR outcomes ($p = 0.111$). No group x time interaction was present for the changes in ASLR between the two groups. No significant changes were found in the BwLE or Trendelenburg in any of the two groups that was statistically analysed using McNemar Tests. **Conclusion:** No intervention modality could show a significantly greater improvement in mobility and stability outcomes compared to the other modality following a six-week Pilates intervention to manage non-specific lower back pain. However, Pilates reformer-based intervention showed to be an effective therapeutic rehabilitation tool for individuals suffering with chronic non- specific lower back pain and the management thereof insofar as disability, stability, mobility, and pain is concerned. The results may assist clinicians in decision-making regarding the treatment of individuals who suffer with chronic non-specific lower back pain.

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LIST OF ABBREVIATIONS

NPRS	Numerical Pain Rating Scale
RMDQ	Roland Morris Disability Questionnaire
VAS	Visual Analogue Scale
PAR-Q	Physical Activity Readiness Questionnaire
cm	Centimetres
kg	Kilograms
BMI	Body Mass Index
BF%	Body Fat percentage
DXA	Dual x-ray absorptiometry
ASLR	Active Straight Leg Raise
GPE	Global Perceived Effect
TSK	Tampa Scale of Kinesiophobia
BwLE	Bridge with Leg Extension
RCT	Randomised Controlled Trial
MDT	McKenzie Method of Mechanical Diagnosis and Therapy

CHAPTER ONE: INTRODUCTION

The reason for this dissertation is to address possible effective treatments in the relief of chronic non-specific lower back pain, which is a debilitating musculoskeletal condition that affects both individuals and strains the global healthcare systems worldwide. Research indicates that a staggering 85% of adults will experience lower back pain at some point in their lives, and about 30% to 40% of those with acute lower back pain end up suffering with chronic lower back pain (Lim et al., 2011). The Global Burden of Disease Study ranks chronic non-specific lower back pain among the top four most prevalent health conditions out of 291 (Mauri´cio Anto^nio da Luz Jr, Fernanda Ferreira Fuhro, & Naiane Teixeira Bastos Oliveira, 2014). It hasbecome a significant part of the global health narrative, demanding urgent and effective interventions to reduce its prevalence and alleviate the associated suffering.

Beyond the statistics, chronic non-specific lower back pain is a major cause of global disability impacting the quality of life for people worldwide. The persistent nature of this condition often leads to limitations in mobility, daily functioning, and even mental health, affecting both physical and psychological well-being (Buchbinder et al., 2018). Amid technologicaladvances and increased sedentary lifestyles, addressing and managing chronic non-specific lower back pain becomes increasingly urgent.

This dissertation responds to the need for effective interventions. It calls for action by recognising the importance of exploring the complexities of chronic non-specific lower back pain, understanding its multi-faceted nature, and discovering different treatment approaches that can reduce pain and disability whilst improving mobility and stability. By analysing the condition in more detail and investigating the potential effectiveness of Pilates methods as an

intervention, this research aims to contribute to the improvement of individuals affected by chronic non-specific lower back pain.

Chronic non-specific lower back pain involves a complex relationship between physical and functional aspects of the body, with the core muscles, spanning from the diaphragm to the pelvic floor, playing a vital role in lumbopelvic stability (Jung et al., 2020). Dysfunctions in core muscles, observed in individuals with chronic non-specific lower back pain, contribute to decreased lumbopelvic stability, manifesting as weaknesses and imbalances and compromising lumbar spine mobility and stability (Noonan & Brown, 2021).

Joseph Pilates, founder of the Pilates, envisioned it as a comprehensive system integrating physical and mental conditioning, aiming to establish a harmonious connection between body and mind through controlled movements (Gladwell, Head, Haggar, & Beneke, 2006). Pilates exercises systematically engage the core muscles, focusing on elements crucial to lumbopelvic stability, using controlled movements, precision, alignment, and synchronised breathing. This unique approach targets both superficial and deeper core muscles, promoting core strengthening. This framework guides the investigation into Pilates exercises as a potential intervention for chronic non-specific lower back pain, given their emphasis on core muscle engagement and stability (Gladwell et al., 2006).

The purpose of this dissertation is two-fold: firstly, to explore the comparative effectiveness of Pilates reformer-based exercises and Pilates mat-based exercises in alleviating pain and reducing disability in individuals with chronic non-specific lower back pain and secondly, to investigate if any factors measured during the intervention could explain the change in disability or pain over the 6 weeks. The significance of this study is rooted in the substantial

global burden of chronic non-specific lower back pain and the imperative need for evidence-based interventions. By scrutinising the differences between the two Pilates exercise modalities, this research seeks to address the existing gap in the current understanding and provide practical insights to enhance the quality of life for individuals with chronic non-specific lower back pain.

The primary aim of this study is to assess the comparative effectiveness of Pilates reformer-based exercises versus Pilates mat-based exercises in individuals suffering from chronic non-specific lower back pain. The secondary aim of the study is to identify factors that may explain a change in pain and disability levels in the total group of participants regardless of the type of Pilates training completed. The specific objectives include evaluating the impact of each exercise modality on pain intensity, disability, hip strength and stability, hip flexibility and mobility. These objectives are designed to offer an understanding of how Pilates exercises, tailored to different modalities, can influence various aspects of chronic non-specific lower back pain.

Structure of the mini-dissertation:

This dissertation unfolds systematically to address the outlined objectives. Chapter 2 provides a comprehensive review of the existing literature on chronic non-specific lower back pain, core muscle dysfunction, and the role of Pilates exercises in rehabilitation. It explores the historical context, theoretical frameworks, and empirical evidence that form the foundation of this study.

Chapter 3 expands on the research methodology by detailing the study design, participant selection, intervention protocols, and outcome measures. This chapter aims to provide transparency in the research process and ensure the diligence of the study design.

Chapter 4 presents the results of the study, offering a detailed analysis of the data collected during the intervention. This chapter aims to provide empirical evidence that contributes to the knowledge base surrounding the two different Pilates methods and chronic non-specific lower back pain.

Chapter 5 explores the implications of the study results, acknowledging its limitations and offering a conclusive summary of the findings. Thus, reiterating their significance in the context of managing chronic non-specific lower back pain and will further provide actionable recommendations for clinicians and exercise scientists.

In conclusion, this dissertation aims to contribute valuable knowledge to the field of musculoskeletal health by unravelling the differences of Pilates exercises in the context of chronic non-specific lower back pain. Through rigorous exploration and empirical investigation, the study aims to advance our understanding of effective interventions, providing practitioners with evidence-based insights to enhance the quality of life for individualssuffering from chronic non-specific lower back pain.

CHAPTER TWO: LITERATURE REVIEW

Chronic non-specific lower back pain is a prevalent and debilitating musculoskeletal ailment affecting millions of people worldwide. Studies indicate that at some stage during one's lifetime, as many as 85% of adults will experience lower back pain. Furthermore, approximately 30% to 40% of individuals afflicted with acute lower back pain, do not achieve complete recovery. Instead, their symptoms progress into a state of chronic pain over time (Lim et al., 2011). According to data from the Global Burden of Disease Study, lower back pain ranks among the four most prevalent conditions out of 291 health-related ailments (Maurı´cio Antoˆnio da Luz Jr et al., 2014). Additionally, it stands as the foremost contributor to global disability in terms of years lived with disability, impacting a substantial number of individuals worldwide (Maurı´cio Antoˆnio da Luz Jr et al., 2014). This high recurrence rate typically leads to disability and significantly impacts quality of life in majority of cases (Buchbinder et al., 2018).

2.1 Chronic non-specific lower back pain

In literature, lower back pain can be defined and characterised as pain and/or discomfort, increased muscle tension and/or stiffness situated below the costal margin and above the inferior gluteal folds, with or without referred lower limb pain (Vrbanić, 2011) (Eliks, Zgorzalewicz-Stachowiak, & Zeńczak-Praga, 2019). Lower back pain can be further categorised into specific lower back pain and non-specific lower back pain, based on its etiology (Bhadauria & Gurudut, 2017). Non-specific lower back pain refers to pain not linked

to identifiable, known specific pathologies such as tumours, spinal canal stenosis, osteoporosis, lumbar radiculopathy or compression fractures (Eliks et al., 2019). Lower back pain can be further classified into three sub-types based on the duration of symptoms: acute - lasting for a few weeks, sub-acute - lasting between six to twelve weeks, and 'chronic' pertaining to an individual experiencing pain for longer than twelve weeks (Bhadauria & Gurudut, 2017) (Vrbanić, 2011). An estimation of between 85% to 90% of patients suffer with chronic non-specific lowerback pain (Eliks et al., 2019).

Studies have revealed a link between chronic undiagnosed lower back pain and the diminished function and strength of what can be referred to as the core muscles. The core muscles, which encompass the trunk muscles extending from the diaphragm down to the pelvic floor, play a pivotal role in regulating spinal movements and contributing to dynamic stabilisation of the lumbar spine and lumbopelvic stability (Lynders, 2019) (Jung et al., 2020). Lumbopelvic stability refers to the capacity to sustain a steady lumbopelvic position while executing limb movements (Jung et al., 2020). Muscles contributing to lumbopelvic stability include localised postural, tonic, and segmental stabilisers, such as the lumbar multifidus, pelvic floor, diaphragm, and transversus abdominis which is the innermost abdominal muscle (Jung et al, 2020). Additionally, global muscles with dynamic, phasic, and torque-generating capabilities, including the rectus abdominis and external oblique, play a role in maintaining lumbopelvic stability (Jung et al., 2020). On the posterior side, the erector spinae muscles cover multiple spinal levels, facilitating an upright posture. The deepest compartment at the back comprises of the multifidus muscles, which contribute to individual vertebrae's segmental stability and enhance spinal stiffness during movement (Lynders, 2019). The transversus abdominis, pelvic floor muscles, and multifidus muscles together establish what is termed the anatomical girdle (Lynders, 2019). These deeply situated muscles are of utmost importance in furnishing crucial

stability to the spine. Instances of dysfunction and weakness of these core muscles leads to a decrease in lumbopelvic stability which are frequently observed among individuals with chronic lower back pain (Noonan & Brown, 2021). Such reports have presented evidence of reduced muscle strength, reduced muscle endurance, and higher fat content, when compared to those without symptoms (Noonan & Brown, 2021).

2.2 Predispositions to lower back pain

Specific demographic groups exhibit a higher susceptibility to developing chronic non-specific lower back pain, in comparison to others. This heightened risk can be attributed to a range of factors including female sex, occupational overload, middle-aged individuals, individuals who live sedentary lifestyles, smokers, obese individuals, and individuals who do vigorous physical activity (Eliks et al., 2019). Several other risk factors including encompassing repetitive motions, inadequate ergonomic design of work setups and heightened work-related burdens display a significant link with the manifestation of pain and discomfort in the lower back area (Stieglitz, Vinson, & Hampton, 2016). Additionally, long periods of driving and sitting, heavy physical labour that involves disproportionate lifting ratios as well as psychosocial factors such as anxiety, social support and depression are closely associated with the occurrence of chronic non-specific lower back pain (Sribastav et al., 2018). It is important to delve into these risk factors to enhance our understanding of the multifaceted nature of this condition and to tailor interventions accordingly.

2.3 Treatment methods to manage non-specific lower back pain

Pain management and treatment strategies display significant diversity. Many medical practitioners commonly utilise non-steroidal anti-inflammatory drugs, opioids, neurotropic medications, or resort to steroid injections and surgical interventions as their primary solution (Coulter et al., 2018). However, owing to potential or perceived risks associated with these methods, non-pharmacological approaches that are believed to carry minimal adverse effects have gained substantial popularity (Coulter et al., 2018). These options encompass a spectrum of interventions, namely manual methods such as spinal manipulation and mobilisation therapy, physiotherapy, massage therapy, physical exercise therapy, the McKenzie Method of Mechanical Diagnosis and Therapy (MDT) as well as Pilates (Shipton, 2018).

Manual methods such as physiotherapy, massage, chiropractic care, occupational therapy, and osteopathic treatments, which encompass techniques like spinal manipulation and mobilisation, are frequently employed either in isolation or in combination to address chronicnon-specific lower back pain (Coulter et al., 2018).

Individuals suffering from chronic non-specific lower back pain are advised to maintain their physical activity levels, as extended periods of inactivity can impede the recovery process. Various forms of exercise have been investigated as treatment options for chronic non-specific lower back pain, including aerobic exercise with a low-to-moderate intensity, high intensity aerobic exercise, exercises targeting muscular strength, stabilisation of the core and flexibility programs (Gordon & Bloxham, 2016). Engaging in physical activity to enhance aerobic capacity and strengthen muscles, particularly those in the lower back, holds significance for individuals dealing with chronic lower back pain as it aids them in

accomplishing their daily tasks. It is worth noting that distinct exercises have demonstrated varying degrees of success in mitigating lower back pain (Gordon & Bloxham, 2016). Furthermore, an imbalance of excessive or insufficient physical activity can be linked to lower back pain occurrences, suggesting that utilising physical activity as an intervention for addressing such pain can be rather complex (Gordon & Bloxham, 2016).

MDT includes classifying patients into 3 mechanical subgroups (derangement, dysfunction, or postural syndrome) or an "other" subgroup using the McKenzie evaluation that is conducted by the healthcare practitioner. The healthcare practitioner will proceed to recommend tailored exercises within this grouping and provide guidance on adopting certain postures while advising against others temporarily (Shipton, 2018).

Pilates comprises of controlled movements, focusing on correct breathing and muscle contraction, fostering a harmonious connection between body and mind that enhances the physical capabilities of individuals across all age groups (Hasanpour-Dehkordi, Dehghani, & Solati, 2017). Moreover, individuals who do Pilates often experience improved sleep quality and reduced fatigue, stress, and anxiety levels (Hasanpour-Dehkordi et al., 2017). This training technique involves grounded positions, standing, sitting, and lying without intervals of jarring forces such as jumping and leaping consequently, therefore, lowering the risk of joint-related injuries (Hasanpour-Dehkordi et al., 2017).

Numerous investigations have been done to explore the management and treatment for chronic non-specific lower back pain. However, for the purpose of this study I will be delving into the body of evidence surrounding the methods of Pilates as a modality for the management and treatment for chronic non-specific lower back pain.

2.4 Pilates

In the past decade, there has been an increasing utilisation of the Pilates method as a treatment for lower back pain (Valenza et al., 2017). Built upon six fundamental principles, the Pilates method encompasses:

1. Centering - During exercise, core muscles like the transversus abdominis, diaphragm, abdominal oblique muscles, multifidus, and pelvic floor muscles should be centered and activated as these muscles aid the stabilisation in the lumbopelvic complex.
2. Concentration - Paying close attention on how to correctly execute the Pilates exercise.
3. Control - Exercise is carried out while maintaining control of posture, movement, and concentration.
4. Precision - Entails giving thoughtful attention to the meticulous exercise and only performing a few repetitions with subtle increase in intensity whilst maintaining the correct breathing rhythm.
5. Breathing - Breathing encourages deep trunk muscles to contract, and each exercise is followed through with correct breath rhythm.
6. Flow – Flow refers to the ease with which exercises are performed as well as the seamless transitions between exercises (Eliks et al., 2019).

The primary aim of Pilates is to increase the strength and toning of core muscles, stretch the lumbar spine to alleviate joint compression, and enhance the stability and mobility of the spine as this is believed to contribute to the reduction of pain and disability associated with chronic non-specific lower back pain (Gladwell et al., 2006). This trend is justified by the notion that individuals with lower back pain exhibit changes in lumbopelvic stability and regulation of spinal muscles (Valenza et al., 2017). The Pilates method presents a postural approach centered

around enhancing lumbopelvic stability and body posture alignment which refers to sufficient adjustment of the head, shoulder and pelvic girdle in neutral position whilst maintaining the curvature of the spine (Valenza et al., 2017) (Eliks et al., 2019). Further changes involve adaptation in muscle activation and sequencing of various muscle within the trunk (Maurı´cio Antoˆnio da Luz Jr et al., 2014). The central attribute of this method involves executing exercises while engaging in isometric contractions of muscles including the transversus abdominis, pelvic floor muscles, gluteal, and multifidus, all synchronized with diaphragmatic breathing (Maurı´cio Antoˆnio da Luz Jr et al., 2014). The involvement of these muscles contributes to the stability of the lumbopelvic region (Valenza et al., 2017).

Pilates, as an exercise modality, has been increasingly applied in the treatment of individuals with lower back pain and has evolved over time. Originally characterised by rigorous exercises of elevated intensity and complexity, has transformed into what can now be termed "modified Pilates" (Maurı´cio Antoˆnio da Luz Jr et al., 2014). This adapted version tailors exercises to suit each patient's needs, progressively raising the exercise difficulty based on individual capabilities (Maurı´cio Antoˆnio da Luz Jr et al., 2014). This modified approach allows its application across diverse age groups and serves as a rehabilitative tool for many (Maurı´cio Antoˆnio da Luz Jr et al., 2014). Pilates sessions can be conducted one-on-one or in a group setting. The exercises are often done on a mat, but specialised apparatus such as a Reformer, Cadillac, Wunda Chair, and ladder barrel may also be utilised (Eliks et al., 2019). These types of equipment incorporate the use of springs and pulleys to facilitate the exercises (Maurı´cio Antoˆnio da Luz Jr et al., 2014). The perception is that Pilates mat-based routines are safer in comparison to exercises performed on an unstable foundation and are more adaptable to individual capacities (Lee, Hyun, & Kim, 2014). Nevertheless, research has indicated that equipment-based Pilates yields better outcomes, with this advantage

stemming from the enhanced sensory stimuli offered by the equipment (Eliks et al., 2019). This increased feedback is thought to significantly promote accurate execution and performance (Eliks et al., 2019).

2.5 Pilates: Mat-based vs Equipment-based (Reformer)

In a research study conducted by Lee and Colleagues that compared the effectiveness of Pilates exercises performed on mats to that of exercises performed using equipment (Lee et al., 2014). They assessed the pain intensity measured with a Visual Analog Scale (VAS) and balance measured using a balance performance monitor in a cohort of 40 businesswomen with chronic non-specific lower back pain (Lee et al., 2014). The intervention spanned 8 weeks, comprising 50-minute sessions held three times a week. Both groups experienced notable improvements in balance and pain reduction. Nevertheless, the group which engaged in Pilates mat exercises displayed greater improvement (Lee et al., 2014). However, contrasting results were discovered in a pilot study conducted by Stieglitz where they analysed whether Pilates equipment-based exercises reduces work-related chronic lower back pain and disability (Stieglitz et al., 2016). In this investigation involving 12 workers suffering from chronic non-specific lower back pain, it was observed that Pilates exercises using equipment resulted in a significant decrease in disability. Additionally, there was a reduction in the frequency, duration, and intensity of pain following the training sessions (Stieglitz et al., 2016). However, the author concluded that more researchwas required to consider Pilates equipment-based exercises as a rehabilitation tool for work-related injuries using a larger population (Stieglitz et al., 2016).

Another study conducted by da Luz and colleagues, in which they examined the effectiveness of Pilates exercises on mats and those using equipment utilising Reformer, Cadillac, Ladder

Barrel, Step Chair within a cohort of 86 individuals dealing with chronic non-specific lower back pain (Maurı´cio Antoˆnio da Luz Jr et al., 2014). The duration of the program spanned over a period of six weeks and comprised of personalised one-hour sessions conducted twice a week, overseen by a qualified physical therapist experienced in Pilates (Maurı´cio Antoˆnio da Luz Jr et al., 2014). The parameters for assessment included pain intensity measured with a Numeric Pain Rating Scale – NPRS, disability assessed with the Roland Morris Disability Questionnaire - RMDQ, overall perceived effect evaluated through the Global Perceived Effect Scale - GPE, kinesiophobia measured with the Tampa Scale for Kinesiophobia - TSK, and patient-specific disability measured using the Patient-Specific Functional Scale (Maurı´cio Antoˆnio da Luz Jr et al., 2014). Re-evaluations were conducted both after the six-week intervention and six months thereafter. Following the six - week program, a notable improvement was observed in all assessed aspects for both the mat-based and equipment-based Pilates exercise groups (Eliks et al., 2019). Although, after the six-month mark, significant differences were detected in kinesiophobia, and disability in the Pilates equipment-based group (Maurı´cio Antoˆnio da Luz Jr et al., 2014).

An additional study was conducted by Cruz-Diaz and colleagues investigated the impact of Pilates exercises performed on mats and those using equipment (specifically the Reformer) on various factors, including pain intensity (measured by VAS), disability (assessed through the RMDQ), kinesiophobia (measured with the TSK), and activation of the transversus abdominis muscle (measured as a change in muscle thickness via real-time ultrasound examination) (David Cruz-Díaza, 2017). The intervention involved 98 patients with chronic non-specific lower back pain who were divided into three groups: Pilates mat group, Pilates apparatus exercise group and a control group (David Cruz-Díaza, 2017). The program spanned over 12 weeks and took place in small groups of four participants, with 50-minute sessions held twice

a week. Evaluations were conducted at baseline, 6-week and at the end of the 12-week period (David Cruz-Díaza, 2017). Notable improvements were observed in all outcome measures for both groups at the six-week and twelve-week mark (David Cruz-Díaza, 2017). However, when comparing the groups, the study found that equipment-based Pilates exercises exhibited quicker improvement (David Cruz-Díaza, 2017). The author suggested that the feedback provided by the use of the equipment in the Pilates apparatus group could help in the assimilation of Pilates principles and therefore show superior results compared to that of mat-based Pilates (David Cruz-Díaza, 2017).

2.6 Pilates vs other exercise methods

A randomized controlled trial (RCT) was conducted by Valenza et al. (2017) and examined the effectiveness of an 8-week Pilates-based exercise programme in reducing pain (measured by a VAS), disability (assessed through the RMDQ), lumbar mobility (modified Schober's test), flexibility (finger-to-floor test) and balance (single leg stance test) in patients with chronic non-specific lower back pain (Valenza et al., 2017). The study included a total of 54 participants who were evaluated at baseline and at 8-weeks post the intervention and randomly assigned participants to either the Pilates exercise programme or to the control group who received information in the form of a leaflet (Valenza et al., 2017). The appropriate levels of difficulty - basic, intermediate, advanced were individualised and progressed accordingly to each participant's capabilities (Eliks et al., 2019). The authors found significant improvements on disability, current pain and pain at its least, flexibility and balance in the Pilates-based exercise group compared to that of the control group (Valenza et al., 2017). Similarly, Cruz-Diaz et al. (2018) conducted a randomised controlled trial of the effectiveness of a 12-week Pilates

intervention on disability, pain and kinesiophobia in individuals with chronic lower back pain with almost identical parameters, however measurements were performed at baseline, six-week and twelve-week post intervention (David Cruz-Díaz, 2018). There was a significant difference and observed improvement in the Pilates intervention group in all variables. Moreover, there was a profound change in disability and kinesiophobia observed at six weeks of the intervention however no significant difference after 12 weeks (David Cruz-Díaz, 2018).

A 2018 study systematically reviewed manipulation and mobilisation as treatments for chronic lower back pain. Moderate-quality evidence indicated that both approaches reduced pain and improved functionality. Manipulation was found to be more effective than mobilisation, with both methods considered safe and well-tolerated (Shipton, 2018).

A recent comprehensive analysis of existing literature, coupled with a meta-analysis involving individuals experiencing chronic lower back pain, revealed substantial evidence of moderate to high quality (Lam et al., 2018). This evidence suggests that the McKenzie method outperforms various other approaches such as exercise, combined manual therapy and exercise, and education being the comparator interventions to utilise as rehabilitation in terms of alleviating pain and decreasing disability (Lam et al., 2018). However, this was dependent on the type of intervention being compared to the Mckenzie method (Lam et al., 2018). When comparing mat-based Pilates to the McKenzie method, it was found that the McKenzie method and mat-based Pilates in treating individuals afflicted with non-specific chronic lower back pain were both effective as no significant statistical difference emerged between the two groups in terms of parameter outcomes (Saravanan Kuppusamy, 2013). A six-week Pilates intervention successfully reduced functional disability, lower back pain intensity, and discomfort in adults with chronic non-specific lower back pain (Saravanan Kuppusamy, 2013).

Both interventions demonstrated favourable impacts on pain reduction, disability, and trunk mobility (Saravanan Kuppusamy, 2013).

A more recent study conducted by de Oliveira et al. (2019) examined the effectiveness of the Pilates method versus aerobic exercises in the treatment of older adults with chronic lower back pain. The study included 74 participants randomised and equally divided into a Pilates Group with exercises based on the Pilates method and an Aerobic Group with treadmill aerobic exercise (de Oliveira et al., 2019). The primary measures of the study was evaluating pain intensity and overall disability, conducted eight weeks post-randomisation (de Oliveira et al., 2019). The evidence showed that through both treatment modalities, they both had the potential to alleviate pain, thereby enhancing the balance and functionality (de Oliveira et al., 2019). Although the author further stated that, Pilates might offer greater efficacy due to its targeted focus on trunk stabilisation muscles (de Oliveira et al., 2019).

Fernandez- Rodriguez et al. (2022) conducted a systematic review with a network meta-analysis of RCT's analysing best exercise options for reducing pain and disability in adults with chronic lower back pain: Pilates, strength, core-based, and mind-body (Fernández-Rodríguez et al., 2022). The study included 118 trials with a total of 9710 participants. The results showed that Pilates, mind-body exercises, and core-based exercises were the most beneficial interventions for pain reduction (Fernández-Rodríguez et al., 2022). Additionally, Pilates, strength exercises, and core-based exercises proved most effective in minimizing disability and displayed the greatest potential for diminishing both pain (93%) and disability (98%) (Fernández-Rodríguez et al., 2022). The author concluded that the most advantageous programs was engaging in Pilates exercises with a frequency of one to two sessions per week, participating in sessions lasting under 60 minutes involving strength, core-based or mind-body

exercises, and following training programs spanning from three to nine weeks (Fernández-Rodríguezet al., 2022).

2.7 Conclusion

Chronic non-specific lower back pain poses a significant challenge, affecting a substantial portion of the population and leading to considerable disability. Within the realm of therapeutic interventions, there is a significant amount of evidence supporting the effectiveness of Pilates exercises in managing and alleviating chronic non-specific lower back pain. However, a critical question remains: do Pilates reformer-based exercises surpass Pilates mat-based exercises in terms of efficacy for alleviating pain and reducing disability among individuals with chronic non-specific lower back pain? The scarcity of comprehensive research directly comparing these two exercise modalities creates a gap in our understanding of their relative benefits. This study aimsto bridge this gap by examining the differential impact of reformer-based and mat-based exercises on pain reduction and disability improvement within a tailored treatment framework for chronic non-specific lower back pain.

In conclusion, this study's primary objective is to contribute to the growing body of knowledge surrounding the management of chronic non-specific lower back pain. By focusing on the specific comparison between Pilates reformer-based and Pilates mat-based exercises, this research seeks to provide valuable insights into which exercise modality could potentially yield superioroutcomes in terms of reduction of pain and disability. The results of the research, could guide and significantly influence the way clinicians and exercise scientists approach the design of treatment plans for chronic non-specific lower back pain, ultimately enhancing the

efficacy of interventions provided to those suffering from this prevalent condition. The anticipated resultshold the potential to shed light on optimal exercise selection, contributing to the optimization of therapeutic strategies and the improvement of overall quality of life for individuals living with chronic non-specific lower back pain.

2.8 Aims

The present study primarily aims to determine the differences in the outcomes of two different Pilates exercise programmes (i.e. Pilates mat-based vs Pilates reformer-based) in terms of alleviation of pain, disability, back mobility and stability for individuals afflicted with chronic non-specific lower back pain. The secondary aim of the study is to determine if the changes in mobility and stability could influence a change in pain and disability in individuals who suffer from chronic non-specific lower back pain.

The primary objective of this study was to determine whether a six-week Pilates reformer-based exercise program led to greater improvements than a Pilates mat-based exercise program in specific areas such as pain and disability, hip strength and stability, hip flexibility and mobility, and dynamic balance in individuals with chronic non-specific lower back pain.

CHAPTER THREE: METHODOLOGY

3.1 Study design

The study was a quasi-observational trial and was conducted in the Biokinetics practice at the Sport Science Institute of South Africa, between April 2022 and October 2023.

Participants were current or previous members of the Sport Science Institute of South Africa Wellness Division (previously registered on Human Research Ethics Committees (HREC) research database – R025/2015) and were recruited via phone call and/or email. All members from mid 2019 to mid 2022 who indicatedthat they suffer from non-specific lower back pain, either during or prior to their respective programmes (that they were part of whilst being a member) which they participated in, were contacted via email and/or phone. They were asked if they would like to volunteer to take partin the study. Further recruitment efforts were completed using social media platforms such as Facebook and Instagram to facilitate more attraction to the study.

If individuals were willing to take part in the study, they received an online screening form/questionnaire (Appendix C) to determine whether they complied with the inclusion criteria. Upon being accepted into the research study, participants were required to attend a one-hour initial consultation session where the eligibility assessment as well as the physical assessment took place to measure the initial parameters of testing, including anthropometry measurements, flexibility, mobility, stability, pain, and disability ratings. In the eligibility assessment, the Physical Activity Readiness Questionnaire (PAR-Q) (Appendix D) was utilised to evaluate contraindications for exercise. This questionnaire is considered to be the

basic standard for pre-participation assessment and it serves as a valuable tool to identify individuals who may require prior medical evaluation and authorisation, as a positive response indicates the need for further examination before engaging in physical activity.

Consent was obtained by means of a signed declaration (Appendix B) during the first consultation session (baseline testing). Participants were then allocated to either Pilates mat-based group (n=14) or Pilates reformer-based group (n = 15). The duration of the programme was six weeks and consisted of bi-weekly Pilates mat-based or Pilates reformer-based sessions. At the end of the six weeks (12 sessions), all participants were re-tested on the initial testing parameters. Data was documented by researchers via a participant assessment form for pre-and post-observational measures. Only researchers and biokineticists involved in the study had access to this data and no data was provided to any other persons. All data gathered was subject to the Protection of Personal Information Act (POPIA).

Three qualified biokineticists that are competent and proficient in the selected testing battery, completed the testing protocols. Researchers were qualified biokineticists with a minimum of two years of experience practicing as a biokineticist. Baseline and post-intervention tests were completed through the same process and at the same venue.

3.2 Study participants

The study design and research on human participants was approved by the Faculty Human Research Ethics Committee (HREC Ref nr: 432/2022) of the University of Cape Town.

The study consisted of 32 participants between the ages of 25 to 60 years who had chronic non-specific lower back pain that had lasted longer than three months. Participants were allowed to have previously undergone prior chronic non-specific lower back pain treatment interventions but were prohibited from having participated in Pilates exercises during the three months prior to the study. Participants who were available and able to attend all allocated sessions to reduce non-compliance, were preferred. Participants were further required to understand both written and spoken English.

Individuals who were willing to take part in the study received an online screening form/questionnaire (Appendix C) to determine whether they complied with the inclusion criteria, namely: Aged between 25-60 years old; suffering from chronic, general, undiagnosed lower back painfor at least three months; absence of radiculopathy or other damages to the spine such as fractures, stenosis or tumors; and have not participated in Pilates exercise for the last two months.

The exclusion criteria were individuals that (i) had suffered from non-specific lower back pain for less than six months; (ii) had been diagnosed with any medical condition affecting the lumbar spine; (iii) had been pregnant or had given birth within the last six months; (iv) had undergone any surgery within the last 12 months; (v) had a history of spinal fracture or inflammatory, rheumatic, or neurological disorders; (vi) had any systemic metabolic disease, nerve root compromise; tumour; infection; osteoporosis or structural deformity. All participants were required to provide informed written consent prior to the study.

Following the online survey, participants were required to attend a one-hour initial consultation session that was conducted by a biokineticist wherein the consent form was signed and the eligibility assessment as well as the physical assessment was completed. This initial

consultation session allowed the biokineticist to collect data on participants' characteristics and information on medication and previous treatment as well as to identify the presence of any other disorders or health concerns that should be considered prior to participating in this intervention. Thereafter, the physical assessment took place to measure the initial parameters of testing, including anthropometry measurements, flexibility, mobility, stability, pain, and disability ratings.

Treatment allocation was based on the availability (days and times) of participants to attend the respective sessions. Following the initial consultation session, participants were allocated to one of two intervention groups, namely (i) Pilates mat-based group, that received treatment with exercises performed on the ground, using a mat, swiss ball, or elastic resistance bands; or (ii) Pilates reformer-based group, that received treatment with Pilates exercises on the reformer and using the reformer box, straps and a belt. This machine was created for providingresistance exercises with springs and pulleys that either can make the exercises easier or moredifficult to execute.

3.3 Detailed experimental procedure

3.3.1. General Health and Medical History Questionnaire

A pre-participation general health and medical questionnaire (PAR-Q) (Appendix D) was completed by participants in the one-hour initial consultation session to determine their risk profile for cardiovascular and metabolic diseases as well as, family medical history, chronic

medications that they are taking, whether they suffer from any other orthopaedic problems and their current physical activity status.

3.3.2 Participants pre-intervention and post-intervention assessment form

Within the one-hour consultation session, initial parameters of testing were measured, including anthropometry measurements, flexibility, mobility, stability, pain, and disability ratings. (Appendix E)

Anthropometry

Anthropometric measures (to the nearest 0.2 decimal) included height (cm) and weight (in kg, with one layer of clothes). Weight was measured using a platform scale (Pentronic A12E, Peninsula Scales, Cape Town, South Africa) and height was measured using a portable stadiometer (SECA, Hamburg, Germany). The body mass index (BMI) was calculated using weight in kilograms (kg) divided by the square of height in meters (m^2). BMI is used for defining anthropometric height/weight characteristics in adults and classifying them into categories. It is commonly understood as an indicator of an individual's fat levels and is extensively utilised as a risk factor for various health problems' occurrence or prevalence (Nuttall, 2015).

Body Fat Percentage

Body composition was measured using a skin fold caliper. The calculation of body fat percentage (%) involved measuring four skinfold sites, triceps, biceps, subscapular and

suprailiac, and substituting the log of their sum into one of the equations contained in table 1 below wherein D = predicted density of the body (g/ml), and L = log of the total of the 4 skinfolds (mm). (Durnin & Womersley, 1974) The density value was then converted to percent body fat (%BF) using the Siri equation: % Body Fat = (495 / Body Density) - 450. *Outcome variable*: Body fat %, fat mass (kg) and fat free mass (kg).

TABLE 1: Density of body equations based on age and gender

Age (years)	Equations for males	Equations for females
20-29	D = 1.1631 - (0.0632 X L)	D = 1.1599 - (0.0717 X L)
30-39	D = 1.1422 - (0.0544 X L)	D = 1.1423 - (0.0632 X L)
40-49	D = 1.1620 - (0.0700 X L)	D = 1.1333 - (0.0612 X L)
>50	D = 1.1715 - (0.0779 X L)	D = 1.1339 - (0.0645 X L)

In previous studies, the Skinfold equation demonstrated a robust level of agreement in estimating body fat percentage across all participants, particularly among women when compared to our established reference, DXA (Silveira, Barbosa, Rodrigues, Noll, & De Oliveira, 2020). However, it's worth noting that both methods tended to underestimate body fat percentage, especially in individuals, both male and female, with elevated body fat levels (Silveira et al., 2020). Notably, a high level of agreement was observed between DXA and the anthropometric equation developed by Durnin and Womersley in men, showcasing a strong concordance (Silveira et al., 2020). This potential limitation may impact the effectiveness of the mentioned method and therefore, we are incorporating it in combination with the BMI values.

Hip Stability Tests

Bridge with Leg Extension(BwLE): The BwLE is a test for stability in the pelvis/lumbar spine/core and especially in the gluteal muscles (Ferrari, Manni, Bonetti, Villafañe, & Vanti, 2015). A positive test is seen when a participant drops the contralateral hip or the hip with the raised leg, thus indicating weakness in the ipsilateral hip or the leg that the weight is being placed on (Ferrari et al., 2015). A positive test indicates inhibition of the glutes and recruitment of the synergistic muscles if either the hamstrings or lower back starts to cramp (Ferrari et al., 2015).

Participants began in the supine position with their knees bent and their feet flat. Participants' knees and feet were placed hip width apart and their arms placed across their chest or next to their body on either side. Participants were asked to raise their pelvis/buttocks off the ground. They were then instructed to maintain a level pelvis along the belt line, which is parallel to the floor and were thereafter asked to raise and extend their one leg off the floor. Participants were required to hold this position for a minimum of five seconds and then asked to alternate their leg, maintaining this position for a minimum of five seconds. *Outcome variable:* If there was a noticeable drop in the contralateral hip or the hip with the raised leg, it was noted as a positive and if there was no drop, it was noted as negative.

Trendelenburg Test: A Trendelenburg sign is a physical examination finding seen when assessing for any dysfunction of the hip (McCarney et al., 2020). A positive Trendelenburg sign usually indicates weakness in the hip abductor muscles consisting of the gluteus medius and gluteus minimus (McCarney et al., 2020). A positive sign is defined by a

contralateral pelvic drop during a single leg stance. The test has been shown to be a valuable part of a testing protocol to test strength of the hip abductors (Grimaldi, 2011). Participants were required to stand on one leg for 30 seconds without leaning to one side or dropping the opposite hip and alternating to the opposite side. *Outcome variable:* If there was a contralateral pelvic drop or if there was leaning to one side, it was noted as a positive and if there was no drop or leaning, it was noted as negative.

In a prior study, the test-retest reliability coefficients was greater than 0.75 for the Trendelenburg score and Cronbach α coefficient for internal consistency of the Trendelenburg tests was greater than 0.73 (Roussel, Nijs, Truijen, Smeuninx, & Stassijns, 2007). It's noteworthy that the test displayed a high level of internal consistency suggesting that the test effectively evaluates the same dimension, specifically, the force-transducing mechanisms of the lumbopelvic region (Roussel et al., 2007).

Individual item scores were then summated to provide a total score out of 4 which was referred to as "total stability", with higher scores reflecting greater dysfunction in hip stability. Once scores were calculated, these were divided into two qualitative categories of good stability (score = 0 - 1) and weak stability (score = 2 - 4).

Hip Flexibility and Mobility Tests

Flexibility Tests: The Sit-and-Reach test measures the flexibility of the lower back and the hamstring muscles (Mier & Shapiro, 2013). Participants were required to sit barefoot on the floor with their legs straight in front of them. Participants were then required to place their feet flat against the box, shoulder-width apart, with the zero mark at 26 cm.

Both knees were required to be kept on the floor and should not bend. Participants were required to (i) place their hands on top of each other with their palms facing down, and (ii) reach forward on the surface of the box along the measuring scale, without bending their knees. Participants were required to hold this position for a minimum of two seconds. An average of three attempts was recorded as the final score.

In prior studies, the sit-and-reach tests, when considered collectively, exhibit a moderate mean criterion-related validity in gauging hamstring extensibility and their mean validity for estimating lumbar extensibility is comparatively low (Mayorga-Vega, Merino-Marban, & Viciana, 2014). However, within the spectrum of sit-and-reach test protocols, it appears that the classic sit-and-reach test (done in this study) stood out as the most effective option for estimating hamstring extensibility (Mayorga-Vega et al., 2014).

Active Straight leg raise Test: The Active Straight Leg Raise (ASLR) is a test used to assess load transference through the pelvis. It is also an important test used to diagnose pelvic girdle pain. However, for this research, the ASLR was used to measure hamstring tightness and pelvic mobility (Camino Willhuber & Piuzzi, 2023). Restricted flexibility in the hamstrings will contribute to lower back, pelvis, hip, and knee malalignment (Camino Willhuber & Piuzzi, 2023). The ASLR focuses on proximal hamstring tightness (Camino Willhuber & Piuzzi, 2023). The test was performed actively. Participants were required to be in the supine position with their hips and knees extended and their pelvis in a neutral position. Participants were required to lift their one leg as high as possible whilst keeping the knee straight and ensuring that the alternate leg remains on the plinth. The biokineticist measured the greatest angle of hip flexion immediately before the knee begins to bend or the alternate leg on the plinth lifts. This measure was taken using a goniometer.

In a prior study mentioned above, the test-retest reliability co-efficients were greater than 0.70 for the ASLR score and the Cronbach coefficient for internal consistency of the ASLR tests was greater than 0.73 (Roussel et al., 2007). The internal consistency of the outcome of this test was notably strong indicating that this test is evaluating the identical dimension, specifically, the force-transducing mechanisms of the lumbopelvic region (Roussel et al., 2007).

Disability and Pain index

Roeland-Morris Questionnaire: Participants were asked to complete the Roland-Morris Questionnaire (Appendix F) wherein they rated their degree of functionality of their spine. The Roland-Morris Disability Questionnaire (RMDQ) was first published in 1983 and is designed to assess self-rated physical disability caused by lower back pain (Roland & Morris, 1983). The Questionnaire is most sensitive for patients with mild to moderate disability due to acute, sub-acute or chronic low back pain (Roland & Morris, 1983). The Questionnaire is a self-administered disability measure wherein greater levels of disability are reflected by higher numbers on a 24-point scale. The Questionnaire comprised of 24 questions that would give participants the degree of disability in their spine. Participants were asked to tick a statement when it applies to them on the specific day, and this allowed us to follow changes in time. *Outcome variable:* Each question is a single score, and the total is the sum of the ticked boxes out of 24. Once scores were calculated, these were divided into two qualitative categories of low disability (score =0 - 3) and high disability (score =4 - 24).

In a research study, Macedo et al. (2011) examined various studies to assess the reliability, internal responsiveness of the test by assessing its capacity to detect changes over time as well as external responsiveness, examining the relationship between RMDQ results and those obtained through the Global Perceived Effect Scale (GPE scale) of the 24-, 18-, and 11-item RMDQ. The findings revealed that the test-retest reliability results for the 24-item RMDQ, the intraclass correlation ranged from 0.42 to 0.91. being slightly less superior to that of the 11-item RMDQ (Macedo et al., 2011). However, when utilising effect sizes as a metric for internal responsiveness and the Pearson's correlation coefficients with the GPE scale, the results for the 24-item version were superior to the rest with the effect size ranging from 0.63 to 0.71. and the correlation ranging from 0.45 to 0.54. respectively (Macedo et al., 2011).

Numerical Pain Rating Scale: Participants were asked to rate their pain from zero to ten on four questions, with ten being the worst pain imaginable and zero being no pain at all. (Appendix G) This is a subjective measure used to gauge the intensity of a participant's lower back pain in the specific moment, their usual level of pain during the last week, their best level of pain during the last week and their worst level of pain during the last week. *Outcome variable*: Each question is a score rating out of 10, and the final score calculated by taking the average of the 4 questions to a total score out of 10. Once scores were calculated, these were divided into two qualitative categories of low pain score (score =0 - 3), high pain score (score = above 3).

Prior investigations have encountered challenges in utilizing this approach to gauge pain levels in individuals with chronic lower back pain, primarily attributed to the fluctuations in experienced symptoms (Hush, Refshauge, Sullivan, De Souza, & McAuley, 2010). This

could present a constraint for the mentioned method; hence, we are employing it in conjunction with the previously described Roland-Morris Disability Questionnaire.

3.4 Interventions:

Each participant underwent interventions guided by the principles of Pilates. The sessions lasted approximately 45 minutes and were administered twice a week for a period of six weeks at the Biokinetics practice at the Sport Science Institute of South Africa.

3.4.1 Pilates mat-based

The Pilates mat-based sessions were performed in groups of a maximum of four to five participants and was facilitated by a qualified biokineticist. During the first session, participants were trained to activate the powerhouse that represents the isometric contraction of the transversus abdominis, perineal, gluteal, and multifidus muscles during diaphragmatic breathing (Mauru´cio Antoˆnio da Luz Jr et al., 2014). In the sessions that follow, participants began withthe specific aforementioned exercises and thereafter, perform an average of ten to 12 exercisesper session, depending on the limitations of each participant. Where a participant could not perform a particular exercise, the exercise was adapted and modified and where modificationswere not possible, the exercise was substituted for another exercise, with a similar objective. The level of difficulty for each exercise was set according to participants' needs and were increased as participants learnt how to perform each exercise correctly, without postural compensation and pain. This was done for example, by increasing the number of repetitions,by increasing the range of motion, as well as by manipulating the exercise with resistance bands, weights, and balls. The exercises were performed independently by each

participant. The mat-based exercises that were completed during both six-week programme, are containedin table 2 below.

3.4.2 Pilates reformer-based

The Pilates reformer-based sessions were done in one-on-one settings due to the limitation of machinesavailable and is noted as a limitation of the study. During the first session, participants were trained to activate the powerhouse, that represents the isometric contraction of the transversus abdominis, perineal, gluteal, and multifidus muscles during diaphragmatic breathing (Maurı´cio Antoˆnio da Luz Jr et al., 2014). In the sessions that followed, all participants began with the specific aforementioned exercise. Thereafter, an average of eight to ten exercises were performed each session, depending on the limitations of each participant. All exercises were adapted and modified by using the spring system that varies the resistance and the intensity of exercises. The level of difficulty of each exercise was set according to participants' needs and was increased as participants learnt how to perform each exercise correctly and without postural compensation and pain. This was done for example, by increasing the number of repetitions, by increasing the range of motion as well as by manipulating the exercise with resistance springs, resistance bands, balls, and step chair. The exercises were performed independently by each participant. The Pilates reformer-based exercises that was completed during both six-week programmes, is noted in table 2.

TABLE 2: Comparison of Pilates Mat-Based Group vs. Pilates Reformer-Based Group Programme Exercises.

Mat-based exercises	**Reformer based exercises**
Mobility and warm up	Mobility and warm up
Diaphragmatic breathing	Diaphragmatic breathing
Windshield wipers*	Pelvic tilting
Pelvic tilting	Back press with core activation
Roll downs*	Back press with belt
Push up plus	Windshield wipers
Activation core	Push down series with core activation
TA activation with breathing	Push downs with legs at table top
TA activation with marches	Push down table-top marches
Slow crunch with breathing	Push down lateral crunch
Bear plank*	Push down table-top single leg extension
TA activation with abduction (band)	Push down table-top toe taps
Bicycle crunch	Push down with triceps extension
Toe taps	Push down seated rows
Full plank hold	
Side-lying series	Side-lying series
Clam shells	Clam shells
Side lying abduction	Clam shells with band
Inner thigh lifts*	Side lying abduction with circles
Side lying abduction with circles	Side lying strap kick
Oblique crunch	Side lying strap kick with circles
Tweezers*	Side plank kick backs
4 point kneeling	4 point kneeling on the step box
Cat cow stretch	Cat cow stretch
Bird-dog, just arms/just legs	Bird-dog, just arms/just legs
Bird dog arms and legs*	Bird dog arms and legs
Kick backs	Kickbacks with pulses
Fire hydrants	Kickbacks with the strap
Side plank modified	Kick back and circles with strap
Supine bridge	Supine series
Bridge-correct form	Leg press, Leg press with calf raises
Pulses	Single leg- leg press
Hamstring variation (walk forward)	Bridge using the bar
TA activation with adduction (ball)	Bridge using bar abductions/adductions
	Single leg bridge
	Bridge with leg press
Supine core	Core work
Hundreds (feet down) Toe taps	Figure 4 cross crunch*
Crunch series with rotation	Tall kneeling anti rotational press
Marches in tabletop	Tall kneeling chest press/ straight arm
	Box crunch hold with assisted belt-feet
	Fury plank hold
	Plank series “fly wheel” using bar-knees
	Plank series fly wheel using bar-feet

Prone	Standing series using the reformer
T's and W's	Step box standing & bent over lunges
T's and W's with weights	Standing side lunges
Stretch and cool down	Stretch and cool down
Figure 4 Supine twist	Figure 4 Window wipers
Seated stretches (lateral flexion)	Childs pose hands side-side
Childs pose hands side-side*	Arm stretches

*Note: * The exercises with an Asterisk to it, will be illustrated by a picture in appendix H.*

3.1 Statistical data analysis

Prior to the study sample size was calculated at n=16 per group. Within the study period the researchers of this study managed to recruit a total sample size of n=29, Pilates mat-based group had a sample size n=14 and the Pilates reformer-based group n=15. For the achieved sample size, with the focuson a large effect size, the result of statistical significant differences among interventions yieldeda statistical power of 0.546.

The data underwent a series of statistical tests for comprehensive exploration. Normality tests (Shapiro-Wilk test assessed is data was normally distributed, Chi-squares: test of two proportions examined possible frequency differences among groups, examined categorical variables. Independent t-tests identified differences between independent groups on continuous outcome variables, and McNemar tests assessed paired categorical data. For analysing variations in outcomes over time between groups, two-way mixed ANOVA for repeated measures tests were applied. Binomial regression analyses explored the impact of predictor variables on binary outcomes. Mann-Whitney U tests were utilised for non-parametric data. Categorical descriptive outcomes were assessed for differences using the Fisher Exact Statistic

when the expected count for all proportions was < 5. Additionally, to assess variations in outcomes between groups over time, the study employed the two-way mixed with repeated measures ANOVA or its non-parametric alternative, the Friedman test.

Participants who dropped out before completing the full six weeks were excluded from subsequent data analyses, and this dropout rate was documented as one of the study outcomes. Multiple linear regression analyses were performed to examine whether any of the independent variables—such as age, gender, BMI, and changes in stability and mobility—could account for the variations in the dependent variables, namely, pain and disability. The data was analysed using, IBM SPSS statistical software version 28.0.1.1 (Chicago, Illinois, USA), with a significance level set at $\alpha = 0.05$.

CHAPTER 4: RESULTS

4.1 Baseline Outcomes: Physical characteristics

A total of 32 participants experiencing chronic non-specific lower back pain participated in the study. Following initial screening, 2 participants were excluded based on not them meeting the inclusion criteria for the study due to a diagnosed spinal pathology and 1 participant dropped out of the study. Demographic characteristics of the remaining participants are detailed in Table 3. Notably, both groups exhibited similar demographic profiles, ensuring a comparable baseline for subsequent analyses.

TABLE 3: Baseline Characteristics of Physical Characteristics in the Pilates Mat-Based Group and Pilates Reformer-Based Group (n=29).

	Pilates Mat-based Group (n=14)	**Pilates Reformer-based Group (n=15)**	**Mean Diff**	**SE of Diff**	**t.**	**Sig.**
Age (yrs)	41.86 ± 9.32	39.73 ± 10.67	2.12	3.7	0.57	0.57
Sex			0.02	0.17	0.11	0.91
Female	10 71.4%	11 73.3%				
Male	4 28.6%	4 26.7%				
Weight (kg)	73.93 ± 5.23	78.23 ± 11.83	-4.30	5.04	-0.85	0.40
Height (cm)	169 ± 8.6	169 ± 0.7	0.00	0.03	-0.03	0.98
BMI (kg/m2)	25.66 ± 4.36	27.33 ± 4.55	-1.67	1.66	-1.00	0.32
Body fat (%)	31.18 ± 9.05	31.41 ± 8.84	-0.23	3.32	-0.07	0.95

Note: The categorical variables are expressed as n (%) and the continuous variables are expressed as mean (sd) Diff = Difference

Both the Pilates mat-based group (71.4%) and the Pilates reformer-based group predominantly consisted of femaleparticipants. There was no difference in the distribution of gender between the Pilates mat-based group(71.4%) and the Pilates reformer-based group (73.3%, $p = 0.91$). In terms of age and body fat percentage, both variables demonstrated normal distribution according to the Shapiro-Wilks test ($p > 0.05$).Additionally, there was homogeneity of variance for age ($p = 0.37$) and body fat percentage ($p= 0.94$) between the two groups, as assessed by Levene's test for equality of variances. There was no significant difference between age and body fat percentage between the two groups at baseline testing. A Mann-Whitney U test was employed to assess differences in BMI betweenthe Pilates reformer-based group and the Pilates mat-based group. Visual inspection indicated unequal distributionsof BMI for both groups. However, the BMI for the Pilates mat-based group (mean rank = 13.43) and Pilates reformer-based group (mean rank = 16.47) did not exhibit statistically significant differences (U = 127, $p = 0.35$). The mean BMI for both groups indicated an average overweight classification. No significant differences were observed between the two groups for the variables of age, body fat percentage, and BMI.

The test of two proportions used was the chi-square test of homogeneity. At baseline, 42,9% of participants in the Pilates mat-based group had a chronic condition compared to that of 73.3% in the Pilates reformer-based group, a non-statistically significant difference in proportions. ($p = 0.09$) The Pilates mat-based group attended an average of 9 ± 2 sessions out of the 12 scheduled (75%), a slightly lower attendance rate compared to the Pilates reformer-based group, which averaged 10 ± 2 sessions (83%).No statistical significant differences were observed between the two groups for their attendanceand adherence. ($p = 0.05$)

4.2 Baseline Outcomes

TABLE 4: Baseline Characteristics of Performance Variables in the Mat-Based and Pilates Reformer-Based Group (n=29).

	Pilates Mat-based Group (n=14)	**Pilates Reformer-based Group (n=15)**	**Mean Diff**	**SE of Diff**	**t**	**Sig.**
Disability - RMDQ	4.57 ± 3.92	4.67 ± 3.18	-0.03	0.19	-0.17	0.86
No disability	7 50%	7 46.6%				
Disability	7 50%	8 53.3%				
Pain – NPRS	4.71 ± 1.39	4.20 ± 1.47	0.19	0.16	1.19	0.25
Low	2 14.3%	5 33.3%				
High	12 85.7%	10 66.7%				
Stability	2.29 ± 1.07	1.60 ± 1.45	0.38	0.18	2.14	0.04*
Good Stability	4 28.6%	10 66.7%				
Weak Stability	10 71.4%	4 33.3%				
Sit & reach avg (cm)	28.25 ± 15.17	26.17 ± 9.23	2.08	4.63	0.45	0.66
ASLR (degrees)	76.11 ± 16.53	74 ± 12.79	2.11	5.47	0.39	0.70

Note: The categorical variables are expressed as n (%) and the continuous variables are expressed as mean(sd) Diff = Difference; RMDQ: No disability = score of 3 and below; disability = score of above 3; NPRS: low = score of 3 and below; high = score of above 3. Asterisk: means it is a significant p value<0.05*

4.2.1 Pain and disability

As seen in table 4, at baseline testing, 85.7% of the Pilates mat-based group had a high NPRS compared to that of the Pilates reformer-based group (66.7%). Due to small sample sizes, Fishers exact test was run. There was nota statistically significant difference in proportions, $p = 0.86$. A Mann-Whitney U test was run to determine if there were differences in NPRS score between the Pilates reformer-based group and the mat-based group. Distributions of the NPRS scores for the Pilates reformer-based group and the Pilates mat-based groupwere similar, as assessed by visual inspection. Median NPRS scores for the Pilates reformer-based group

(4.75) and the Pilates mat-based group (4.87) were not statistically significantly different, U = 85.5, p = 0.40, using an exact sampling distribution for U.

The chi square test of two proportions was conducted between the 2 intervention groups and the individuals disability scores based on the RMDQ. All expected cell frequencies were greater than 5. At baseline testing, the Pilates mat-based group (50%) as well as the Pilates reformer-based group (53.3%) showed similar results when assessing disability based on their RMDQ scores. There was no statistical significant difference between intervention groups and their disability scores.(p = 0.86) A Mann-Whitney U test was run to determine if there were differences in RMDQ score between the Pilates reformer-based group and the Pilates mat-based group. Distributions of the RMDQ scoresfor the Pilates reformer-based group and the Pilates mat-based group were similar, as assessed by visual inspection. Median RMDQ scores for Pilates reformer-based group (4.00) and the Pilates mat-based group (3.50) was not statistically significantly different, U = 110.50, p = 0.81, using an exact sampling distributionfor U.

4.2.2 Mobility

There was homogeneity of variances, as assessed by Levene's test for equality of variances, for both mean sit and reach results and average left and right active straight-leg-raise (ASLR) results for the Pilates mat-based group and Pilates reformer-based group, respectively. (p = 0.07, p = 0.80) There was no statistically significant difference in sit-and-reach baseline results between the Pilates mat-based group and Pilates reformer-based group, p = 0.67. Similarly, there was also no statistically significant difference in the ASLR average results as seen in table 4. (p = 0.70)

4.2.3 Stability

Indicated in table 4, a higher proportion of individuals showed a positive Trendelenburg test result at baseline in the Pilates mat-based group compared to that of the Pilates reformer-based group. Specifically, on the left side, the Pilates mat-based group displayed a positive test percentage of 28.6%, slightly lower than that of the Pilates reformer-based group's percentage of 33.3%. (p = 0.55) Conversely, for the right side, there was a statistical significant difference between the two groups where the Pilates mat-based group exhibited a positive test percentage of 64.3%, while the Pilates reformer-based group reported a lower percentage of 20.0% (p = 0.02).

A 11% higher proportion of individuals showed a positive BwLE test result at baseline in the Pilates mat-based group compared to that of the Pilates reformer-based group. Specifically, when assessing the leftside, the Pilates mat-based group displayed a positive test percentage of 64.3%, whereas the Pilates reformer-based group showed a lower percentage at 53.3%. (p = 0.55) Similarly, for the right side, the Pilates mat-based group demonstrated a positive test percentage of 71.4%, while the Pilates reformer-based group reported a lower percentage of 53.3%. (p = 0.32)

The test of two proportions used was the chi-square test of homogeneity. There was a statistically significant greater distribution of individuals who had good stability in the Pilates reformer-based group compared to that of the Pilates mat-based group. Sixty-seven percent of individuals in the Pilates reformer-based group had good stability whereas in the Pilates mat-based group, only 28.6% of individuals had good stability based on their performance in the Trendelenburg test and BwLE test. (p = 0.04)

The chi square test of association was conducted between the 2 intervention groups and the individual's stability scores. All expected cell frequencies were greater than 5. There was a statistically significant association between intervention groups and their stability scores. (p = 0.04)

4.3 Changes over time

4.3.1 Pain and Disability

NPRS scores were normally distributed at baseline ($p > 0.05$) except for at the end of the intervention ($p < 0.001$) as assessed by the Shapiro-wilks test of normality on studentised residuals. (Violation on normality). Sphericity assumed. No statistically significant two-way interaction effect was observed between group and time ($p > 0.05$), indicating that the changes over time did not significantly differ between the groups. Nevertheless, a significant main effect for time was observed ($p < 0.001$), showing that there were overall changes across both groups.

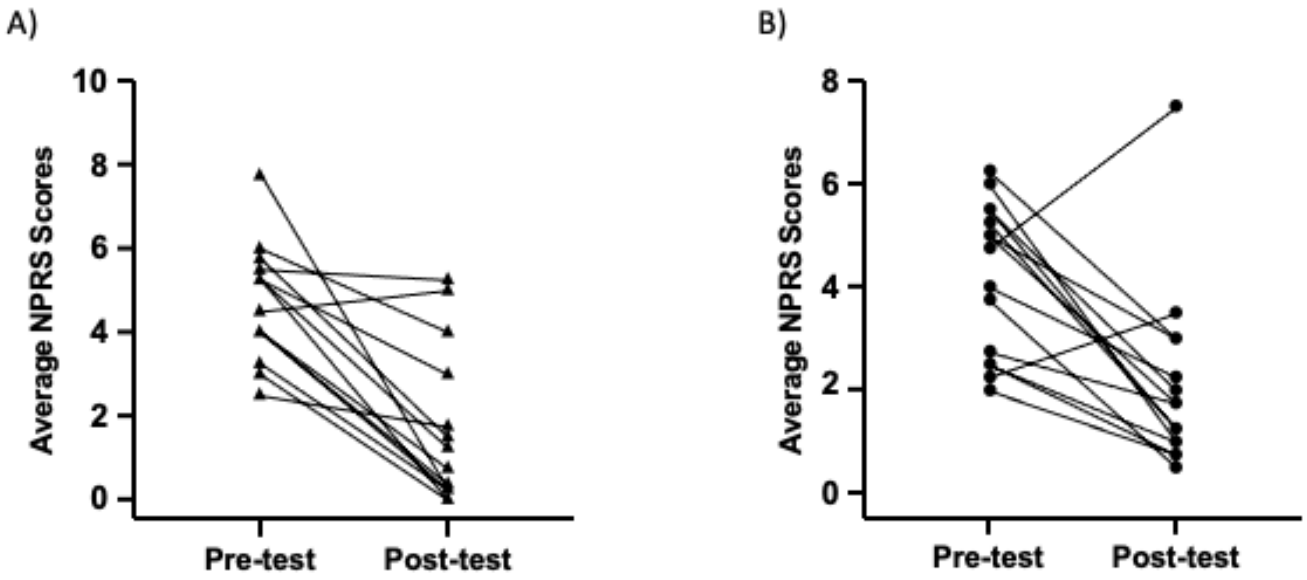

FIGURE 1: Pre- and Post-intervention Pain Scores. A) Pilates Mat-Based Group: Average NPRS Scores Before and After Intervention (n=14). B) Pilates Reformer-Based Group: Average NPRS Scores Before and After Intervention (n=15).

RMDQ scores were normally distributed as assessed by the Shapiro-wilks test of normality on the studentised residuals. Sphericity assumed. No statistically significant group by time interaction effect was observed ($p > 0.05$), indicating that the type of Pilates did not have a differential impact across time points. However, a significant main effect for time emerged, showing that there were overall changes in RMDQ scores across both groups. ($p = 0.001$).

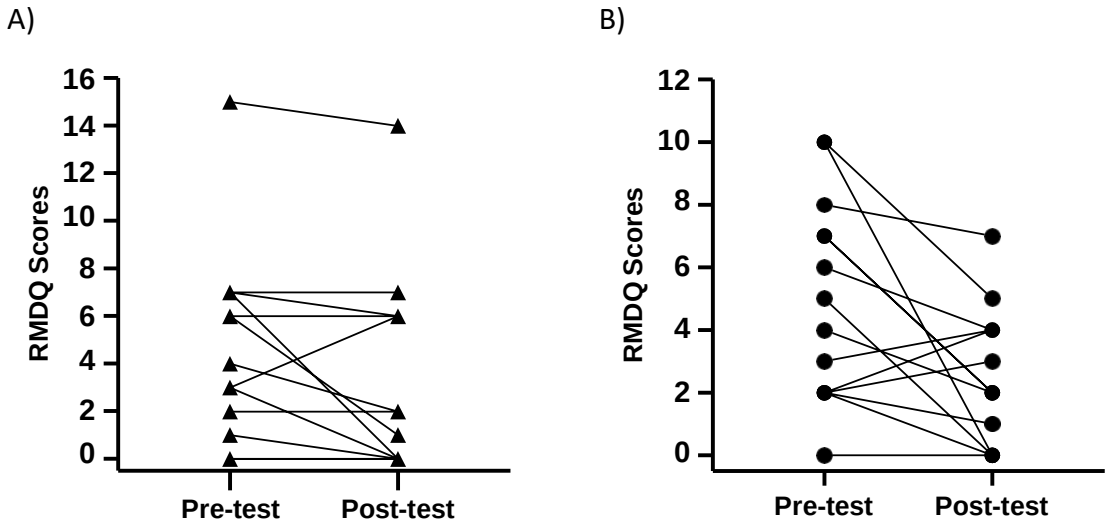

FIGURE 2: Pre-intervention and Post-intervention Disability Scores. A) Pilates Mat-Based Group: Average RMDQ Scores Before and After Intervention (n=14). B) Pilates Reformer-Based Group: Average RMDQ Scores Before and After Intervention (n=15).

4.3.2 Mobility

Mean sit-and-reach scores were normally distributed by the Shapiro-wilks test ($p > 0.05$). There was homogeneity of variances, as assessed by Levenes test of homogeneity. ($p > 0.05$) There was homogeneity of co-variance as assessed by Box's test of equality of co-variance matrices ($p = 0.30$).

No statistically significant interaction effect on mean sit-and-reach scores was observed ($F = 0.50$, $df = 1$, $p = 0.49$, sphericity assumed), indicating that the impact of the intervention did not vary significantly across different Pilates interventions. Furthermore, the main effect of time revealed no statistically significant difference in mean sit-and-reach scores at various time

points (F = 3.13, df = 1, p = 0.09, sphericity assumed), suggesting that, overall, there were no substantial changes in scores over the duration of the study. Additionally, the main effect for group demonstrated that there was no statistically significant difference in mean sit-and-reach scores between intervention groups (F = 0.07, df = 1, p = 0.80, sphericity assumed), highlighting the absence of group-related variations in the

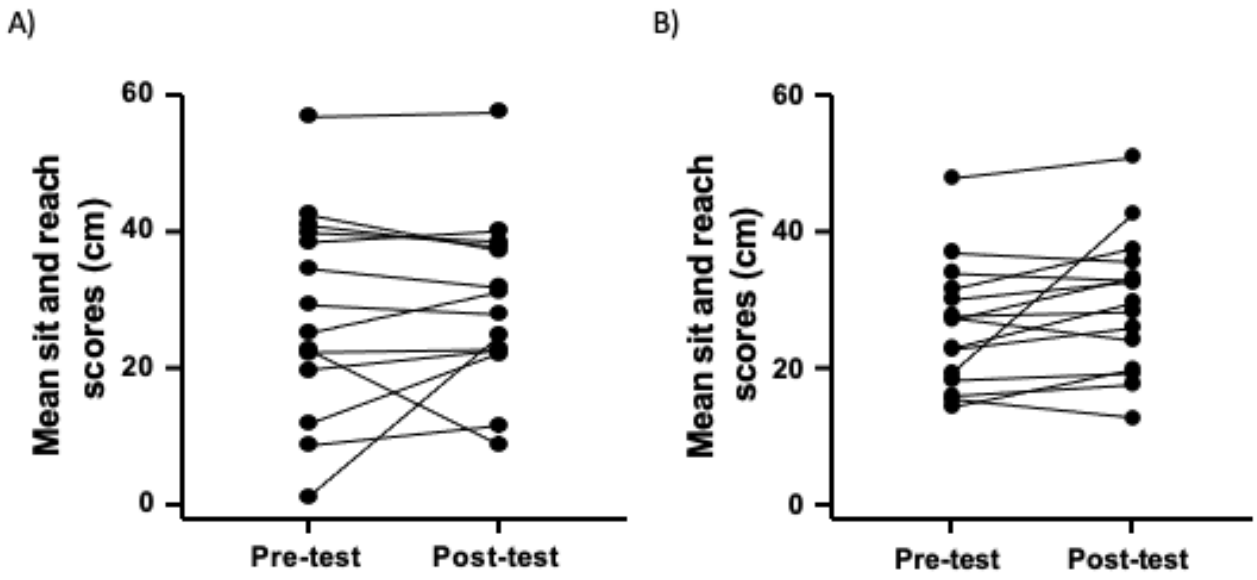

FIGURE 3: Pre-intervention and Post-intervention Sit-and-reach Scores. A) Pilates Mat-Based Group: Average Sit-and-Reach Scores Before and After Intervention (n=14). B) Pilates Reformer-Based Group: Average Sit-and-Reach Scores Before and After Intervention (n=15).

The normality assumption for ASLR was not met, confirmed by Shapiro-Wilk's test. Despite non-normal distribution, there was no statistically significant interaction effect on ASLR scores (F = 0.10, df = 1, p = 0.76, sphericity assumed). However, the main effect of time indicated a statistically significant difference in ASLR scores at different time points (F = 8.15, df = 1, p = 0.008, sphericity assumed), suggesting changes over time irrespective of groups.

For cases where the change was not normally distributed, a non-parametric test (Friedman) was employed, but this did not result in a significant difference in the change between the two groups.

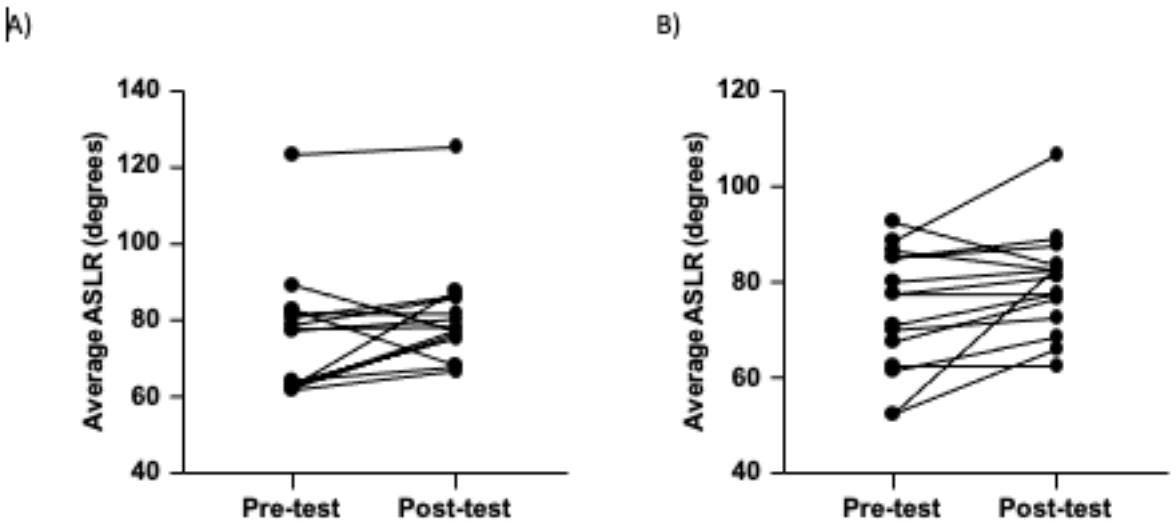

FIGURE 4: Pre-intervention and Post-intervention Active Straight-Leg-Raise Scores. A) Pilates Mat-Based Group: Average Active Straight-Leg-Raise Scores Before and After Intervention (n=14). B) Pilates Reformer-Based Group: Average Active Straight-Leg-Raise Scores Before and After Intervention (n=15).

4.3.3 Stability

Upon analysis using McNemar tests, it was determined that both left and right Trendelenburg tests exhibited non-significant results This suggests that there were no statistically significant differences in the outcomes of these tests between the two intervention groups as shown in figure 5. ($p > 0.05$)

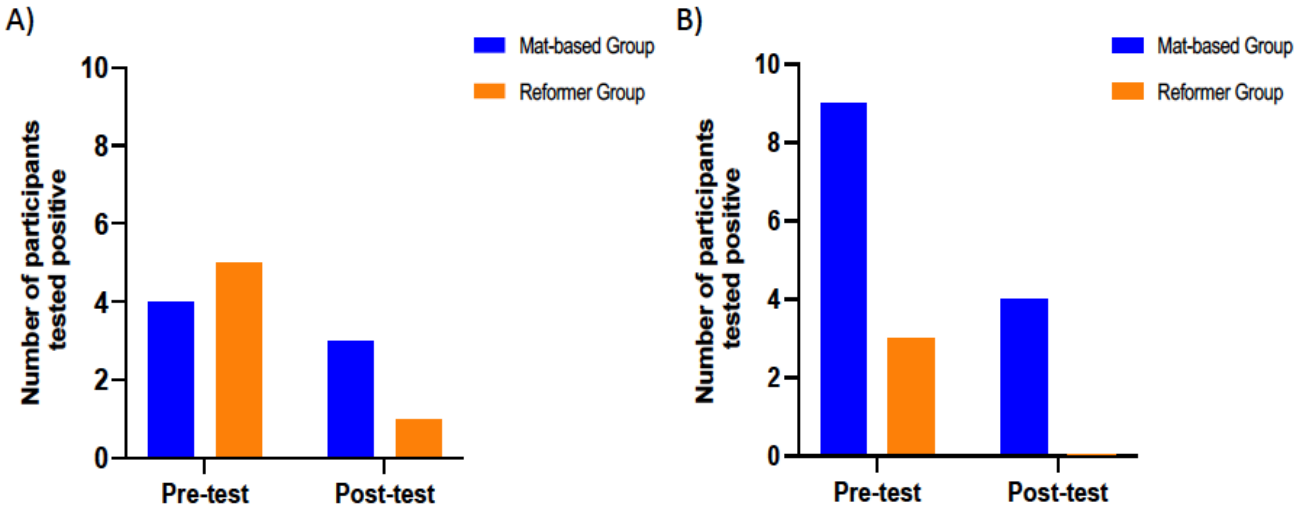

FIGURE 5: Pre-intervention and Post-intervention Positive Trendelenburg Test Outcomes. A) Comparison of Positive Test Outcomes for Left-side Trendelenburg Before and After Intervention: Pilates Mat-Based Group vs Pilates Reformer-Based Group (n=29). B) Comparison of Positive Test Outcomes for Right-side Trendelenburg Before and After Intervention: Pilates Mat-Based Group vs Pilates Reformer-Based Group (n=29).

Examining the McNemar tests revealed non-significant results for the left and right BwLE tests. This suggests that there were no statistically significant differences in the outcomes of these tests observed between the two intervention groups ($p > 0.05$), as shown in Figure 6.

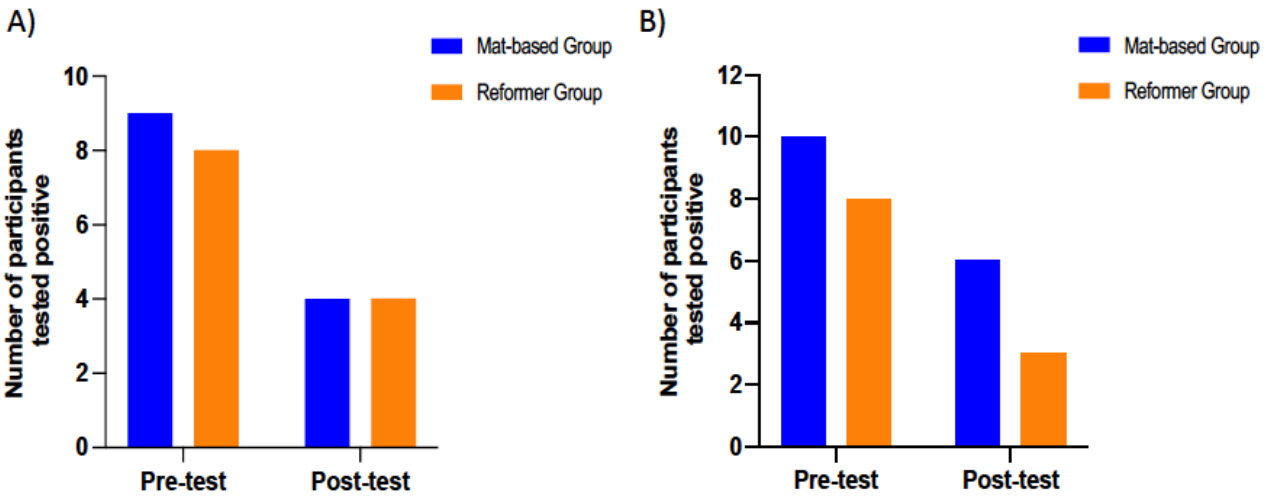

FIGURE 6: Pre-intervention and Post-intervention Positive Bridge and Leg Extension Test Outcomes. A) Comparison of Positive Test Outcomes for Left-side Bridge and Leg Extension Before and After Intervention: Pilates Mat-Based Group vs Pilates Reformer-Based Group (n=29). B) Comparison of Positive Test Outcomes for Right-side Bridge and Leg Extension Before and After Intervention: Pilates Mat-Based Group vs Pilates Reformer-Based Group (n=29).

4.3.4 Factors influencing Post-Intervention Pain and Disability

Multivariate linear regression model (Table 5) was conducted to determine the influence of independent factors: Baseline pain level, change in ASLR, change in Sit-and-Reach, and change in total stability on the dependent variable, change in pain level (NPRS score), irrespective of the type of intervention.

The Model could significantly contribute to the variance in change in NPRS, but only baseline NPRS score significantly contributed ($P < 0.001$) to the change in NPRS over the six weeks.

TABLE 5: Multiple regression of the change in NPRS (n=29).

	B	***SE B***	β	**T**	**SIG.**	**R^2**	**Adj R^2**
Model					<0.001	0.937	0.927
Constant	-0.280	0.268		-1.046	0.306		
BA NPRS Scores	1.008	0.055	0.986	18.187	***<0.001***		
Sit & reach Diff	0.009	0.012	0.045	0.774	0.447		
ASLR Diff	0.007	0.009	0.048	0.812	0.425		
Stability Diff	0.041	0.172	0.013	0.238	0.814		

Note: MS= modal significance; B = Unstandardized regression coefficient; SE B = standardized error of the coefficient; β = standardised coefficient; R^2 = coefficient of determination; Adj R^2 = adjusted R^2 ; BA = Baseline Average; Diff = Difference, Bold and Italics:means it is a significant p value<0.05.

Multiple linear regression model (Table 6) was conducted to determine the influence of independent factors: Baseline disability level, change in ASLR, change in Sit-and-Reach, and change in total stability on the dependent variable, change in disability level (RMDQ score), irrespective of the type of intervention.

The model failed to significantly explain a change in RMDQ, except for baseline RMDQ which significantly contributed to the change in RMDQ over the six-week intervention period.

TABLE 6: Multiple Regression of Change in RMDQ (n=29).

	B	***SE B***	β	**T**	**SIG.**	**R^2**	**Adj R^2**
Model					0.057	0.308	0.192
Constant	-0.122	0.813		-0.150	0.882		
BA RMDQ Scores	0.331	0.153	0.408	2.162	***0.041***		

Sit & Reach Diff	0.080	0.074	0.209	1.090	0.287
ASLR Diff	-0.011	0.057	-0.037	-0.191	0.850
Stability Diff	1.253	1.199	0.201	1.045	0.306

Note: B = Unstandardized regression coefficient; SE B = standardized error of the coefficient; β *= standardised coefficient;* R^2 *= coefficient of determination; Adj* R^2 *= adjusted* R^2 *;BA = Baseline Average; Diff = Difference, Bold and Italics:means it is a significant p value<0.05.*

CHAPTER 5: DISCUSSION

This study sought to determine whether Pilates reformer-based exercises demonstrate greater efficacy in alleviating pain; reducing dysfunction and disability when compared to Pilates mat-based exercises as part of a 6-week intervention for individuals suffering with chronic non-specific lower back pain. The results showed that one intervention group was not more beneficial or superior to the other intervention group, however, a significant reduction in pain and disability, along with improvements in mobility and stability, irrespective of the intervention group was found. In a systematic review conducted by Wells and colleagues (2014), short- term Pilates interventions ranging from 4 to 15 weeks, with sessions occurring one to three times per week for 60 minutes each, demonstrated statistically significant improvements in pain based on the VAS or NPRS scale in three out of four Randomized Controlled Trials (RCT's), with the fourth RCT indicating no clinically meaningful difference (Wells, Kolt, Marshall, Hill, & Bialocerkowski, 2014). Similarly, within the scope of the same studies, concerning disability or functional ability, three high-quality RCTs reported statistically significant improvement inshort-term Pilates interventions lasting from four to twelve weeks. However, in the same systematic review, two high quality RCT's did not observe this effect (Wells et al., 2014). Within the context of treatment, both Pilates methods were effectively and adequately administered. One such reason validating the latter is the adherence rate for both groups during the interventions.Both groups underwent a comparable number of sessions for similar durations, with 76% of participants attending nine or more out of the twelve sessions, representing over three-quarters of sessions attended. Specifically, 71% of participants in the Pilates mat-based group and 80% of participants in the Pilates reformer-based group attended nine or more sessions out of the total twelve, consequently resulting in an overall decrease in pain and disability, as well as improved stability and mobility outcomes.

Most baseline measures with regards to gender, age, body fat percentage, BMI, pain, disability, mobility, and stability measures, including bridge with leg extension (BwLE) tests on both sides and the left-side Trendelenburg test revealed similar distributions between the two groups at the outset of the study except for the right-side Trendelenburg test and overall total stability. A higher percentage of participants in the Pilates mat-based group (60%) showed weaker stability during the Trendelenburg test on the right side (Fisher exact significance = 0.02), thereby influencing the overall total stability (Fisher exact significance = 0.04) compared to the Pilates reformer-based group. Despite initial disparities in stability, especially on the right-side Trendelenburg test and overall total stability, most measures at baseline were similar between the mat-based and Pilates reformer-based groups. It is important to have similar baseline measures, as it allows researchers to isolate the effects of the intervention by minimising the influence of inherent group differences, indicating that any subsequent variations in post-intervention outcomes can be attributed more reliably to the nature of the interventions rather than pre- existing group differences. Six-weeks post intervention, there was no significant difference between the mat-based and the Pilates reformer-based group for any of the assessed outcomes.

Both the Pilates mat-based and Pilates reformer-based groups experienced comparable adaptations in pain and RMDQ scores throughout the intervention period. Despite this, a notable main effect of time was observed, showing a statistically significant decrease in pain and RMDQ scores over timeduring the six-weeks across both groups. Similar results were observed in the study conducted by da Luz and colleagues in 2014 where both groups showed a notable improvement (Maurı´cio Antoˆnio da Luz Jr et al., 2014). Although, after the six-month mark, significant differences were detected in disability, favouring the group engaging in equipment-based Pilates exercises (Maurı´cio Antoˆnio da Luz Jr et al., 2014). In an additional study conducted by Cruz-Diaz and colleagues in 2017, both mat-based Pilates as well

as equipment-based Pilates were equally effective in reducing pain and disability in individuals suffering with chronic non-specific lower back pain. In similar, yet contrasting literature, in Lee and colleagues (2014) study, although both groups showed significant enhancements in balance and pain reduction, the group performing Pilates mat exercises exhibited greater improvement(Lee et al., 2014). This suggests that the collective changes noted in pain and RMDQ scores inboth groups may have been impacted by the exercises incorporated into both interventions in the strengthening of similar muscle groups, thus making them equally beneficial in alleviatingpain and mitigating disability outcomes. Moreover, another rationale could be that the engagement of deep trunk muscles through Pilates practice in general, enhanced the perceptionof pain (David Cruz-Díaza, 2017).

The statistical analysis revealed no significant interaction effect on mean sit-and-reach scores and ASLR scores. Similarly, the main effect of time indicated no statistically significant difference in mean sit and reach scores at various time points. However, the main effect of time indicated a statistically significant difference in ASLR, irrespective of intervention group. There was no meaningful difference between the two groups in terms of changes in mean sit-and-reach scores as well as ASLR. However, there was an equal change across both groups regarding ASLR. Thus again, showing that the exercises incorporated into both intervention groups could have been one of the reasons for the improvement in mobility outcomes, more specifically ASLR scores. Similar results were noted in the study conducted by Valenza et al. (2017) where the Pilates method improved mobility and flexibility over an eight-week intervention. However, a finger to floor test was used to assess flexibility in this study and the modified Schobers test was used to assess the lumbar mobility (Valenza et al., 2017). Additionally, in research exploring the impact of Pilates on mobility and flexibility,

Phrompaet and colleagues observed a significant enhancement in flexibility, as measured by the sit-and-reach test (Phrompaet, Paungmali, Pirunsan, & Sitilertpisan, 2011). The finding of this study contributes to the body of evidence that Pilates improves flexibility. This is also noted with the findings of Gladwell and associates (2006), where Pilates is believed to contribute to the reduction of pain and disability associated with chronic non-specific lower back pain (Gladwell et al., 2006). The increased flexibility observed in this study can also be corroborated by another Pilates investigation conducted by Segal et al., which used the finger-to-floor test. This study similarly demonstrated the positive effects of Pilates exercises on improving flexibility (Segal, Hein, & Basford, 2004).

The non-significant comparison of results among the two groups with regards to Trendelenburg outcomes suggests that there were no differences between the two groups post-intervention. This finding suggests that the intervention did not lead to distinctive improvements or variations in stability, as assessed through the Trendelenburg tests, for eithergroup. Similarly, both the left and right BwLE tests yielded no significant results. The absenceof substantial significant changes in both Trendelenburg as well as BwLE outcomes throughout the intervention period suggests that the intervention did not significantly influence participants' overall stability outcomes. Similar results were observed in a study conducted in 2017 by Bhadauria and Gurudut where they completed a comparative analysis on the effectiveness between lumbar stabilisation, dynamic strengthening and Pilates on chronic non-specific lower back pain. This study found that the Pilates group showed minimal improvementin stabilising the lumbar-pelvic region with neuromuscular control and spinal stability post a six-week intervention (Bhadauria & Gurudut, 2017). In contrasting evidence, a study conductedby Phrompaet et al. observed a significant enhancement in stability, more specifically, lumbo-pelvic stability which was measured using the pressure biofeedback

test. He concluded that Pilates can be used as an exercise regimen to improve flexibility and improve control and mobility of the trunk and pelvic segments. (Phrompaet et al., 2011)

The secondary aim of this study involved examining whether the change in mobility and stability could account for the significant changes observed in pain and disability, as assessed by NPRS and RMDQ, respectively. No changes in sit-and-reach, ASLR, and total stability could explain the changes in pain and disability outcomes. Additionally, it should be noted that to our knowledge, the investigation into the influence of changes in mobility, stability, and pain and disability among individuals with chronic lower back pain have not been previously explored or established in the existing literature. This suggests that factors beyond those measured (unknown factors or a combination thereof) influenced the reduction in pain and disability, ultimately resulting in the improvement thereof. However, in a study conducted by Sirbu and colleagues, examining predictors of disability in patients with chronic lower back pain, they discovered that factors such as age, pain intensity, helplessness, and depression accounted for the variance in disability among patients with chronic non-specific lower back pain (Sirbu, Onofrei, Szasz, & Susan, 2023). Their findings indicated significant correlations between disability and age, residence, and work status; however, only age emerged as a significant predictor of disability in chronic lower back pain patients (Sirbu et al., 2023). These findings present a stark contrast to our study's results. When age, gender, and BMI were included as independent variables in the model initially, they demonstrated no significant influence and were subsequently removed from the regression model.

Limitations:

Sample size: The study's findings are influenced by a small sample size, and the limitations associated with it impacted the results. Expanding the participant pool in future studies could enhance the statistical power and increase the external validity of the findings.

Limits of self-reported data: The reliance on self-reported data such as the RMDQ and pain scales assumes participant honesty and transparency, introducing potential biases. Future research could incorporate more diverse data collection methods to cross-verify self-reported information, enhancing the reliability of findings.

Variability: The inclusion of three different testers in the study, along with the involvement of various testers at different time points, introduces variability in data collection. This discrepancy impacts the accuracy of assessing the true effects of the intervention, as any observed changes may be confounded by the measurement variations. If the test-retest reliability of any of the measures had been assessed, it would provide evidence regarding their reliability.

Time: There was a time constraint that was imposed on this research study. Future investigations could explore a more prolonged intervention period by doing a three or six month follow up for a more comprehensive analysis.

Lacking a control group: The study design adopted was lacking a true control or non-intervention group. Future research studies should consider incorporating a control group to enhance the internal validity of the findings and provide a better understanding of the intervention's specific effects.

Limited availability of reformers for group sessions: Due to the limited availability of reformers, as previously mentioned, only individual sessions could be conducted, unlike the group sessions held with the Pilates mat-based group. This limitation may have impacted the findingsbetween the Pilates mat-based and Pilates reformer-based group and may potentially have further influenced the interpretation of results regarding the efficacy of the two different Pilates interventions.

Group stability difference at onset: A key limitation was the unequal stability outcomes between groups at the study's outset. This disparity made direct intervention comparisons challenging, potentially affecting result interpretation.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

In conclusion, both Pilates interventions likely contributed to the improvement of mobility and stability, and more notably, a significant reduction in pain and disability. However, neither intervention could show superior results in improving pain, mobility, and stability when compared to the other. This further contributes to the current body of evidence supporting the efficacy of Pilates in alleviating chronic non-specific lower back pain. Comparative studies were conducted over longer durations (average weeks), but this study demonstrates that significant improvements can occur in as little as six weeks. This indicates that adaptations can occur within this timeframe, rendering it effective in reducing pain and disability, as well as improving stability and mobility.

Further research comparing these two interventions should explore the effects of Pilates on various performance variables, such as mobility assessed through the sit-and-reach test and ASLR, as well as stability variables including Trendelenburg and BwLE. It may also be worth considering using other, more quantifiable methods in evaluating stability on a continuum scale. Moreover, consistency in using a single tester across the study cohort could enhance the reliability and validity of measurement outcomes. Further investigation is necessary to examine factors that could explain changes in disability and pain, more specifically, exploring mobility and stability variables. As recommended by several other studies, it is important to also conduct a follow-up period to assess the sustained long-term effects of the two different Pilates interventions as this could provide insights into the long-term effects of Pilates on pain, disability, mobility, and stability in individuals with chronic non-specific lower back pain (Wells, Kolt et al., 2014). Evaluating the maintained improvements over time in future studies

may also provide valuable insights into preventing relapses for individuals with chronic non-specific lower back pain.

REFERENCES

Bhadauria, E. A., & Gurudut, P. (2017). Comparative effectiveness of lumbar stabilization, dynamic strengthening, and Pilates on chronic low back pain: randomized clinical trial. *J Exerc Rehabil, 13*(4), 477-485. doi:10.12965/jer.1734972.486

Buchbinder, R., van Tulder, M., Oberg, B., Costa, L. M., Woolf, A., Schoene, M., . . . Lancet Low Back Pain Series Working, G. (2018). Low back pain: a call for action. *Lancet, 391*(10137), 2384-2388. doi:10.1016/S0140-6736(18)30488-4

Camino Willhuber, G. O., & Piuzzi, N. S. (2023). Straight Leg Raise Test. In *StatPearls*. Treasure Island (FL): StatPearls Publishing

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Coulter, I. D., Crawford, C., Hurwitz, E. L., Vernon, H., Khorsan, R., Suttorp Booth, M., & Herman, P. M. (2018). Manipulation and mobilization for treating chronic low back pain: a systematic review and meta-analysis. *Spine J, 18*(5), 866-879. doi:10.1016/j.spinee.2018.01.013

David Cruz-Díaz, M. R., Carmen Velasco-González, Antonio Martínez-Amat and Fidel Hita-Contreras. (2018). The effectiveness of 12 weeks of Pilates intervention on disability, pain and kinesiophobia in patientswith chronic low back pain: a randomized controlled trial. *Sage, 32(9)*, 1249-1257.

David Cruz-Díaza, M. B., S. Gobbob, Antonio Martínez-Amata, Fidel Hita-Contrerasa. (2017). Comparative effects of 12 weeks of equipment based and mat Pilates in patients with Chronic Low Back Pain on pain, function and transversus abdominis activation. A randomized controlled trial. *Complementary Therapies in Medacine, 33*, 72-77.

de Oliveira, N. T. B., Ricci, N. A., Dos Santos Franco, Y. R., Salvador, E., Almeida, I. C. B., & Cabral, C. M. N. (2019). Effectiveness of the Pilates method versus aerobic exercises in the treatment of older adults with chronic low back pain: a randomized controlled trial protocol. *BMC Musculoskelet Disord, 20*(1), 250. doi:10.1186/s12891-019-2642-9

Durnin, J. V., & Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr, 32*(1), 77-97. doi:10.1079/bjn19740060

Eliks, M., Zgorzalewicz-Stachowiak, M., & Zeńczak-Praga, K. (2019). Application of Pilates-based exercises in the treatment of chronic non-specific low back pain: state of the art. *Postgrad Med J, 95*(1119), 41-45. doi:10.1136/postgradmedj-2018-135920

Fernández-Rodríguez, R., Álvarez-Bueno, C., Cavero-Redondo, I., Torres-Costoso, A., Pozuelo-Carrascosa, D. P., Reina-Gutiérrez, S., . . . Martínez-Vizcaíno, V. (2022). Best exercise options for reducing pain and disability in adults with chronic low back pain: Pilates, strength, core-based and mind-body. A network meta-analysis. *The Journal of orthopaedic and sports physical therapy*, 1-49.

Ferrari, S., Manni, T., Bonetti, F., Villafañe, J. H., & Vanti, C. (2015). A literature review of clinical tests for lumbar instability in low back pain: validity and applicability in clinical practice. *Chiropr Man Therap, 23*, 14. doi:10.1186/s12998-015-0058-7

Gladwell, V. F., Head, S., Haggar, M., & Beneke, R. (2006). Does a program of pilates improve chronic non-specific low back pain? *Journal of Sport Rehabilitation, 15*, 338-350.

Gordon, R., & Bloxham, S. (2016). A Systematic Review of the Effects of Exercise and Physical Activity on Non-Specific Chronic Low Back Pain. *Healthcare, 4*(2), 22. Retrieved from https://www.mdpi.com/2227-9032/4/2/22

https://mdpi-res.com/d_attachment/healthcare/healthcare-04-00022/article_deploy/healthcare-04-00022.pdf?version=1461575475
Grimaldi, A. (2011). Assessing lateral stability of the hip and pelvis. *Man Ther, 16*(1), 26-32. doi:10.1016/j.math.2010.08.005
Hasanpour-Dehkordi, A., Dehghani, A., & Solati, K. (2017). A Comparison of the Effects of Pilates and McKenzie Training on Pain and General Health in Men with Chronic Low Back Pain: A Randomized Trial. *Indian J Palliat Care, 23*(1), 36-40. doi:10.4103/0973-1075.197945
Hush, J. M., Refshauge, K. M., Sullivan, G., De Souza, L., & McAuley, J. H. (2010). Do numerical rating scales and the Roland-Morris Disability Questionnaire capture changes that are meaningful to patients with persistent back pain? *Clin Rehabil, 24*(7), 648-657. doi:10.1177/0269215510367975
Jung, S.-h., Hwang, U.-j., Ahn, S.-h., Kim, H.-a., Kim, J.-h., & Kwon, O.-y. (2020). Lumbopelvic motor control function between patients with chronic low back pain and healthy controls: a useful distinguishing tool: The STROBE study. *Medicine, 99*(15), e19621. doi:10.1097/md.0000000000019621
Lam, O. T., Strenger, D. M., Chan-Fee, M., Pham, P. T., Preuss, R. A., & Robbins, S. M. (2018). Effectiveness of the McKenzie Method of Mechanical Diagnosis and Therapy for Treating Low Back Pain: Literature Review With Meta-analysis. *J Orthop Sports Phys Ther, 48*(6), 476-490. doi:10.2519/jospt.2018.7562
Lee, C. W., Hyun, J., & Kim, S. G. (2014). Influence of pilates mat and apparatus exercises on pain and balance of businesswomen with chronic low back pain. *J Phys Ther Sci, 26*(4), 475-477. doi:10.1589/jpts.26.475
Lim, E. C., Poh, R. L., Low, A. Y., & Wong, W. P. (2011). Effects of Pilates-based exercises on pain and disability in individuals with persistent nonspecific low back pain: a systematic review with meta-analysis. *J Orthop Sports Phys Ther, 41*(2), 70-80. doi:10.2519/jospt.2011.3393
Lynders, C. (2019). The Critical Role of Development of the Transversus Abdominis in the Prevention and Treatment of Low Back Pain. *HSS J, 15*(3), 214-220. doi:10.1007/s11420-019-09717-8
Macedo, L. G., Maher, C. G., Latimer, J., Hancock, M. J., Machado, L. A., & McAuley, J. H. (2011). Responsiveness of the 24-, 18- and 11-item versions of the Roland Morris Disability Questionnaire. *Eur Spine J, 20*(3), 458-463. doi:10.1007/s00586-010-1608-2
Mauru´cio Antoˆnio da Luz Jr, L. O. P. C., Fernanda Ferreira Fuhro, A. C. T. M., & Naiane Teixeira Bastos Oliveira, C. M. N. C. (2014). Effectiveness of Mat Pilates or Equipment-Based Pilates Exercises in Patients With Chronic Nonspecific Low Back Pain: A Randomized Controlled Trial. *Physical Therapy, 94*, 624
Mayorga-Vega, D., Merino-Marban, R., & Viciana, J. (2014). Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. *J Sports Sci Med, 13*(1), 1-14.
McCarney, L., Andrews, A., Henry, P., Fazalbhoy, A., Selva Raj, I., Lythgo, N., & Kendall, J. C. (2020). Determining Trendelenburg test validity and reliability using 3-dimensional motion analysis and muscle dynamometry. *Chiropr Man Therap, 28*(1), 53. doi:10.1186/s12998-020-00344-3
Mier, C. M., & Shapiro, B. S. (2013). Sex differences in pelvic and hip flexibility in men and women matched for sit-and-reach score. *J Strength Cond Res, 27*(4), 1031-1035. doi:10.1519/JSC.0b013e3182651d79

Noonan, A. M., & Brown, S. H. M. (2021). Paraspinal muscle pathophysiology associated with low back pain and spine degenerative disorders. *JOR Spine, 4*(3), e1171. doi:10.1002/jsp2.1171

Nuttall, F. Q. (2015). Body Mass Index: Obesity, BMI, and Health: A Critical Review. *Nutr Today, 50*(3), 117-128. doi:10.1097/nt.0000000000000092

Phrompaet, S., Paungmali, A., Pirunsan, U., & Sitilertpisan, P. (2011). Effects of Pilates Training on Lumbo-Pelvic Stability and Flexibility. *Asian journal of sports medicine, 2*, 16-22. doi:10.5812/asjsm.34822

Roland, M., & Morris, R. (1983). A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. *Spine (Phila Pa 1976), 8*(2), 141-144. doi:10.1097/00007632-198303000-00004

Roussel, N. A., Nijs, J., Truijen, S., Smeuninx, L., & Stassijns, G. (2007). Low Back Pain: Clinimetric Properties of the Trendelenburg Test, Active Straight Leg Raise Test, and Breathing Pattern During Active Straight Leg Raising. *Journal of Manipulative and Physiological Therapeutics, 30*(4), 270-278. doi:https://doi.org/10.1016/j.jmpt.2007.03.001

Saravanan Kuppusamy, R. N., JohnsonDillip Christopher. (2013). Effectiveness of Mckenzie Exercises and Mat Based Pilates Exercises in Subjects with Chronic Non-Specific Low Back Pain: A Comparative Study. *International Journal of Prevention and Treatment, 2 (4)*, 47-54. doi:10.5923/j.ijpt.20130204.01

Segal, N. A., Hein, J., & Basford, J. R. (2004). The effects of Pilates training on flexibility and body composition: an observational study. *Arch Phys Med Rehabil, 85*(12), 1977-1981. doi:10.1016/j.apmr.2004.01.036

Shipton, E. A. (2018). Physical Therapy Approaches in the Treatment of Low Back Pain. *Pain Ther, 7*(2), 127-137. doi:10.1007/s40122-018-0105-x

Silveira, E. A., Barbosa, L. S., Rodrigues, A. P. S., Noll, M., & De Oliveira, C. (2020). Body fat percentage assessment by skinfold equation, bioimpedance and densitometry in older adults. *Arch Public Health, 78*, 65. doi:10.1186/s13690-020-00449-4

Sirbu, E., Onofrei, R. R., Szasz, S., & Susan, M. (2023). Predictors of disability in patients with chronic low back pain. *Arch Med Sci, 19*(1), 94-100. doi:10.5114/aoms.2020.97057

Sribastav, S., Long, J., He, P., He, W., Ye, F., Li, Z., . . . Zheng, Z. (2018). Risk Factors Associated with Pain Severity in Patients with Non-specific Low Back Pain in Southern China. *Asian spine journal, 12*, 533-543. doi:10.4184/asj.2018.12.3.533

Stieglitz, D. D., Vinson, D. R., & Hampton, M. C. (2016). Equipment-based Pilates reduces work-related chronic low back pain and disability: A pilot study. *J Bodyw Mov Ther, 20*(1), 74-82. doi:10.1016/j.jbmt.2015.06.006

Valenza, M. C., Rodriguez-Torres, J., Cabrera-Martos, I., Diaz-Pelegrina, A., Aguilar-Ferrandiz, M. E., & Castellote-Caballero, Y. (2017). Results of a Pilates exercise program in patients with chronic non-specific low back pain: a randomized controlled trial. *Clin Rehabil, 31*(6), 753-760. doi:10.1177/0269215516651978

Vrbanić, T. S. (2011). [Low back pain--from definition to diagnosis]. *Reumatizam, 58*(2), 105-107.

Wells, C., Kolt, G. S., Marshall, P., Hill, B., & Bialocerkowski, A. (2014). The effectiveness of Pilates exercise in people with chronic low back pain: a systematic review. *PLoS One, 9*(7), e100402. doi:10.1371/journal.pone.0100402

APPENDICES

Appendix A: Ethics approval copy

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room 45, E-52 Old Main Building
Groote Schuur Hospital
Observatory 7925
Tel:0214066492
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/home/human-research-ethics

20 November 2023

HREC REF: 432/2022

A/Prof J Kroff
Division of Physiological Sciences
Human Biology-FHS
Email: Jacolen.krofff@uct.ac.za

Dear A/Prof Kroff

PROJECT TITLE: THE EFFECT OF PILATES REFORMER-BASED EXERCISES COMPARED TO PILATES MAT-BASED EXERCISES ON GENERAL LOWER BACK PAIN AND FUNCTION IN INDIVIDUALS SUFFERING FROM NON-SPECIFIC LOWER BACK PAIN-

Thank you for submitting the study staff amendment dated 12 October 2023 to the Faculty of Health Sciences Human Research Ethics Committee (HREC).

The HREC has approved the study staff amendment for Mphil student-Ms Natalia Ferreira.

Please supply an updated FHS 013 to depict the new student.

Please quote the HREC REF 432/2022 in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

HREC/REF:432.2022

Appendix B: Consent form

PILOT STUDY 1: CONSENT FORM

PARTICIPANT INFORMATION SHEET AND CONSENT FORM

PROJECT TITLE: The influence of Pilates reformer vs mat-based Pilates exercises on general lower back pain

Dear Volunteer,

We would like to provide you with information about the above-mentioned study, which will be conducted by researchers from the University of Cape Town (UCT)'s Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences.

WHY ARE WE DOING THIS STUDY?

Pilates is an exercise modality developed by Joseph Pilates in the 20th Century. Pilates based exercises have been shown to improve ratings of general lower back pain. But we don't know if there is a difference with respect to floor based Pilates exercises and using a Pilates Reformer machine in terms of the pain ratings, quality of life rating, strength and flexibility of individuals with lower back pain.

WHAT IS THE STUDY ABOUT?

One study group will be taking part in floor-based rehabilitation sessions and the other group will take part in Reformer rehabilitation sessions. Pain ratings, quality of life rating, strength and flexibility will be compared.

WHO CAN TAKE PART IN THIS STUDY?

We are looking for Men or women between the ages of 30-60 years of age, who are apparently healthy and have not participated in Pilates exercise for the last 2 months. These individuals must have chronic, general, undiagnosed lower back pain.

The following individuals can unfortunately not take part in the study even if they do fit in the criteria above:

- Any diagnosed medical condition affecting the lumbar spine.

WHAT WILL HAPPEN IF YOU DECIDE TO TAKE PART IN THIS STUDY?

Volunteers will be asked to visit Avinesh Pursad Biokineticist's practice, located on the 1st floor of The

Sports Science Institute of South Africa. Participants will be required to come in for testing before the start of the exercise programme as well as after. During the programme participants are required to attend 2 Pilates group classes per week for 6 weeks or 2 reformer individual sessions per week for 6 weeks.

Initial Testing (±1 hour in duration)

- ***Informed Consent:*** A researcher will clearly explain all of the experimental procedures to you, after which you will be requested to sign a consent form if you are willing to take part in the study.
- ***Survey Completion via 1-on-1 interview:*** A researcher will interview you about your health, medical and family medical history, physical activity levels, emotional well-being and sleeping habits.
- ***Roeland Morris Questionnaire:*** You will be asked to complete this questionnaire where you have to rate the degree of functionality of your spine. This test will give participants the degree of disability in the spine.
- ***Bridge Leg Extension:*** Participants will lie supine with knees bent in crook lying position. They will be asked to extend their hips and then extend one leg. This will be performed on both sides. This test looks for degree of pelvic instability by determining whether or not the participant drops the hip of the leg extending. A positive test indicates weakness of the pelvic stabilizers.
- ***Sit-and-reach Test:*** Participants are required to sit with their feet placed on the sit and reach box, legs should be extended. The participant reaches forward with extended arms. Placing one hand on top of the other and reaches as far as possible on the measuring tape. 3 attempts are allowed and the best of 3 is used as the measure. This test is used to measure the flexibility of the lower back and the hamstrings.
- ***Active straight leg raise:*** Participants are required to lie supine and raise one leg in complete extension. A measure is taken using a goniometer. This is then performed on the other leg. This test is used to test a participants mobility and ability to load the pelvis through the limb.
- ***Trendelenburg Test:*** Participants are required to stand on one leg for 30 seconds without leaning to one side or dropping the opposite hip. If there is a contralateral hip drop, this is indicative of ipsilateral weakness of the lateral stabilizers of the leg.
- ***Numerical Pain Rating Scale (NPRS):*** Participants are asked to rate their pain from 0-10. Ten being the worst pain imaginable, zero being no pain at all. This is a subjective measure used to gauge the intensity of a participants lower back pain.

Exercise Observation:

You will be asked to visit the practise again during the exercise programme at arranged times twice a week for 6 consecutive weeks.

Post-testing: (±1 hour in duration)

During the final assessment, all the above-mentioned test in the initial testing will be repeated.

Participants are informed that there will not be any direct individual benefits by taking part in this study.

WHAT ARE THE RISKS AND DISCOMFORTS OF THIS STUDY?

You may experience discomfort during the exercise classes or individual sessions, however a trained Pilates instructor and Biokineticist will be there to offer modifications and advice should you need.

The only other risks may be those associated with completing questionnaires which may ask probing questions about medical history and functional disability. Researchers will make every effort to treat all volunteers respectfully and with empathy. You are not required to answer any questions which may make you feel uncomfortable.

ARE THERE ANY BENEFITS TO YOU FOR BEING IN THIS STUDY?

Through participating in this study, you will gain valuable information about yourself pertaining to your flexibility, mobility and pelvic stability. You will take part in a 6-week Pilates based programme structured and instructed by Biokineticists and Pilates instructors free of charge.

WHAT ARE THE OTHER ETHICAL CONSIDERATIONS?

The University of Cape Town's Faculty of Health Sciences Human Research Ethics Committee (contact information below) has approved this study. The study will be performed in accordance with the principles of the Declaration of Helsinki (2013, Fortaleza, Brazil), International Conference on Harmonisation and the European Good Clinical Practice (GCP) guidelines, the South African GCP guidelines, and the laws of South Africa. The study will be covered by the University of Cape Town's no-fault insurance policy (more details below).

You will not be included in the study unless you have signed a consent form, after the investigator has provided substantial verbal and written explanation of the study, including risk factors. Participation in the study is entirely voluntary and you have the right to withdraw from the study at any time without

stating a reason. The investigator may also withdraw you from the study at any time. All records and results generated from this study will be stored in a password-protected computer database to ensure your confidentiality and your information will not be passed on to any other parties. You will remain anonymous in any publication resulting from this study.

WHAT HAPPENS IF I GET HURT TAKING PART IN THIS STUDY?

This research study is covered by an insurance policy taken out by the University of Cape Town if you suffer a bodily injury because you are taking part in the study. The insurer will pay for all reasonable medical costs required to treat your bodily injury, according to the SA Good Clinical Practice Guidelines 2006 (or latest version), which are based on the Association of the British Pharmaceutical Industry Guidelines. The insurer will pay without you having to prove that the research was responsible for your bodily injury. You may ask the study doctor for a copy of these guidelines.

The insurer will not pay for harm if, during the study, you:

- Use medicines or other substances that are not allowed
- Do not follow the study doctor's instructions
- Do not tell the study doctor that you have a bad side effect from the exercise
- Do not take reasonable care of yourself

If you are harmed and the insurer pays for the necessary medical costs, usually you will be asked to accept that insurance payment as full settlement of the claim for medical costs. However, accepting this offer of insurance cover does not mean you give up your right to make a separate claim for other losses based on negligence, in a South African court. It is important to follow the instructions of the study investigator, medical doctors and biokineticists and to report straightaway if you have become injured as a result of participation in this study.

WHO DO I SPEAK TO (OR CONTACT) IF I HAVE ANY QUESTIONS ABOUT THE STUDY

Should you have any ethical concerns or questions about the study, please contact the **Human Research Ethics Committee:**

Prof Marc Blockman	Faculty of Health Sciences – Human Research Ethics Committee Room E53-46, Old Main Building, Groote Schuur Hospital Observatory, 7925	Tel: (021) 406 6338 Fax: (021) 406 6441 Email: nosi.tsama@uct.ac.za

Should you have any queries directly related to the study itself, please contact any of the investigators:

Principal Investigator:

Dr Jacolene Kroff	Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences, Unversity of Cape Town	Tel: 021 650 5126 jacolene.kroff@uct.ac.za

Co-Investigators:

Avinesh Pursad	Co-Investigator & Study administrator	apursad@ssisa.com	+27 82 875 7085
Olivia Bloomer	Co-Investigator	obloomer@ssisa.com	+27 76 245 2772

Honours Students

Zintle Fanele	**Honours Student**	**Fnlzin001@myuct.ac.za**	**+27**
Tumelo Lethule	**Honours Student**	**Tumelolethule@gmail.com**	

Please note that this research will contribute to the completion of the students honours degree.

CONSENT FORM

I, the undersigned, have been fully informed about the study entitled "The influence of Pilates reformer vs mat-based Pilates exercises on general lower back pain" to be conducted by researchers from the Division of Exercise Science and Sports Medicine within the Department of Human Biology, Faculty of Health Sciences at the University of Cape Town.

- I agree to complete questionnaires disclosing my personal details and information relating to my medical, health and physical activity habits and eating behaviour.
- I understand that I will perform structured Pilates classes twice a week for 6 weeks.
- I understand that I will take part in initial and post testing protocols stated above.

I have read the information, or it has been read to me. I have had the chance to ask questions about it and I am satisfied with the answers I was given. I consent voluntarily and understand that I have the right to withdraw my consent without this affecting the research I am currently taking part in or my medical care. I have been informed about the risks involved in participating in this study. I understand that my personal details will be treated confidentially. I understand that I may (i) ask the investigator any questions about the tests and results of the study and (ii) withdraw from this study at any time without stating any reason. I also understand that the investigator may withdraw me from this study at any stage. I understand that I will receive general feedback regarding my personal results and that I will not be remunerated for participating in this study. I agree to participate in the study.

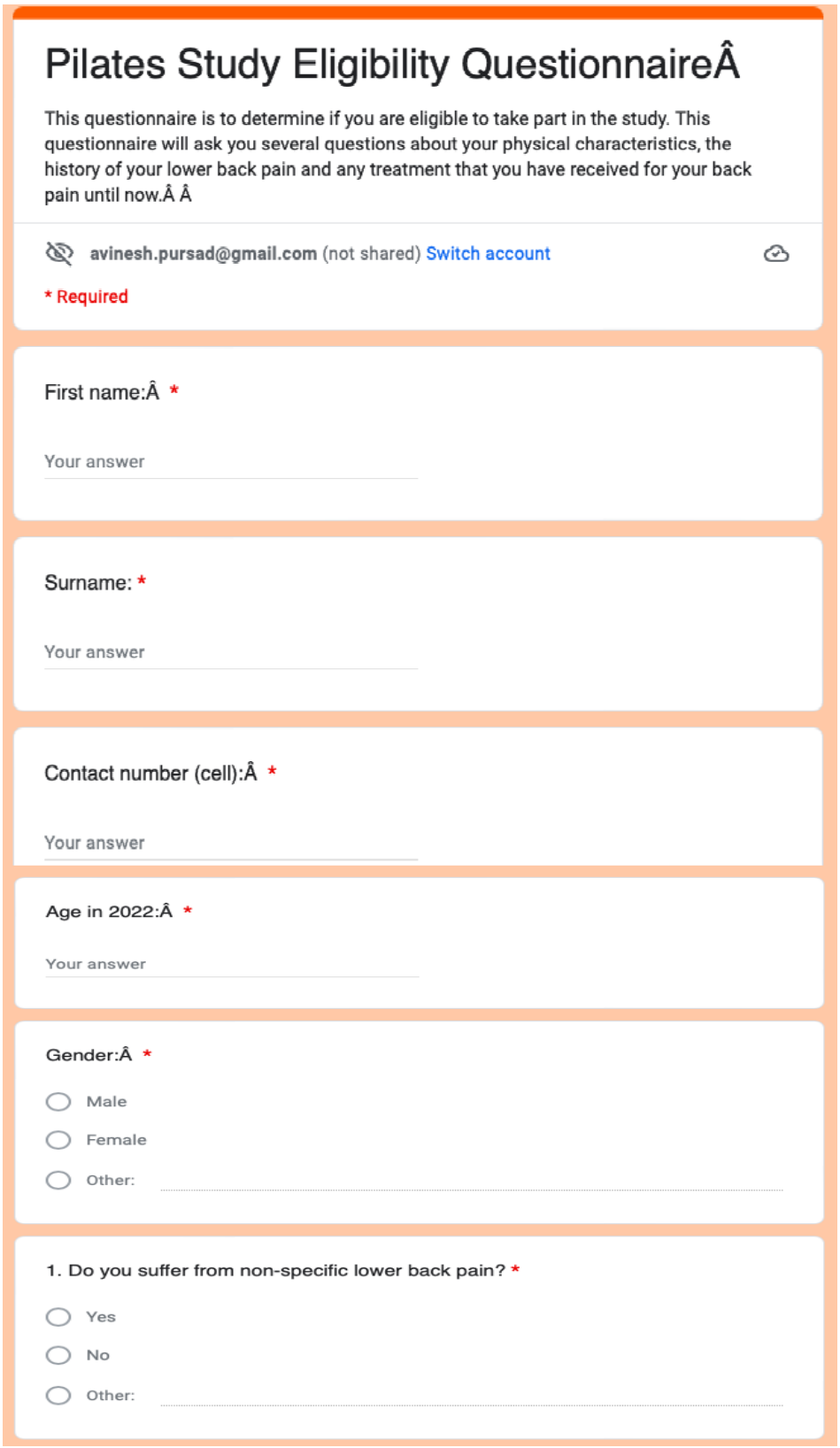
Participant:

Full name	**Signature**	**Date:**
_____	_____	_____

Investigator

Full name	**Signature**	**Date:**
_____	_____	_____

Appendix C: Online Screening form



Pilates Study Eligibility QuestionnaireÂ

This questionnaire is to determine if you are eligible to take part in the study. This questionnaire will ask you several questions about your physical characteristics, the history of your lower back pain and any treatment that you have received for your back pain until now.Â Â

avinesh.pursad@gmail.com (not shared) Switch account

* Required

First name:Â *

Your answer

Surname: *

Your answer

Contact number (cell):Â *

Your answer

Age in 2022:Â *

Your answer

Gender:Â *

- Male
- Female
- Other:

1. Do you suffer from non-specific lower back pain? *

- Yes
- No
- Other:

2. For how long have you been experiencing non-specific lower back pain?Â *

- ◯ < 3 months
- ◯ longer than 12 weeks but less/equal to 18 weeks
- ◯ longer than 18 weeks
- ◯ Other: .....

3. Have you been doing any pilates exercises within the last 3 months?Â *

- ◯ Yes
- ◯ No
- ◯ Other: .....

4. On average during the day, on a the scale (0-10), how much pain do you experience during movement, loading or any form of physical exertion?Â Â *

	1	2	3	4	5	6	7	8	9	10	
Very little pain/almost no pain (little disability)	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Extremely severe pain (struggle, avoid walking)

Screenshot

5. Have you received any specific treatment regime to improve/manage your lower back pain within the last 2 months?Â Â *

- ◯ Yes
- ◯ No
- ◯ Other: .....

6. If yes in question 4, what treatment did you undergo?Â *

Your answer

7. Please indicate if any of the following are currently applicable to you and/or your lower back condition:Â *

- [ ] diagnosed medical condition affecting your lumbar spine
- [ ] have been pregnant or given birth in the last 6 months
- [ ] have undergone surgery within the last 12 months
- [ ] have a history of being diagnosed with lower back pain
- [ ] have a history of being diagnosed with a spinal fracture
- [ ] have a history of being diagnosed with any inflammatory, rheumatic or neurological disorders
- [ ] have a history of systemic metabolic disease
- [ ] have ever suffered from nerve root compromise, tumour, infection, osteoporosis or structural deformity
- [ ] do you, or have you ever suffered from a condition that prevents you from doing whole body exercise/movements

8. If you have ticked "Yes" on any one of the above statements in Question 6, please elaborate by identifying the date, the issue and the duration of symptoms? Â *

Your answer

Would you be able to attend Pilates classes at 4:30pm on either Monday, Tuesday, Wednesday or Thursdays?Â

- ◯ Yes
- ◯ No

If you clicked "no", what times and days would work for you?Â

Your answer

Submit Clear form

Never submit passwords through Google Forms.

Appendix D: PAR-Q+

2022 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE: _____	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE: _____	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but it does not limit your current ability to be physically active. PLEASE LIST CONDITION(S) HERE: _____	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Global Physical Activity Guidelines for your age (https://www.who.int/publications/i/item/9789240015128).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for its records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

 1 / 4
01-11-2021

2022 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c. If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	YES ☐ NO ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	YES ☐ NO ☐

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b. If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	YES ☐ NO ☐
2b.	Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)?	YES ☐ NO ☐

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm

If the above condition(s) is/are present, answer questions 3a-3d. If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	YES ☐ NO ☐
3c.	Do you have chronic heart failure?	YES ☐ NO ☐
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	YES ☐ NO ☐

4. Do you currently have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b. If **NO** ☐ go to question 5

4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	YES ☐ NO ☐

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes

If the above condition(s) is/are present, answer questions 5a-5e. If **NO** ☐ go to question 6

5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?	YES ☐ NO ☐
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	YES ☐ NO ☐
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?	YES ☐ NO ☐
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	YES ☐ NO ☐
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	YES ☐ NO ☐

2022 PAR-Q+

6. Do you have any Mental Health Problems or Learning Difficulties? This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome

If the above condition(s) is/are present, answer questions 6a-6b — If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES☐ NO☐
6b.	Do you have Down Syndrome **AND** back problems affecting nerves or muscles?	YES☐ NO☐

7. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d — If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES☐ NO☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES☐ NO☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES☐ NO☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES☐ NO☐

8. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c — If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES☐ NO☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES☐ NO☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES☐ NO☐

9. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c — If **NO** ☐ go to question 10

9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES☐ NO☐
9b.	Do you have any impairment in walking or mobility?	YES☐ NO☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES☐ NO☐

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?

If you have other medical conditions, answer questions 10a-10c — If **NO** ☐ read the Page 4 recommendations

10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES☐ NO☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES☐ NO☐
10c.	Do you currently live with two or more medical conditions?	YES☐ NO☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: _____

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

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If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

For more information, please contact

www.eparmedx.com
[illegible]@gmail.com

Citation for this tool:
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The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Key References
1. Jamnik VK, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation: background and overall process. APNM 36(S1):S3-S13, 2011.
2. Warburton DER, Gledhill N, Jamnik VK, Bredin SSD, McKenzie DC, Stone J, Charlesworth S, and Shephard RJ. Evidence-based risk assessment and recommendations for physical activity clearance: Consensus Document. APNM 36(S1):S266-s298, 2011.
3. Chisholm DM, Collis ML, Kulak LL, Davenport W, and Gruber N. Physical activity readiness. British Columbia Medical Journal. 1975;17:375-378.
4. Thomas S, Reading J, and Shephard RJ. Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Canadian Journal of Sport Science. 1992;17:4:338-345.

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Appendix E: Data collection templates - Pre-assessment and Post-assessment form

Participant Assessment Form

Name: Surname:
Age: Gender:
Date:
Participant Code:

Participation Assessment

Height	
Weight	
BMI	
Body Fat %	

Sit and reach	1st attempt	2nd attempt	3rd attempt
	Comments		
Active straight leg raises	Left	Right	
	Comments		
Single leg bridge test	Left	Right	
	Comments		
Trendelenburg test	Left	Right	
	Comments		
Roland Morris disability score	Score:		
Numerical pain rating scale (Average)	Score:		

Appendix F: Roland-Morris Questionnaire

Roland-Morris Low Back Pain and Disability Questionnaire (RMQ)

Instructions

Patient name:_____ File #:_____ Date:_____

Please read instructions: When your back hurts, you may find it difficult to do some of the things you normally do. Mark only the sentences that describe you today.

- ☐ I stay at home most of the time because of my back.
- ☐ I change position frequently to try to get my back comfortable.
- ☐ I walk more slowly than usual because of my back.
- ☐ Because of my back, I am not doing any jobs that I usually do around the house.
- ☐ Because of my back, I use a handrail to get upstairs.
- ☐ Because of my back, I lie down to rest more often.
- ☐ Because of my back, I have to hold on to something to get out of an easy chair.
- ☐ Because of my back, I try to get other people to do things for me.
- ☐ I get dressed more slowly than usual because of my back.
- ☐ I only stand up for short periods of time because of my back.
- ☐ Because of my back, I try not to bend or kneel down.
- ☐ I find it difficult to get out of a chair because of my back.
- ☐ My back is painful almost all of the time.
- ☐ I find it difficult to turn over in bed because of my back.
- ☐ My appetite is not very good because of my back.
- ☐ I have trouble putting on my socks (or stockings) because of the pain in my back.
- ☐ I can only walk short distances because of my back pain.
- ☐ I sleep less well because of my back.
- ☐ Because of my back pain, I get dressed with the help of someone else.
- ☐ I sit down for most of the day because of my back.
- ☐ I avoid heavy jobs around the house because of my back.
- ☐ Because of back pain, I am more irritable and bad tempered with people than usual.
- ☐ Because of my back, I go upstairs more slowly than usual.
- ☐ I stay in bed most of the time because of my back.

Appendix G: Numerical Pain Rating Scale

Numerical Pain Rating Scale

1. On a scale of 0 to 10, with 0 being no pain at all and 10 being the worst pain imaginable, how would you rate your pain RIGHT NOW.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Worst Pain Imaginable

2. On the same scale, how would you rate your USUAL level of pain during the last week.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Worst Pain Imaginable

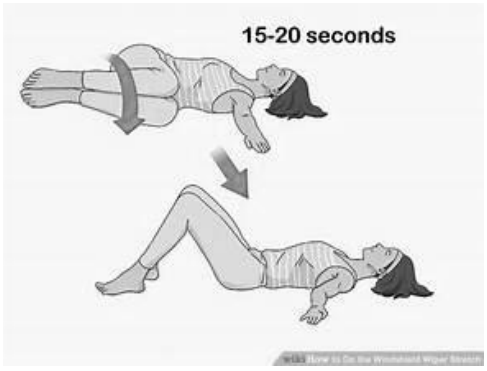
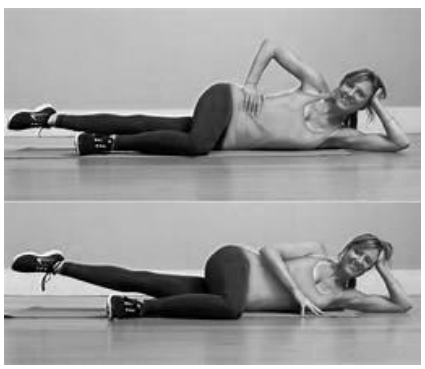
3. On the same scale, how would you rate your BEST level of pain during the last week.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Worst Pain Imaginable

4. On the same scale, how would you rate your WORST level of pain during the last week.

0	1	2	3	4	5	6	7	8	9	10
No Pain										Worst Pain Imaginable

Appendix H: Illustrations of Exercises

Windshield wipers 	Tweezers 
Roll downs 	Bird dog arms and legs 
Bear plank 	Figure 4 cross crunch 
Inner thigh lifts 	Childs pose hands side-side 

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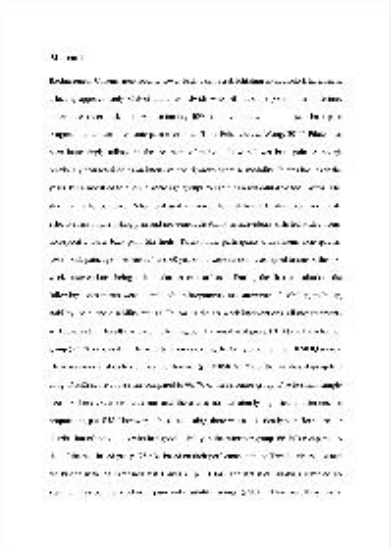

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