A COMPARISON OF SPINAL CURVATURES AND POSTURE BETWEEN ACTIVE KAYAKERS AND PHYSICALLY ACTIVE NON-KAYAKERS

By

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I, Matthew Beaumont Tasker, do hereby declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgments indicate to the contrary)

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DEDICATION

I dedicate this dissertation to my grandfather, Dr Geoffrey Beaumont Tasker. From a young age, you sparked my interest in chiropractic and you have been a strong role model as a man and professional throughout my life. I am grateful for the time spent together and I hope to continue to learn from you for as long as possible.

I have seen how you go about your practice and I acknowledge all your teachings and hands-on knowledge that you have passed on to me. You have encouraged me and supported me along this journey and I cannot thank you enough for the many invaluable lessons and experiences shared.

It is through your example that I found the determination and discipline to pursue a career in chiropractic. This work, I dedicate to you partner.

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ABSTRACT

Background: Kayaking is a sport that places repetitive demands on the spinal column and upper body musculature to propel the body and kayak forward. There is significant potential for curvature changes attributed to sustained periods of the kayaking posture as well as the effect of ageing on spinal curvatures. The study aimed to investigate the association between kayaking and spinal curvature anomalies (cervical lordosis, thoracic kyphosis, and lumbar lordosis) in males between the ages of 40 to 60 years.

Materials and Methods: Fifty-two male participants were included in this study, with two groups – Kayaking (K) and Non-kayaking (NK) - comprising 26 participants respectively. Full-body photographs were taken and analysed using PosturePro™. Spinal curvatures were measured using a Flexicurve ruler and angles were then calculated using BiomechFlex software.

Results: There was no significant difference in mean spinal angles between the groups. T-Flex and T-Cobb angles showed trends toward differences between the groups, with the K group having larger values than the NK group. There were statistically significant positive correlations between activity years and T-angles (T-Flex: p=0.015 and T-Cobb: p=0.014) seen in the sample population. In the K group, a moderate negative correlation between activity years and L-angles (L-Flex: p=0.028 and L-Cobb: p=0.023) was noted.

Conclusion: Spinal alignment changes can be affected through exposure to specific postural states. The activity of kayaking has a specific postural pattern and although not all results were of statistically significant value, a clinically significant value of altered spinal curvature associated with kayaking was found.

Keywords: Kayaking, spinal curvature, posture, physical activity

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LIST OF ABBREVIATIONS

DUT	—	Durban University of Technology
IREC	—	Institutional Research and Ethics Committee
IVDs	—	Intervertebral discs
K	—	Kayaking
KNCU	—	KwaZulu-Natal Canoe Union
NK	—	Non-kayaking
WHO	—	World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND

The spine is a key element of human anatomy that serves as a major structural foundation for posture and locomotion (Been, Gómez-Olivencia & Kramer 2019: 1). The human spine is a complex biomechanical structure that enables walking and normal movement through specific skeletal alterations (Diebo *et al.* 2015: 295). The development of the 'S' shaped spinal curvature is an example of these skeletal alterations that permit normal human movement and posture control (Diebo *et al.* 2015: 295).

The spinal column is made up of vertebrae with unique features, categorised into different groups, based on the region of the spine — these being cervical, thoracic, and lumbar vertebrae (Moore, Dalley & Agur 2013: 440). Each vertebra is separated by an intervertebral disc and has various prominences, joint surfaces, and articulations that allow for the functioning of the spinal column (Moore, Dalley & Agur 2013: 440-443).

The spinal column is designed to assume a wide range of positions in response to different stimuli, therefore being adaptable and dynamic by design (Hawes & O'Brien 2006: 3). Sagittal spinal curves appear as a person grows and are well established when walking and standing are achieved (Roussouly & Pinheiro-Franco 2011: 578). Viewed from the sagittal plane, spinal curvatures with an anterior concavity are named kyphosis, and curvatures with a posterior concavity are referred to as lordosis (Roussouly & Pinheiro-Franco 2011: 579). Therefore, according to anatomical segmentation, the spinal curvatures are divided into cervical lordosis (C1-C7), thoracic kyphosis (T1-T12), and lumbar lordosis (L1-L5) (Roussouly & Pinheiro-Franco 2011: 579; Moore, Dalley & Agur 2013: 441).

Spinal curvatures undergo progressive change through one's lifespan, as general trends indicate a deterioration of sagittal spinal alignment and posture as age increases past the fourth to fifth decade of life (Boyle, Milne & Singer 2002: 366). Changes in spinal curvature associated with increased age include increases in cervical lordosis and thoracic kyphosis, as well as a decreased lumbar lordosis

(Katzman *et al.* 2010: 352; Katzman, Vittinghoff & Kado 2011: 85-86; Skaf *et al.* 2011: 1; Arshad *et al.* 2019: 2; Tang *et al.* 2019: 1449)

Significant alterations to normal spinal alignment and posture can result from pathological processes and injury (Moore, Dalley & Agur 2013: 480-481). When disorders of the spinal column occur, the natural spinal curvatures are misaligned or exaggerated in certain areas with common examples including scoliosis, hyperkyphosis, and hyperlordosis (Kuo *et al.* 2019: 1).

After 40 years of age, the thoracic kyphosis begins to increase. The increase is associated with a reduction in physical performance (Katzman *et al.* 2010: 352; Katzman, Vittinghoff & Kado 2011: 86). Age-related hyperkyphosis is defined as a kyphosis angle greater than 40˚, and is described as an exaggerated anterior curvature in the thoracic spine, that occurs commonly with advanced age (Katzman *et al.* 2010: 352). Clinical consequences of hyperkyphosis are often seen in the elderly, and include functional limitations in performing activities of daily living, musculoskeletal alterations, including vertebral compression fractures and degenerative disc disease, as well as decreases in quality of life and increased mortality (Katzman *et al.* 2010: 354).

Posture and postural equilibrium is described as the proper alignment of body segments with respect to gravity (Ivanenko & Gurfinkel 2018: 3). Regular exercise and sporting activities have positive effects according to the exercise-specific features on body posture (Yamak *et al.* 2018: 1377). However, chronic poor postures as a result of bad habits or repeated postural positions, can lead to various detrimental effects on muscles, increase load and strain on passive structures, and ultimately, increase the risk of hyperkyphosis (Roghani *et al.* 2017: 575).

Each sporting discipline is unique in its specific postural and movement patterns, and repeated exposure to these postures may induce specific modifications in spinal curvatures when training for long periods (López-Miñarro *et al.* 2017: 110). Therefore, the long-term effects of repetitive movements and sustained postures adopted during a specific sporting activity, as seen in kayaking, may pose a risk for altered postural states, changes in spinal and disc loading, as well as changes in muscle relationships.

Kayaking is a sport that places repetitive demands on the spinal column and upper body musculature, to propel the body and kayak forward. Significant potential for curvature changes is found attributed to sustained periods of seated posture, over years of kayaking, as well as the effect of aging on spinal curvatures. Studies suggest that repetitive strain injuries are among the most common pain syndromes associated with kayaking (Davidek, Andel & Kobesova 2018: 15). Davidek, Andel and Kobesova (2018) assessed the influence that the dynamic neuromuscular stabilisation programme had on kayakers, to improve strength and decrease pain by way of trunk and shoulder girdle stabilisation. The study highlights the importance of the deep muscle-stabilising system as well as the integrated spinal stabilisation system through which the body works as a whole to move effectively (Davidek, Andel & Kobesova 2018: 23). By the activity of kayaking, kayakers naturally strengthen trunk stability; however, during the kayaking stroke, the trunk and spinal column must rotate. If core stabilisation is insufficient, the trunk and spinal column deviate and cause postural scoliosis (Davidek, Andel & Kobesova 2018: 24).

Fisher (2015: 18) found that when changing from a slouched to an erect posture while kayaking, reduced stability occurs which makes the activity more difficult (Fisher 2015: 18). This indicates that if poor postural positions are assumed, the kayaker is less likely to change their posture and will maintain a poor postural position while kayaking. With reference to a study by Kruger and Saayman (2013: 1159), over the past 20 years kayaking has grown in popularity as a sport. Despite the interest and increase in participants wanting to kayak, little research has been done involving the sport or investigating the people who participate (Kruger & Saayman 2013: 1159). Sport research in South Africa has mainly focused on the following three sporting disciplines of swimming, cycling, and running. Herein lies a gap in the research to investigate the topic of kayaking in the South Africa context.

Research has extensively documented the advantages of physical activity, and the significance of good posture in relieving back and neck pain. However, poor postures assumed while kayaking may have adverse effects on spinal curvatures. This study, therefore, explored the relationship between age, kayaking, spinal curvature alignment, and posture.

1.2 AIM

This study aimed to investigate the association between kayaking and spinal curvature anomalies (cervical lordosis, thoracic kyphosis, and lumbar lordosis) in healthy males between the ages of 40 to 60 years.

1.3 OBJECTIVES

- Assess the spinal curvatures (cervical lordosis, thoracic kyphosis, and lumbar lordosis) and posture in active male kayakers and physically active male non-kayakers.
- Assess any significant differences between the selected spinal curvature parameters within or between the kayaking and non-kayaking groups.
- Establish the association, if any, between factors such as age, activity, sitting time, and the selected spinal curvatures.

1.4 RATIONALE

The eThekwini Metropolitan Municipality is home to a large population of active kayakers. According to the KwaZulu-Natal Canoe Union (KNCU), the KNCU is the most active union in South Africa, with over 3800 active kayakers (KwaZulu-Natal Canoe Union 2011). KwaZulu-Natal is also home to one of South Africa's biggest kayaking marathons, the Dusi Canoe Marathon, which has been taking place since 1951 (Dusi Canoe Marathon 2015).

Exercise has been seen to have positive effects on posture, specifically exercise that focuses on core stabilisation, which involves the abdominal muscles, lower back, and pelvic musculature (Yamak *et al.* 2018: 1377). Findings of a study done by Salavati *et al.* (2016: 446) demonstrate that spinal stabilisation exercises improve postural control and functional capability (Salavati *et al.* 2016: 446). It is understood that exercise that involves spinal stabilisation has a direct relationship and effect on posture, therefore improving posture.

To provide forward motion and boat speed while kayaking, correct technique and skill are important driving forces (Bulgan *et al.* 2017: 129). Bulgan *et al.* (2017: 129) stated that for a continuous strong kayaking technique, optimum body posture is needed. However, a problem arises that with certain exercises where good posture is neglected and poor postures are maintained, exercise can affect and alter spinal curvatures. In kayaking, altered lumbar curvature postures are maintained for long training periods, which have been shown to have effects on other curvatures, notably an increased standing thoracic kyphosis curvature in kayakers (López-Miñarro *et al.* 2017: 110). Investigation into posture seen in kayakers is needed to identify any postural patterns as a result of the sustained kayaking posture.

1.5 DELINEATION OF CHAPTERS

In Chapter One, spinal curvatures and posture are introduced and explored with emphasis on the activity of kayaking. The aims, objectives, and rationale of the study are presented.

In Chapter Two, the literature relating to spinal curvatures and kayaking is presented. The association of spinal curvatures with aging and physical activity (with emphasis on kayaking) is explained.

In Chapter Three, the study methodology is explained. This includes study design, data collection, statistical analysis strategies, sampling methods, participant recruitment (kayakers and physically active non-kayakers), and measurement tools (Posture Pro and Flexicurve ruler). The data extraction and analysis procedures are also discussed in this chapter.

Chapter Four is presented in the form of a manuscript. The manuscript has been submitted to the Journal of Pain, Joints and Spine and is currently under review.

In Chapter Five, the interpretation and discussion of the study results with respect to the relevant literature relating to spinal curvature, posture, and the activity of kayaking, are discussed.

In Chapter Six, a conclusion is presented, including the strengths and limitations of the study, as well as recommendations for future research.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Human spinal alignment and posture are adaptable and evolve throughout a person's life, influenced by age, physical activity, pathology, and/or injury to the spine and surrounding tissues (Moore, Dalley & Agur 2013: 480; Zemková & Kováčiková 2023: 2). As one grows and the anatomy develops, significant changes occur throughout childhood, adolescence, and adulthood, which include changes to a developing spine (Moore, Dalley & Agur 2013: 471; Been & Kalichman 2014: 91). These changes have no precise timing, and the factors affecting the change are numerous. However, it is known that after the ages of 40 to 50, spinal alignment and posture in healthy individuals begin to deteriorate (Boyle, Milne & Singer 2002: 366; Katzman *et al.* 2010: 352).

Kayaking is a form of physical exercise that mainly involves the upper body and significant core activation. By the nature of the activity of kayaking, it is difficult to maintain a neutral lumbar spine alignment in the seated position (McKean & Burkett 2010: 538). A prolonged seated position is, therefore, associated with kayaking and may lead to poor movement patterns and postural trends. McKean and Burkett (2010: 538) highlight that although strong trunk and pelvic girdle muscles are needed for optimal function when kayaking, there is no evidence to assess if hip or trunk posture influences performance in kayaking.

Boyle, Milne and Singer (2002: 361) state that ''the consequence of an accentuated thoracic curvature is mirrored in the cervical region with compensatory adjustments to head posture required for forward gaze'' (Boyle, Milne & Singer 2002: 361). Therefore, altered cervical curvatures may be adopted in the kayaking position due to varied thoracic curvatures.

López-Miñarro, Alacid and Rodriguez-Garcia (2010) conducted a study to compare the sagittal spinal curvatures between junior kayakers and non-kayakers, in participants aged 13 to 14 years old. They found that repeated specific kayaking training produced a reduction in lumbar lordosis in standing positions and a greater thoracic and lumbar curvature seen in forward bending with maximal trunk flexion (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 310). In this study, it was suggested that long-term studies for sagittal spinal curvatures are necessary, as spinal curvatures are known to change as a child grows. This indicates a need for follow-up assessment over years, or to assess spinal curvatures in older age groups, where specific kayaking postural patterns may have been adopted.

A gap in the literature is that postural studies of spinal curvatures and posture in individuals who kayak are limited. Studies have been conducted on younger individuals, but the spinal curvature effects of years of kayaking combined with aging are undetermined. This chapter aims to review and discuss relevant literature pertaining to factors affecting spinal alignment, such as age and physical activity, with a particular focus on kayaking.

2.2 KAYAKING

The term kayaking is explained as propelling a kayak forward in a body of water by the use of a paddle blade (Fisher 2015: 2). According to Rowe (1989), paddling refers to ‘‘a primitive battle with a hostile environment’’ (Rowe 1989; Hudson & Beedie 2006: 65). The act of paddling can be done in a canoe (unilateral stroke) and a kayak (bilateral strokes). The terms paddling, canoeing, and kayaking are frequently used interchangeably. In this study, the term ‘’kayakers’’ has been used to describe individuals who partake in the activity of kayaking.

Kayaking is a popular sport and recreational activity that involves paddling a small watercraft known as a kayak. The activity of kayaking has been around for hundreds of years and was introduced as an Olympic sport in 1936 (Isorna-Folgar *et al.* 2021: 1). Historically, kayaking served as a means for hunting, fishing, and transportation, originating from Arctic regions. Over the years, kayaking has evolved into a diverse sport and takes place in various settings including wilderness areas, the ocean, rivers, and lakes (Kruger & Saayman 2013: 1158).

Recreational kayaking is perhaps the most accessible form for beginners, and emphasises leisurely paddling on calm waters such as lakes, slow-moving rivers, and coastal areas. This broad accessibility has contributed to kayaking popularity worldwide, appealing to individuals seeking adventure and competition. As a longstanding Olympic sport, canoeing and kayaking continue to grow in popularity on a worldwide scale, with over 150 member countries forming part of the International Canoe Federation (sport governing body of sprint canoeing and kayaking) (Pelham, Robinson & Holt 2020: 22). In South Africa, kayaking has grown in popularity. The formalisation of the sport dates back to 1951, with the initiation of the Dusi Canoe Marathon (Kruger & Saayman 2013: 1158).

The kayak typically features a closed cockpit and is propelled forward using a double-bladed paddle. Unlike canoeing, where athletes paddle on one side while kneeling, kayakers employ a bilateral paddling technique while seated in the craft. The kayak stroke, as described by Mann and Kearney (1980), involves a rhythmic sequence starting with blade contact in the water, moving through the water in the power phase, followed by the blade exiting the water, and concluded by recovery (Mann & Kearney 1980: 184-186). This stroke mechanism is critical for maintaining horizontal velocity efficiently during competition and forward motion.

Another model, as seen in Figure 1, explains the stroke cycle as being divided into two phases, propulsion and recovery. The propulsion phase can be further divided into four subphases: entry, pull, exit and recovery. For a detailed breakdown, the stroke cycle has been divided according to the paddle's interaction with the water, namely, blade catching, immersion, extraction, and release. The duration of the pull phase and the ratio of propulsion time to recovery time significantly influence overall kayaking performance (Liu *et al.* 2021: 9).

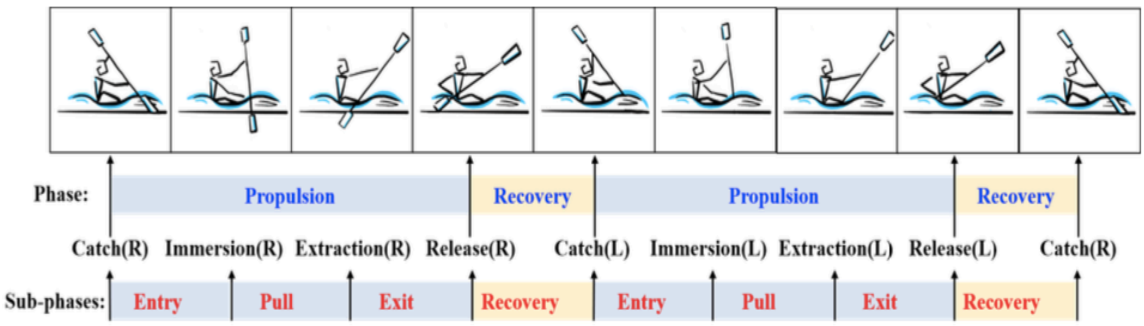

Figure 1. The model of kayak motion analysis including two levels

Phases and subphases. The phases defining positions are entry, pull, exit, and return. R, Right side; L, left side (Liu *et al.* 2021: 9)

2.3 ANATOMY OF THE VERTEBRAL COLUMN

The vertebral column is made up of 33 vertebrae and is categorised into five regions: seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, five sacral, and four coccygeal vertebrae (Moore, Dalley & Agur 2013: 440). Notably, in adulthood, the inferior nine vertebrae (five sacral and four coccygeal), and the sacral vertebrae fuse to form the sacrum, and the coccygeal vertebrae fuse into the coccyx. This restricts movement in this area of the spine and therefore means that the superior twenty-five vertebrae are responsible for spinal movement (Moore, Dalley & Agur 2013: 440).

In adults, the vertebral column typically measures 72-75 cm in length, extending from the base of the skull (cranium) to the tip of the coccyx (Moore, Dalley & Agur 2013: 440). Each vertebrae is separated by fibrocartilaginous Intervertebral Discs (IVDs) (Moore, Dalley & Agur 2013: 440). A typical vertebra includes the vertebral body, vertebral arch composed of two pedicles and two laminae, and seven processes: two transverse processes, one spinous process, two superior and two inferior articular processes, as seen in Figure 6 (Moore, Dalley & Agur 2013: 441). Despite limited movement between adjacent vertebrae, along with intervertebral discs (IVDs), the vertebral column is a sturdy yet flexible column that encases and safeguards the spinal cord (Moore, Dalley & Agur 2013: 440).

Vertebrae exhibit varying sizes and specific characteristics with respect to regions along the spine, yet each vertebra maintains a fundamental structural design. The vertebrae progressively increase in size as they descend towards the sacrum, accommodating the increasing weight-bearing responsibility of the lower vertebral column. The superior articular processes connect with the inferior articular processes of the vertebra above, forming the zygapophysial joints, commonly known as facet joints. (Moore, Dalley & Agur 2013: 443).

2.4 MUSCLES INVOLVED IN KAYAKING

Upper body musculature is utilised to propel oneself forward in a kayak. Previous literature has described the latissimus dorsi muscle as the prime mover during kayaking (Fisher 2015: 6). This is consistent with its anatomical role, as described by Moore, Dalley and Agur (2013: 700), where the muscle pulls the body towards an outstretched arm (Moore, Dalley & Agur 2013: 700). The latissimus dorsi muscle works in combination with the pectoralis major muscle to act on the arm (Moore, Dalley & Agur 2013: 701).

When the paddle blade is submerged in the water, there is a concentric contraction of the ipsilateral latissimus dorsi muscle that results in pulling the boat toward the outstretched arm (Fisher 2015: 6). This muscle also contributes to ipsilateral trunk rotation, a noted movement in the kayaking stroke. This rotation further assists the forward movement where the trunk is rotated towards the stroke side.

According to Moore, Dalley and Agur (2013: 486), the spinal extensor muscles are most involved in maintaining correct spinal alignment and upright posture (Moore, Dalley & Agur 2013: 486). The erector spinae muscles in the lumbar spine are activated bilaterally to extend the spine, and are known to stabilise the torso during trunk rotation (Fisher 2015: 95). Due to their stabilising function, in seated positions, the erector spinae muscles are activated to control weight shifting as the trunk rotates (Fisher 2015: 95). Along with the extensor spinae muscles, the gluteus medius muscles serve as stabilisers during the kayak stroke, and the combination of extensor spinae and gluteus medius activation contributes significantly to the stability of the individual in the kayak (Fisher 2015: 95).

Associations have been found between the external oblique muscle on contralateral kayaking strokes. Contraction of the external oblique muscle causes trunk rotation towards the opposite side (Fisher 2015: 7). Activation of these muscles is significant with relation to performance, using trunk torque production and alternating kayaking strokes (Fisher 2015: 7).

Fisher (2015: 7) explains that the pectoralis major aids in shoulder adduction, making it active during the contralateral pull phase, along with the contralateral latissimus dorsi. The lower fibres of the trapezius muscle facilitate upward scapular rotation during arm elevation, and are expected to engage throughout all phases of the kayaking stroke, with most activity when under load during the ipsilateral pulling phase of the stroke (Fisher 2015: 7).

2.5 ANATOMICAL PLANES AND STRUCTURES RELEVANT TO SPINAL ALIGNMENT

2.5.1 Anatomical Planes

According to Moore, Dalley and Agur (2013: 5), in the anatomical position, the body is imagined as standing upright with the head, eyes, and toes directed forward. The arms are positioned alongside the body with the palms facing forward, and the feet are spaced hip-width apart and parallel (Moore, Dalley & Agur 2013: 5).

The anatomical description of the body is based on four imaginary planes (Moore, Dalley & Agur 2013: 5-6), as seen in Figure 2 and explained:

- **Median plane**: This vertical plane divides the body longitudinally into left and right halves. It is also known as the body's midline.
- **Sagittal plane**: Any vertical plane parallel to the median plane that passes through the body.
- **Frontal plane / Coronal plane**: Any vertical plane that passes through the body at a right angle to the median plane.
- **Transverse plane**: Any horizontal plane that passes through the body at a right angle to the median and frontal planes, dividing the body into upper (superior) and lower (inferior) segments.

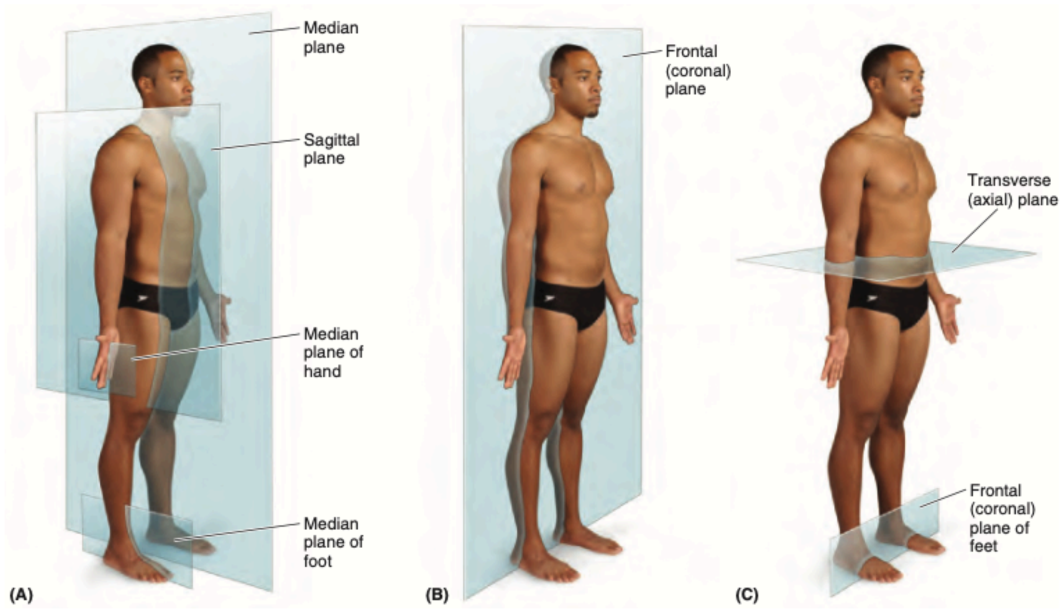

Figure 2. Anatomical planes (Moore, Dalley and Agur 2013: 6)

2.5.2 Spinal Curvatures

The vertebral column is made up of 33 spinal vertebrae and IVDs, and extends from the cranium to the apex of the coccyx (Moore, Dalley & Agur 2013: 464). In adults, the vertebral column has four curvatures that exist in the cervical, thoracic, lumbar, and sacral regions of the spine. The thoracic and sacral curvatures are described as kyphotic (concave anteriorly), while the cervical and lumbar curvatures are described as lordotic (concave posteriorly). At birth, the human spinal column forms a single C-shaped curve that is described as concave anteriorly. The thoracic and sacral curvatures are described as primary curvatures, and are kyphotic in nature, which exists with reference to the flexed foetal position. As the musculoskeletal system matures and undergoes change as one ages, the spinal column and resultant curvatures undergoes significant transformation and secondary curvatures develop, namely, the cervical and lumbar lordotic curves, as seen in Figure 3 (Moore, Dalley & Agur 2013: 470-471).

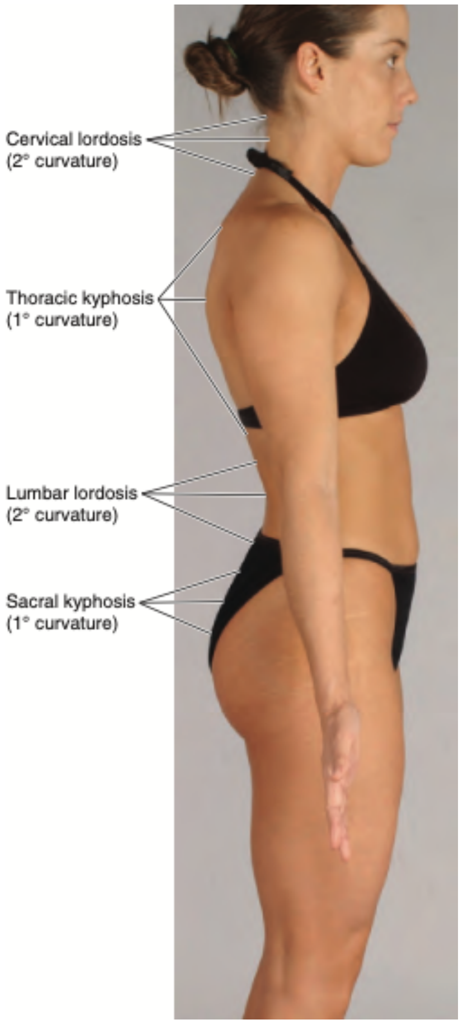

Figure 3. Surface anatomy of curvatures of the vertebral column (Moore, Dalley & Agur 2013: 471)

Throughout life, both primary and secondary curvatures undergo varying degrees of change during different stages of growth (Moore, Dalley & Agur 2013: 471). In the normal spine, these curvatures are adaptable, and flexible, and can be altered through the process of normal movements (Hawes & O'Brien 2006: 1). Spinal curvatures serve as shock absorbers, enhancing flexibility beyond what IVDs provide (Moore, Dalley & Agur 2013: 471).

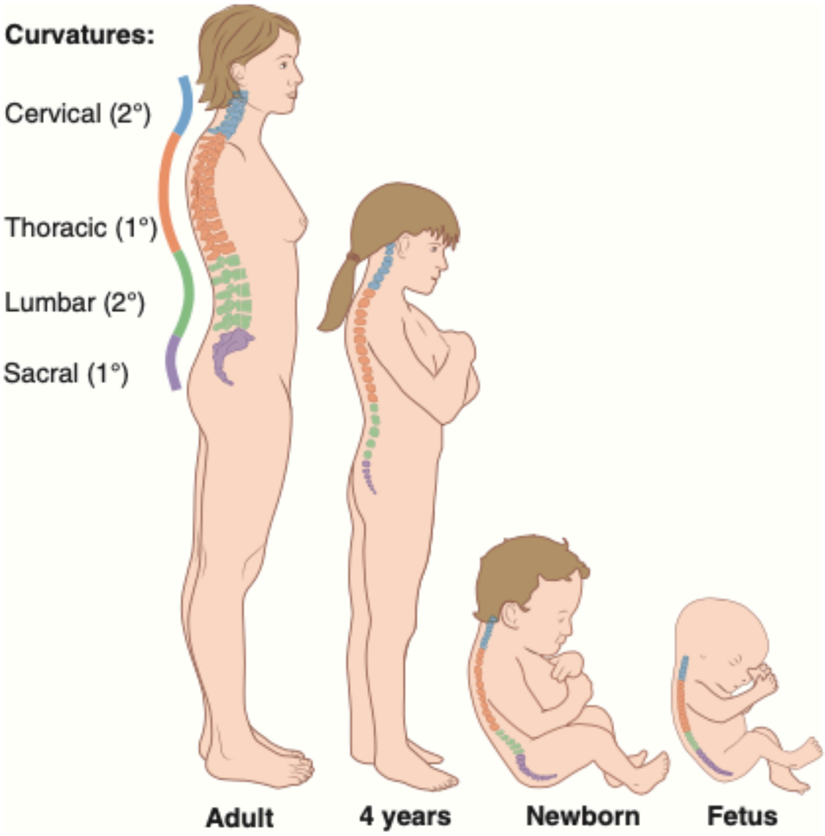

Figure 4. Curvatures of the vertebral column (Moore, Dalley & Agur 2013: 471)

Increased weight-bearing compresses both the IVDs and spinal curvatures (Moore, Dalley & Agur 2013: 471). While IVD flexibility is passive due to facet joints and spinal ligaments limiting excessive movement, spinal curvatures exhibit dynamic flexibility. They respond to weight-bearing by accentuating, and are actively countered by antagonistic muscle contraction, adding a dynamic, adaptable element (Moore, Dalley & Agur 2013: 471).

The degree of spinal curvature (lordosis and kyphosis) results from internal factors such as vertebral body and IVD shape, and external factors broadly categorised as age, physical activity, pathology or injury (Moore, Dalley & Agur 2013: 471).

2.5.3 Posture

Posture is defined as the alignment of the body segments at a particular time, and is crucial for maintaining musculoskeletal health and functional independence throughout life (Ruivo, Pezarat-Correia & Carita 2015: 74). Posture is described as dynamic, as it is influenced by a series of body positions that change with movement (Wietlisbach, DeMott & Flinn 2019: 21). While optimal posture is typically associated with youth, its adaptability becomes increasingly significant as individuals age. Aging brings about various physiological changes, such as decreased bone and muscle mass, altered joint mobility, and sensory perception, which significantly influence posture (Amarya, Singh & Sabharwal 2018: 7-8).

Posture is adaptable and influenced by several factors, which reflect the body's ability to adjust to various conditions and external demands. Factors such as sensory feedback, motor control, muscle recruitment patterns, exposure to environmental stimulus, and adaptation to task-specific demands influence posture (Zemková & Kováčiková 2023: 2) and can have positive and/or negative consequences.

Researchers describe how "posture follows movement like a shadow", a concept that has been further expanded upon to include posture anticipating movement as well (Ivanenko & Gurfinkel 2018: 7). In this regard, human movement and posture are linked with various biomechanical and neurophysiological approaches considered, in order to understand how postural control mechanisms function. It is understood that the central nervous system manages sensory input and motor output, which significantly influences posture regulation. Clinical observations have long established that central nervous system lesions can significantly alter posture (Ivanenko & Gurfinkel 2018: 1). Posture is sustained through constant muscle contractions that counteract gravity and stabilise body segments. Postural tone refers to the mild muscle tension observed in skeletal muscles; distal and proximal (trunk and neck), and is the foundation of typical human posture during sitting or standing (Ivanenko & Gurfinkel 2018: 3).

Correct posture is considered to be the ''position in which minimum stress is placed on each joint'' (Yamak *et al.* 2018: 1379). While incorrect posture is any position that increases stress on joints. Studies indicate that among various skeletal anomalies, head forward posture, thoracic hyperkyphosis, flat back, kypholordotic posture, and scoliosis are among the most common (Yamak *et al.* 2018: 1379). These postural deformities are frequently encountered issues and can be exacerbated by sedentary lifestyles, such as prolonged television viewing, motorised transportation, fast food consumption, and insufficient physical activity (Yamak *et al.* 2018: 1378). Additionally, improper sitting, standing, carrying heavy objects, wearing inappropriate clothing, genetic factors, cultural norms, and body proportions can contribute to deviations from ideal posture, and predispose individuals to skeletal abnormalities (Yamak *et al.* 2018: 1380)

Physical activity is crucial for maintaining healthy skeletal function. Engaging in sports and regular exercise can positively impact posture depending on an individual’s specific characteristics (Yamak *et al.* 2018: 1377). Exercises that focus on strengthening the core, abdominal muscles, and lower back can significantly reduce muscle imbalances and therefore improve posture (Yamak *et al.* 2018: 1377).

2.6 FACTORS THAT AFFECT SPINAL CURVATURES

Spinal curvatures are adaptable and change over time, with many factors influencing the change that occurs (Moore, Dalley & Agur 2013: 470-471). Factors including age and sex, physical activity, pathology, and injury are discussed in the following section.

2.6.1 Age and Sex

Age-related changes occur in every part of the musculoskeletal complex including the spine (Diebo *et al.* 2015: 299), with trends indicating that sagittal spinal alignment deteriorates as age increases past the fourth to fifth decade of life (Boyle, Milne & Singer 2002: 366; Katzman *et al.* 2010: 352; Roghani *et al.* 2017: 567).

The aging process plays a major role in spinal curvature changes, along with degenerative changes in the spine. Postural changes, notably hyperkyphosis, are only starting to be recognised as a significant health concern for medical clinicians (Bansal, Katzman & Giangregorio 2014: 129) and current treatment programmes include surgery, bracing, and physiotherapy. This highlights the importance of identifying postural patterns early in life, to avoid postural abnormalities and the associated health implications where possible.

As one ages many physiological changes that occur. As noted by Benoist (2005: 4), it is difficult to distinguish aging from degenerative changes, as degeneration as a consequence of ageing (Benoist 2005: 4). The degree of degeneration people experience varies, with many factors influencing how someone ages. Benoist (2005: 4) explains that age-related changes in spinal structure primarily result from genetic predispositions and lifelong exposure to mechanical forces (Benoist 2005: 4).

Despite the mechanism, the degenerative changes in the spine begin with subtle biochemical alterations, progress to micro-structural changes, and eventually, culminate into noticeable gross structural changes of the spinal unit (Benoist 2005: 4). Structural change that is observed in a spinal unit consists of decreased bone density, decreased intervertebral disc height, loss of intervertebral disc flexibility, ligamentous weakening, loss of muscle size and strength (Benoist 2005: 4).

As previously noted, significant variations exist amongst individuals, with some older individuals exhibiting characteristics of a younger spine. While many factors contributing to spinal degradation and degeneration remain unidentified, genetic predisposition plays a crucial role, alongside the significant influence of the physical environment. Building on this, Benoist (2005: 7) adds that currently, the only available understanding of prevention or inhibition of these changes includes maintaining proper nutrition, engaging in sufficient physical exercise, and refraining from excessive physical strain (Benoist 2005: 7).

An association has been found in older individuals between trunk deformities in the sagittal plane and functional impairment in daily activities (Takahashi *et al.* 2005: 278). Furthermore, Takahashi *et al.* (2005: 273) suggest that as a result of postural abnormalities, balance is affected and the risk of falling is increased.

The effect of age on spinal curvature differs between males and females, with females developing hyperkyphosis earlier than males and generally have a greater degree of kyphosis (Roghani *et al.* 2017: 568). According to Katzman *et al.* (2017b: 2), thoracic kyphosis greater than 40 degrees is commonly defined as 'hyperkyphosis'. Katzman *et al.* (2017b: 2) further explains that there is no standard intervention to reduce the effect of age-related hyperkyphosis, however, the study found that older males had greater spinal extensor muscle strength than females, which may affect responses to exercise, targeted to reduce hyperkyphosis (Katzman *et al.* 2017b: 2).

In a large cohort study involving individuals aged 60 to 70 years, the prevalence of hyperkyphosis differed significantly between males and females, with 28% of females affected, compared to 14% of males (Katzman *et al.* 2017b: 2). Researchers Kado *et al.* (2013: 179) and Katzman *et al.* (2017b: 2) highlight that factors such as osteoporosis, vertebral fractures, degenerative disc disease, weakness and density of spinal extensor muscles contribute to the severity of thoracic kyphosis (Kado *et al.* 2013: 179; Katzman *et al.* 2017b: 2). Katzman *et al.* (2017b: 2) continues to explain that these musculoskeletal impairments are more prevalent in females, and potentially explain the higher incidence and progression of kyphosis observed in this group as they age. Older males generally exhibit greater spinal extensor muscle strength, and less fatty infiltration in their muscles compared to females, which may influence the incidence of hyperkyphosis between the sexes (Katzman *et al.* 2017b: 2).

2.6.2 Physical Activity

There are many documented and well-known benefits of physical activity with respect to lifespan and quality of life. Being physically active is widely recognised as a fundamental pillar of a healthy lifestyle. It is well-established that sports and physical activities provide significant benefits, not only to physical but also to mental health (Yamak *et al.* 2018: 1378).

Exercise is a deliberate form of physical activity aimed at improving or maintaining physical fitness. Exercise is planned, structured, repetitive, and purposeful, with the specific goal of enhancing one or more components of physical fitness (Yamak *et al.* 2018: 1378). Additionally, regular physical activity plays a crucial role in maintaining muscle strength, joint structure, joint function, and bone health (Yamak *et al.* 2018: 1378).

The health advantages of physical activity and exercise are undeniable. Virtually everyone stands to gain from increasing their physical activity levels or fitness. Regular physical activity and exercise serve as an effective measure to prevent and manage chronic medical conditions, and premature mortality (Pedersen & Saltin 2015: 47; Warburton & Bredin 2016: 501). According to the World Health Organization (WHO), physical inactivity ranks as the fourth leading risk factor for global mortality, contributing to approximately 3.2 million deaths annually (WHO 2010).

Previous research indicates that adults typically spend more than half of their waking hours engaged in sedentary behaviours (Matthews *et al.* 2008: 3; Tudor-Locke *et al.* 2011: 1385-1386). While the connection between sedentary behaviour and health outcomes such as low back pain, remains uncertain, some studies have found an association between sitting time and low back pain (Gupta *et al.* 2015: 11;

Kastelic, Kozinc & Šarabon 2018: 78; Shiri *et al.* 2019: 290). Potential mechanisms linking sedentary behaviour to low back pain include biomechanical factors, such as reduced lower back muscle strength and increased stiffness in the lumbar spine (Waongenngarm, Areerak & Janwantanakul 2018: 230) due to prolonged sitting.

Sedrez *et al.* (2015: 76) found that increased time spent in seated positions and participating in certain physical exercises, specifically the type of sport practiced, can influence the type of musculoskeletal response and lead to postural change (Sedrez *et al.* 2015: 76). López-Miñarro *et al.* (2017: 113) concluded that sport-specific exercise has been associated with adaptations in sagittal spine curvatures. This study found that because specific positions and movements during training and competition are maintained for extended periods, adaptations in the spine and pelvic postures are generated (López-Miñarro *et al.* 2017: 113).

2.6.3 Sedentary Behaviour

A prolonged seated posture and associated poor seated postures are becoming more and more prevalent, as many people spend a lot of time sitting down. This is commonly seen in scholars, the workplace, and during time spent travelling. Van Uffelen *et al.* (2010: 380) found that occupational sitting is likely to be the biggest contributor to daily time spent seated as many adults in Western, developed countries, are in occupations that require prolonged sitting time (Van Uffelen *et al.* 2010: 380). Numerous factors contribute to increased sitting time with varied positions of the sitting posture. A study conducted by Tsagkaris *et al.* (2022: 2), investigated spinal configuration in standing, versus seated positions in healthy individuals. The study demonstrated that sitting predominantly affects the thoracolumbar region of the spine. The findings of the study revealed that while in a seated position there is a decrease of approximately 50% in the lumbar lordosis, compared to standing (Tsagkaris *et al.* 2022: 2). Furthermore, the lumbar lordosis was further reduced among middle-aged and elderly individuals compared to young adults. Due to the nature of different seated positions, lack of a strict definition for a standard seated posture, and predisposing factors that may affect posture while seated, there is a variability that arises regarding spinal alignment while seated.

Sitting for extended periods does not only affect spinal alignment, there is evidence that increased amounts of daily total sitting time and physical inactivity are associated with an increased risk of all-cause mortality (Rezende *et al.* 2016: 253).

A meta-analysis investigating sitting time found that even with taking physical exercise into account, there was a 5% increased risk of all-cause mortality for each one hour increment of sitting time per day, for adults who sit for more than seven hours per day (Rezende *et al.* 2016: 253-254). Rezende *et al.* (2016: 257) found that eliminating sitting time would increase life expectancy by 0.23% on average. Although this is lower than factors such as smoking and obesity, it can be deduced that less time spent in sedentary behaviour and promoting physical activity is an important aspect in reducing premature mortality (Rezende *et al.* 2016: 257).

As per a Canadian movement guideline study, it is recommended to limiting sedentary behaviour to eight hours or less per day and that breaking up long periods of sitting is beneficial for adults (Ross *et al.* 2020: 70). According to the WHO, adults aged between 18 to 64 years should partake in regular physical exercise for at least 150 to 300 minutes of moderate-intensity aerobic physical activity or 75 to 150 minutes of vigorous-intensity aerobic physical activity throughout the week, with additional muscle-strengthening exercises that include major muscles groups at least twice per week (WHO 2020: 2). These guidelines focus on physical activity guidelines, and recommend that adults should limit time spent in sedentary behaviour, however, they do not give any time frames with regards to sedentary behaviour.

2.6.4 Pathology of the Spinal Column

Pathology and traumatic injuries can significantly impact spinal curvatures, leading to deformities and/or misalignments that can affect the overall structure and functioning of the spine. Common examples of pathological conditions affecting the spine include osteoporosis, osteoarthritis, spinal tumours, and congenital disorders (i.e. scoliosis) (Moore, Dalley & Agur 2013: 580-581). These conditions can weaken or alter the normal structure of the spine and surrounding tissues, leading to spinal curvature changes.

Back pain is a common pathology of the spine and associated symptoms may occur as a result of biomechanical alterations of degeneration (Iorio, Jakoi & Singla 2016: 377). Individuals with back pain and structural spinal deformities often use compensatory mechanisms including changes in lordosis and pelvic tilt angles, to stand in an upright position (Buckland *et al.* 2017: 30). Consequences of spinal deformity such as the development of a pathological gait, and change in spinal curvature and alignment is dependent on the severity of the deformity (Syczewska *et al.* 2012: 212-213).

Degeneration of the functional spinal unit is a pathological change that ultimately results in modification of spinal segmental motion, and changes to the structure of the spinal unit (Iorio, Jakoi & Singla 2016: 382). These changes produce mechanical and clinical symptoms as a result of permanent structural change of the spinal unit, and are associated with sagittal spinal malalignment and imbalance (Bao *et al.* 2014: 1446; Iorio, Jakoi & Singla 2016: 382).

2.6.5 Injury to the Spinal Column

The natural curvatures of the vertebral spine can be misaligned or exaggerated when disorders of the spinal column occur (Kuo *et al.* 2019: 1). Altered or abnormal spinal curvatures seen in scoliosis, hyper or hypokyphotic (flatback) and hypo and hyperlordotic (swayback) postures can predispose individuals to spinal injuries and have negative musculoskeletal consequences (Kuo *et al.* 2019: 6).

The spinal column is designed to have a shock absorption mechanism, maintained by the healthy IVDs and natural spinal curvatures (Moore, Dalley & Agur 2013: 471). Injuries to the spinal column can be attributed to loss of the natural shock absorption function seen in altered spinal curvatures. Alterations such as an exaggeration, flattening and displacement of these normal curvatures, can lead to increased risk of injury to the spinal column, ranging from IVD bulges to IVD herniation, and muscles imbalances, which influence the biomechanical strength of the spine and is associated with injury to the spinal column (Desmoulin, Pradhan & Milner 2020: 463).

Common spinal injuries include traumatic events such as falls or motor vehicle accidents (Patek & Stewart 2023: 406) which can result in vertebral fractures or dislocations, disrupting the normal alignment of the spine. The cervical spine is reported to be the most common site of traumatic injury when compared to the lumbar and thoracic regions of the vertebral column (Patek & Stewart 2023: 407).

Fractures of the spine alter the load-bearing ability of the vertebral column and may lead to instability with resultant abnormal spinal curvatures (Luo *et al.* 2017: 872; Liebsch & Wilke 2022: 152). Altered spinal curvatures because of injury to the spine are highly dependent on the location and severity of the injury. As noted by Luo *et* *al.* (2017: 864), injury to the spine can often affect multiple spinal levels, leading to biomechanical changes throughout the spinal column (Luo *et al.* 2017: 864).

Severe trauma to the spine can also lead to spinal cord injuries. These injuries do not only cause neurological deficits, but can also impact the stability and alignment of the spine (Goel 2022: 2). Injuries to the spinal cord can result in muscle weakness and paralysis (Hornby *et al.* 2020: 70), which ultimately affects the supporting structures of the spine and can lead to abnormal curvatures.

2.7 PHYSIOLOGICAL DEMANDS OF KAYAKING

Kayaking is an activity that involves a prolonged seated posture and places specific demands on upper body posture (Chung 2015: 1). Although physical exercise is known to be beneficial to one's health, it is theorised that over time, posture can be altered due to a prolonged seated position maintained when kayaking. The fact that postures are altered by increasing age also contributes to the theory that older kayakers may display altered spinal curvatures.

The unstable water surface creates a complex interaction of forces acting on the man-boat system, which presents a challenge for postural balance to avoid capsizing (Stambolieva *et al.* 2012: 1808). Spinal curvatures may be affected by sports training that is specific and repetitive (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 302). López-Miñarro *et al.* (2017: 109) explained that exposure to intense athletic training over the years increases the risk of developing spinal disorders in athletes of certain sports disciplines (López-Miñarro *et al.* 2017: 109). López-Miñarro *et al.* (2017: 110) further explained that kayaking specifically involves forward trunk flexion while sitting, which over years of repetitive training may influence one's posture.

2.8 KAYAKING BIOMECHANICS

As described by Mann and Kearney (1980: 187), the kayaking stroke is a complex skill that involves applying repetitive horizontal force to generate and sustain boat speed (Mann & Kearney 1980: 187). This force is achieved through a movement pattern described by Mann and Kearney (1980), using a paddling blade to perform a bilateral push-then-pull action carried out by upper body musculature while seated in a kayak (Mann & Kearney 1980: 186; Liu *et al.* 2021: 13). To do this there needs to be sufficient trunk rotation, glenohumeral and scapular motion, as well as balance and stability in the kayak (Mann & Kearney 1980: 186). In any activity that involves generating force, maximising the distance over which optimal force is applied, leads to greater changes in velocity (Mann & Kearney 1980: 186). For maximal efficiency while kayaking, maintaining optimal paddle position for an extended time is crucial. Mann and Kearney (1980: 188) explained that once the paddle passes the power position, it is quickly withdrawn as effective force production diminishes (Mann & Kearney 1980: 188).

While seated in a kayak, the surface of the water is unstable and is more complex than sitting or standing on stable ground. Raising the centre of gravity by transitioning from a slouched posture to an upright posture is likely to decrease the paddler's stability, making it more challenging to control the kayak's three-dimensional movements (Fisher 2015: 18). Fisher (2015: 18) continues to explain that the interaction between the benefits and drawbacks of an upright posture or straight spine is likely influenced by factors such as core strength, balance, and flexibility (Fisher 2015: 18).

Mann and Kearney (1980: 187) add that balance in a kayak is preserved by shifting the kayaker's weight to construct external forces that could disrupt lateral stability. Performing loaded shoulder flexion is more effective in an upright (straight spine) posture, than in a slouched posture, as it allows for significantly greater force generation (Fisher 2015: 18). Fisher (2015: 18) further explains that when the spine is in an erect posture, the scapula can tilt posteriorly, bringing the muscle attachments closer to the humerus. Mann and Kearney (1980: 183) hypothesise that incorporating some hip flexion, leading to a forward lean of the torso, could be advantageous during the kayak stroke. This positioning places the portion of the stroke in front of the hip, which makes the stroke more efficient (Mann & Kearney 1980: 183). This suggests a change from a normal neutral posture, into a forward-leaning posture, causing some degree of change to the spinal curvatures.

The curvature of the thoracic spine closely influences the position of the scapula due to their connection at the scapulothoracic joint (Fisher 2015: 17). Increased thoracic kyphosis restricts the scapula's ability to tilt posterior, thus affecting proper scapulohumeral movement (Fisher 2015: 17).

The cervical spine also affects the position of the scapula (Thigpen *et al.* 2010: 701; Weon *et al.* 2010: 368). This posture, characterised by the head being positioned forward rather than aligned superiorly with the neck, combined with rounded shoulders relative to the thoracic spine (often referred to as forward head and rounded shoulder posture), has been linked to notably increased anterior tilting of the scapula (Thigpen *et al.* 2010: 701; Weon *et al.* 2010: 368). Altered scapular positions and movements may be the link to the prevalence of shoulder pain and injuries among kayakers, with the influence of posture having major significance in scapula and shoulder biomechanics.

Pelvic rotation initiates trunk rotation, which is crucial for enhancing mechanical efficiency during kayaking (Begon, Colloud & Sardain 2010: 388). In light of this, Fisher (2015: 51), hypothesises that kayakers benefit from greater hamstring flexibility to achieve neutral pelvic tilt and facilitate the forward lean, which is known to be a favourable kayaking posture (Fisher 2015: 51).

2.9 KAYAKING INJURIES

As with any sporting or physical activity, injuries range in incidence and severity. As kayaking primarily uses the upper limbs to paddle the kayak forward, the shoulder is reported to present with the greatest number of injuries, compared to other body segments (Spittler, Gillum & DeSanto 2020: 425; Isorna-Folgar *et al.* 2021: 4). A study conducted by Isorna-Folgar *et al.* (2021), found that the second area of most injury incidence in males is the lumbar area (Isorna-Folgar *et al.* 2021: 4). According to Pelham, Robinson and Holt (2020: 22), musculoskeletal injuries, especially in the shoulder, thoracic and scapular regions, are frequent. Overtraining may cause muscle imbalances, dysfunction in glenohumeral and scapular movement patterns, soft tissue damage, and pain (Pelham, Robinson & Holt 2020: 22).

Injuries can range from acute to chronic in presentation, with acute injuries having the capability of persisting and becoming a chronic issue or an overuse injury. Studies indicate that sprains and strains are among the most common acute injuries, followed by lacerations, contusions, fractures, and dislocations (Spittler, Gillum & DeSanto 2020: 424), with the majority of these injuries being caused by falling out of the kayak and dependent on the water conditions one is kayaking in.

Chronic injuries are often related to overuse and are more common in kayakers who participate more frequently (Spittler, Gillum & DeSanto 2020: 425). Spittler, Gillum and DeSanto (2020: 426) note that chronic injuries to the hand, wrist, elbow, shoulder, and forearm are common, and are caused by high repetitions of the symmetrical stroke cycle (Spittler, Gillum & DeSanto 2020: 426). Chronic injuries to the lower extremities are relatively uncommon among kayakers, although cases of ischial tuberosity bursitis and hamstring tendinitis have been documented (Spittler, Gillum & DeSanto 2020: 426). These injuries are thought to arise from extended periods of sitting on a hard seat.

Some studies cite low back pain as a frequent issue among kayakers, constituting approximately 15% of reported injuries, and is often chronic and persisting in nature (Spittler, Gillum & DeSanto 2020: 426). Research has shown that a six-month programme focused on strengthening the trunk musculature led to enhanced core strength, improved lumbar motor control, and better posture (Kiss *et al.* 2019: 377).

2.10 SUMMARY

Spinal curvature alignment and posture change throughout life, often deteriorating with age (Katzman *et al.* 2010: 352; Katzman, Vittinghoff & Kado 2011: 86; Roghani *et al.* 2017: 567). This deterioration is marked by significant alterations in cervical and lumbar lordosis, and especially in thoracic kyphosis (Katzman *et al.* 2010: 352; Been & Kalichman 2014: 91; Diebo *et al.* 2015: 299). While these changes are naturally associated with aging, they can also be influenced by other factors such as physical activity or a lack thereof.

The activity of kayaking involves sustained seated positioning and repetitive trunk rotation while maintaining a forward flexed posture, and although exercise is regarded beneficial for one's health, the long-term consequences of sustained poor postural and movement patterns seen in kayaking may add to the already progressive postural change associated with ageing.

CHAPTER THREE: METHODS

3.1 INTRODUCTION

This chapter discusses the study design, location, sampling, measurement tools, participant recruitment, procedure, ethical guidelines, and statistical analysis.

3.2 STUDY DESIGN

This observational study design used a quantitative approach to compare spinal curvatures and posture between the two groups (kayakers and non-kayakers). Observational studies allow data to be captured without intervention. Participants in observational studies are observed in a natural setting, where independent variables are not manipulated and tend to vary naturally (Turner & Houle 2019: 981). This study design suits the purpose of the study as no intervention is required and the outcomes of the study are purely observational. The results found indicate common postures in kayakers and serve as a basis for understanding curvatures related to kayaking.

3.3 STUDY LOCATION

This study was conducted at the Durban University of Technology (DUT) Chiropractic Day Clinic. An additional data collection location was approved (Appendix N and P), of which participants had the option to meet the researcher, if this proved more convenient. The location of the additional site was The Chiropractic Collective Practice (Abrey Office Park, 5 Abrey Road, Kloof, KwaZulu-Natal) supervised by Dr T Naidoo. Data collection commenced once formal approval had been acquired from the IREC (Appendix O), and permission from the Clinic Director (Appendix A), and the Director of Research and Postgraduate Support (Appendix B) was granted.

3.4 SAMPLE GROUP

The study consisted of two groups: (1) A control group, consisting of physically active individuals who do not participate in kayaking (non-kayakers), and (2) a kayaking group, consisting of individuals who actively kayak. For sample homogeneity, the sample group was limited to males between the ages of 40 and

60 years. Male participants were chosen, as the majority of the kayaking population in KwaZulu-Natal consists of males (Kruger & Saayman 2013: 1163) and additionally, the effect of spinal alignment also differs between males and females (Roghani *et al.* 2017: 568), thus females were not included in this study.

3.5 RESEARCH PARAMETERS

With regards to the spinal alignment parameters measures, cervical lordosis, thoracic kyphosis, and lumber lordosis angles were measured using a Flexicurve ruler (C, T, and L-angles (Flex)). Biomech-Flex software was used to estimate Cobb angles based on the flex angles from each region. The parameters used to measure posture included the use of PosturePro photographic postural analysis software, which calculates a Posture Number.

3.6 MEASUREMENT TOOLS

3.6.1 Demographic Information

Participant demographics and additional information were recorded. This included age, anthropometric variables (height and weight), primary activity, activity frequency, and hours spent participating in their activity as well as activity years. Estimated time spent sitting and time spent stretching was also recorded.

3.6.2 Postural Examination

A postural examination was done to determine participant eligibility. The postural exam identified common postures in the sample population and helped rule out conditions that may influence the natural curvature change associated with aging and the possible curvature changes associated with kayaking. A standing posture evaluation form was completed (Appendix H) which assesses posture in anterior, lateral, and posterior view (Magee 2014: 1142). It was also important to note any past trauma or musculoskeletal deformities that may have had an effect on the patient’s posture and possibly exclude them from the study.

3.6.3 Posture Pro 8 Software

Posture Pro software is an electronic postural analysis system available at DUT. The software requires full-body anterior and lateral photographs and can quantitatively collect data relating to a patient’s posture. Markers were placed in specific anatomical positions which the software interprets and provides the examiner with a postural number that corresponds to a scale that describes the posture. Senthil *et al.* (2018: 3) used Posture Pro 8 software to analyse upper body dysfunction, and found that the postural evaluation of participants using Posture Pro 8 software was reliable and repeatable (Senthil *et al.* 2018: 3).

3.6.4 Flexicurve Ruler

A Flexicurve ruler is a 70cm flexible metal strip covered with plastic and marked in millimetres. This ruler is a measurement tool that can be manipulated to mould and replicate its contact surface (Figure 7) Once the ruler has adopted the relevant spinal curvatures, it can be placed onto graph paper and the curvatures traced onto the graph paper for further evaluation. de Oliveira *et al.* (2012: 8) and Raupp *et al.* (2017: 508) found the Flexicurve to be a valid and reliable instrument to evaluate spinal curvatures and recommended the use of the Flexicurve in the clinical setting (de Oliveira *et al.* 2012: 8; Raupp *et al.* 2017: 508).

3.7 SAMPLE SIZE

In a previous study on surfers and non-surfers over the age of 50 years, the variables cervical lordosis, thoracic kyphosis, and lumbar lordosis were measured and compared for surfer and non-surfer groups. Using a two-sample T-test with a 5% level of significance, a power of 80%, and an effect size of 0.8 (which was regarded as a large effect size) the sample size for each group was calculated to be 26. GPower version 3.1 was used to calculate the sample size (Faul *et al.* 2009: 1149-1160).

3.8 PARTICIPANT RECRUITMENT/SAMPLING METHOD

Participants in both groups needed to meet inclusion requirements that limited participation and this did present some difficulty in recruitment. Study participants were encouraged to relay study information to fellow kayakers and physically active non-kayakers.

A convenience snowball sampling strategy was applied to recruit study participants. This method is a type of non-probability strategy. Snowball sampling is a type of convenience sampling that is used in cases where the sample population needs to meet certain criteria indicated for the nature of the research (Etikan, Musa &

Alkassim 2016: 2) and due to the study specifically looking at males between the ages of 40 to 60 years, the research does not aim to generate results that are representative of all kayakers. The study required one group to share a common characteristic which is the activity of kayaking, and another group to share the common characteristic of being physically active.

Advertisements (Appendix D) regarding the study were sent to relevant kayaking clubs and groups to attract kayakers. Advertisements were also placed in local sporting facilities. Permission to post advertisements using a letter of request was attained before sending the advertisements out (Appendix E). The researcher approached kayakers and non-kayakers and relayed information about the study enquiring if the person would like to participate. It was also anticipated that awareness about the study would spread via word of mouth. Potential participants had the option to contact the researcher telephonically for more information. No coercion was used in participant recruitment.

3.9 INCLUSION AND EXCLUSION CRITERIA

3.9.1 Group 1 — Kayakers

Inclusion criteria:

- Between 40 and 60 years of age.
- All participants are male for sample homogeneity.
- Kayaking is the participant’s primary form of exercise.
- Kayak training history of at least three years.
- Participants need to have been actively training for a minimum of three days a week or three hours per week.

Exclusion criteria:

- Identified structural spinal anomalies (i.e. structural scoliosis, block vertebrae, hemi-vertebrae).
- Musculoskeletal deformities as determined by the postural exam.
- History of spinal surgery (i.e. spinal vertebral fusion).
- History of spinal trauma (i.e. intervertebral disc bulge/herniation, compression fractures).
- Ongoing treatment for back pain (i.e. chiropractic, physiotherapy).

- Chronic respiratory conditions (i.e. chronic bronchitis/emphysema).

3.9.2 Group 2 — Non-kayakers (control)

Inclusion criteria:

- Between 40 and 60 years of age.
- Participants are males for sample homogeneity.
- Participation in at least three hours of physical activity (purposeful exercise) per week.

Exclusion criteria:

- Participation in kayaking training.
- Identified structural spinal anomalies (i.e. structural scoliosis, block vertebrae, hemi-vertebrae).
- Musculoskeletal deformities as determined by the postural exam.
- History of spinal surgery (i.e. spinal vertebral fusion).
- History of spinal trauma (i.e. intervertebral disc bulge/herniation, compression fractures).
- Ongoing treatment for back pain (i.e. chiropractic, physiotherapy).
- Chronic respiratory conditions (i.e. chronic bronchitis/emphysema).

3.10 STUDY PROCEDURE

Upon obtaining ethical approval from the Institutional Research and Ethics Committee – IREC number 158/23 (DUT) (Appendix O), DUT gatekeeper permission (Director of research and post-graduate support) (Appendix B and C) and DUT Chiropractic Day Clinic Director's permission (Appendix A), the data collection commenced.

Once participants had responded to the advertisement or approached the researcher having been referred, the researcher explained the research details and the participant answered pre-screening questions (Appendix F) to ensure that they met the inclusion criteria. These questions related to inclusion and exclusion criteria. Once the inclusion criteria were met, the participant was given an appointment at the DUT Chiropractic Day Clinic or had the option to meet the researcher at the Chiropractic Collective Practice.

Before the commencement of the respective procedures, the participant read and signed the letter of information and consent (Appendix I). A verbal explanation of the research was provided, as well as an opportunity to ask any questions that were answered by the researcher. The participant was placed either into the kayaking or non-kayaking group depending on the screening and inclusion details. Participants completed a brief case history (Appendix G), which included questions regarding past medical history, injuries to the spine, surgeries, or relevant history that would affect inclusion and/or exclusion criteria. A postural examination (Appendix H) was also done to determine if any notable musculoskeletal deformities may have influenced postural development. Once considered eligible, participants were allocated alphanumeric codes to maintain anonymity.

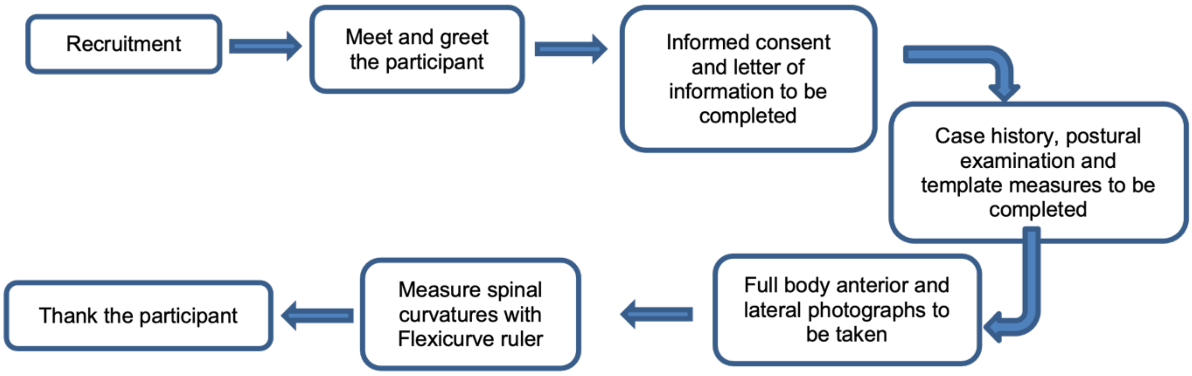

Figure 5. Flow diagram of the research procedure

Anterior and lateral full-body photographs were taken and analysed by Posture Pro software. The participants were instructed as per the Posture Pro user manual. For the anterior view, markers were placed on the following bilateral landmarks: centre of the shoulder and hips (anterior superior iliac spine). Once imported into the software, the participant's eyes also acted as a landmark. For the lateral view, the right side of the participant was used, and markers were placed on the centre of the shoulder, lateral hip, lateral knee, and slightly anterior to the lateral malleolus. Once the markers were correctly placed, the participant was positioned in front of a postural grid and two meters away from the Canon digital camera. The camera was positioned on a tripod stand which was 115 cm above the ground. The distance between the participant and the camera was maintained using markers on the ground. The participants were instructed to stand in a relaxed position. Anterior and right lateral photographs were taken and thereafter imported to the Posture Pro software. Using the lateral view, the Posture Pro software generates a Posture

Number™ which is done by forming a multi-segmented line between the specific anatomical markers. This line is then compared to a straight plumb line and the Posture Number is calculated. A Posture Number of zero indicates no deviation and as the number increases, the greater the deviation from the plumb line (Ventura Designs 2018).

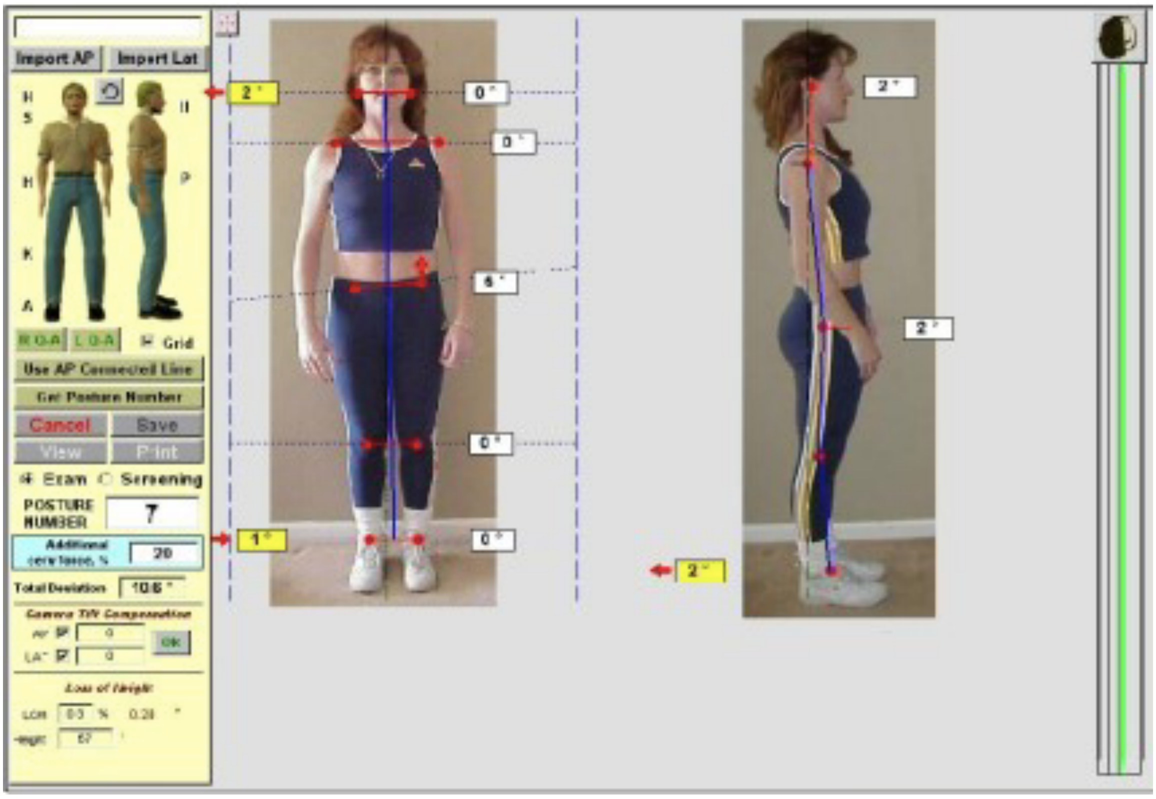

Figure 6. Marker placement and Posture Pro analysis (Ventura Designs 2018)

Using protocols described by Raupp *et al.* (2017: 502-503) and de Oliveira *et al.* (2012: 2-4) the spinal curvatures were measured using a Flexicurve ruler. Once cervical and thoracolumbar curvatures were measured, they were traced onto graph paper, and relevant spinal angles were calculated using the Biomech-Flex software.

For the cervical spine, according to the procedure carried out by Raupp *et al.* (2017: 502-503), participants were instructed to sit on a chair, lower and raise their heads, stop in the neutral position, and gaze forward. The external occipital protuberance (C0), atlas posterior tubercle (C1), and the spinous processes of C2, C7, T1, and T2 were palpated and marked with stickers. The Flexicurve ruler was immediately moulded to the skin covering the cervical spine, and stickers were placed onto the ruler according to and indicating the relevant matching anatomical locations on the skin. Immediately afterward, the Flexicurve ruler was carefully removed and placed onto graph paper, illustrated in Figure 7.

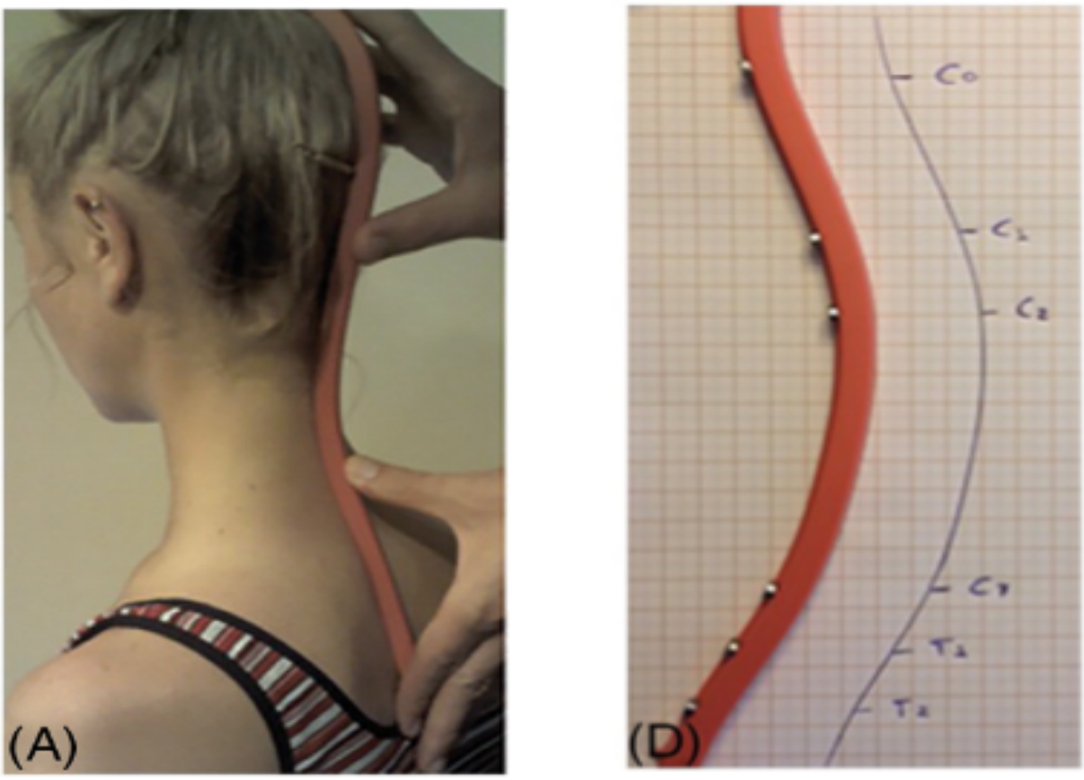

Figure 7. Evaluation using the Flexicurve (Cervical)

A. Moulding the Flexicurve to the shape of the cervical spine

D. Transferring the shape to graph paper (Raupp *et al.* 2017: 503)

The thoracic and lumbar spinal curvatures were evaluated together as per the protocol described by de Oliveira *et al.* (2012: 2-4). Participants were standing with their shoulders and elbows flexed to 90 degrees and resting against a wall, to prevent any movement during the moulding of the Flexicurve ruler. Anatomical landmarks used were the spinous presses of C7, T1, T12, L1, L5, and S1. These landmarks were palpated and marked with a sticker at each level. The Flexicurve ruler was then placed and moulded to the thoracolumbar curvature. Once moulded, the Flexicurve ruler was removed and carefully placed on the graph paper to be traced.

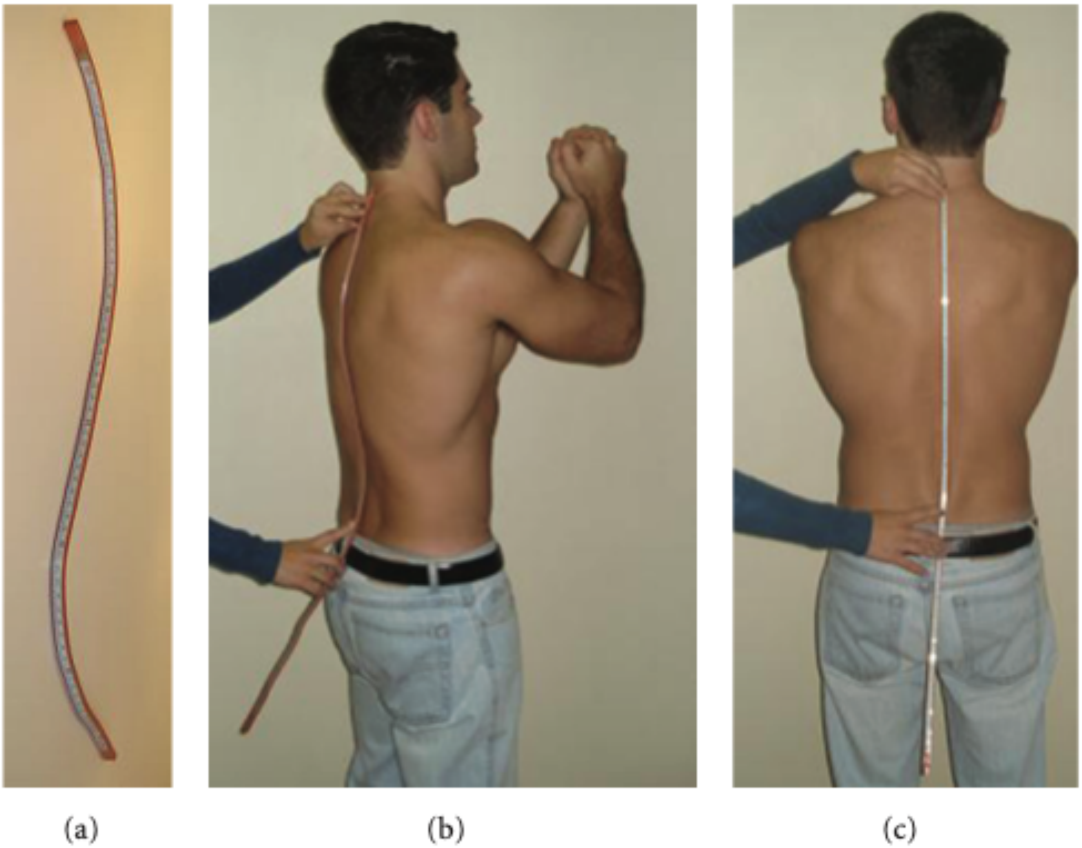

Figure 8. Evaluation using the Flexicurve (Thoracolumbar)

A. Flexicurve

B. Moulding the Flexicurve to the spine, lateral view

C. Moulding the Flexicurve to the spine, posterior view (de Oliveira *et al.* 2012: 3)

With the outline of the cervical and thoracolumbar curvatures on graph paper, a system of Cartesian coordinates was defined, of which the x-axis represented the cranial-caudal direction and the y-axis represented the anterior-posterior direction (de Oliveira *et al.* 2012: 3; Raupp *et al.* 2017: 502). The paired x and y coordinates of each anatomical point, as well as another six intermediate points along each curve, were noted and entered into the Biomech-Flex software (https://www.ufrgs.br/biomec/materiais/) as illustrated in Figures 9 and 10. For the cervical spine curvature, two equidistant intermediate points were placed between C0 and C1, and another four equidistant points were placed between C2 and C7. This produced a total of 12 paired (x and y) coordinates. For the thoracic and lumbar curvatures, six equidistant intermediate points were placed between T1 and T12 for the thoracic spine, and another six equidistant intermediate points were placed between L1 and L5 for the lumbar spine.

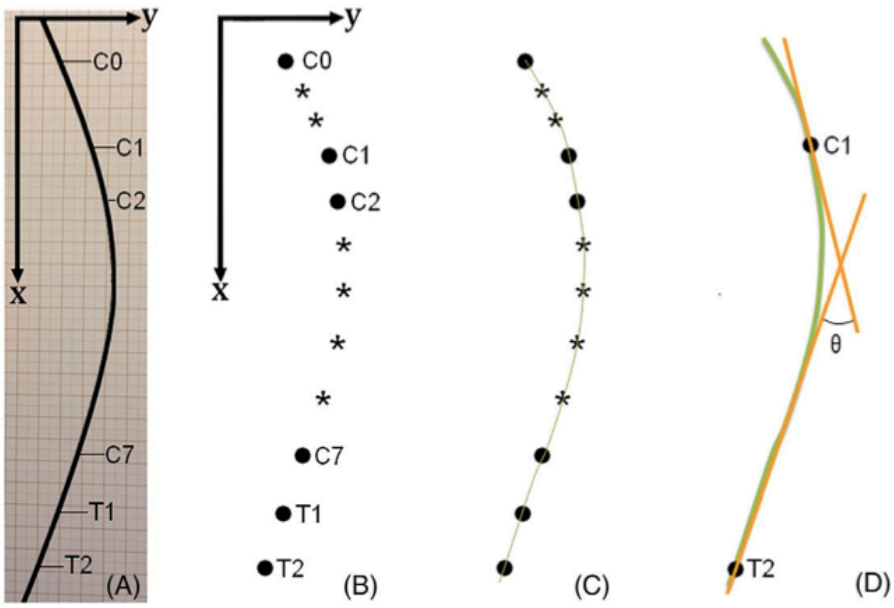

Figure 9. Analysis using the Flexicurve (Cervical)

A. Example of cervical spine curvature
B. Defining the Cartesian system on the outline of the cervical spine; including 6 equidistant intermediate points
C. Third-order polynomial produced by the software
D. Representation of the calculated Flexicurve angle (Raupp *et al.* 2017: 503)

Using the point coordinates for the cervical and thoracolumbar curvatures, the software produced a third-order polynomial representing each curvature. The Flexicurve angle was then calculated (C, T, and L-angles (Flex)). The C-angle (flex) was calculated using straight lines that formed tangents with the coordinates of C1 and T2. For the T and L-angles (flex), perpendicular lines to the tangents at T1 and T12 (thoracic spine), and L1 and L5 (lumbar spine) were drawn. The respective angles were then measured at the intersection points of the perpendicular lines in the thoracic spine (T-Flex) and lumbar spine (L-Flex). The Biomech-Flex software then used Flex values to estimate the Cobb angle of each spinal region. The Cobb angle is a method for assessing a curvature quantitatively and is done by measuring the angle between two lines, drawn perpendicular to the uppermost point involved and the lowest point involved (Horng *et al.* 2019: 1).

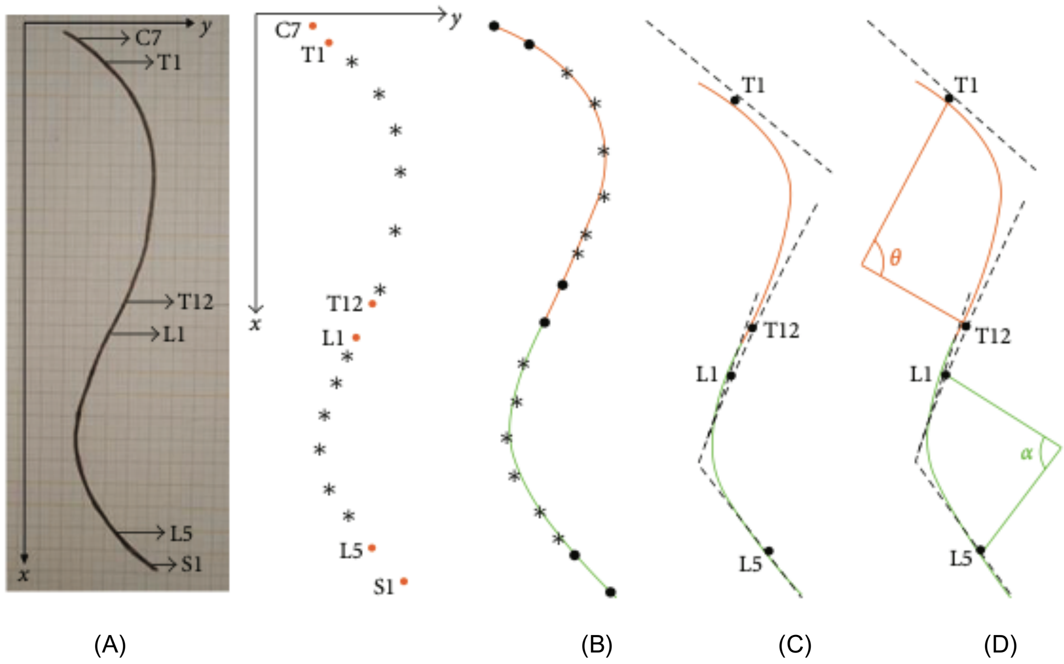

Figure 10. Analysis using the Flexicurve (Thoracolumbar)

A. Outline on graph paper of the spine and points representing the shape of the lumbar and thoracic curvatures;

B. Drawing of the curvatures obtained using two 3rd polynomial;

C. Drawing the tangents on the limit points of the curvatures (T1/T12 for thoracic, L1/L5 for lumbar);

D. Drawing the straight lines perpendicular to the tangents and establishing the thoracic (θ) and lumbar (α) angles (de Oliveira *et al.* 2012: 4)

3.11 ETHICAL CONSIDERATIONS

3.11.1 Justice

Participants were treated fairly and without prejudice. Participant details are confidential and were not published in the final dissertation. Although the study has inclusion and exclusion criteria, participants were not discriminated against based on other criteria (i.e. demographic details, kayaking ability, past medical history, overall fitness).

3.11.2 Non-maleficence

This study carried very low risk to the participants as it was an observational study that required no treatment or intervention. The researcher was under supervision and medical liability in line with the Chiropractic Day Clinic protocols.

Professionalism and ethical considerations were considered and participant's details were kept in the patient's file.

3.11.3 Beneficence

By conducting this study, the kayaking communities and related kayaking clubs will be informed of findings, and in cases where postural abnormalities were detected in participants where treatment or referral is indicated, adequate referral and advice were provided to the participant.

3.11.4 Autonomy

Participants were treated professionally and in line with the Chiropractic Clinic as well as the Allied Health Professions guidelines. Confidentiality of personal details and results of the study are kept secure.

Informed consent (Appendix I) was obtained from each participant, which ties in with the principle of autonomy. Participants were free to leave the study should they wish to do so, without prejudice.

3.11.5 Data storage and disposal

Research data was submitted to the chiropractic programme for storage and disposal and after five years will be shredded. During the duration of the study, all information was stored in the DUT Chiropractic Clinic, in a locked room where it is kept safe. Electronic data was password-secured and will be stored in the Chiropractic Day Clinic for five years, after which it will be deleted. The information was accessible to the researcher, supervisor, research head of the department, and the chiropractic head of the department.

3.11.6 Ethical clearance

Permission from the Clinic Director, gatekeeper, and Director of research and post-graduate support was obtained before the data collection. Clearance from the Institutional Research Ethics Committee (IREC) was obtained on 10 October 2023, and a clearance number of 158/23 was provided (Appendix O). An application for permission to add an additional data collection site was requested and approved by IREC on 10 April 2024 (Appendix P).

3.12 STATISTICAL ANALYSIS

An Excel spreadsheet was used to capture and record the data. The data was coded and checked, and then analysed by a statistician. IBM SPSS version 28 was used to analyse the data. A significant p-value was set at <0.05, and testing was two-tailed. The mean, median, standard deviation, range and percentiles were found and used as the summary measures for the spinal angle and posture variables.

Shapiro-Wilk's tests were used to check continuous variables for normality of distribution, and if normally distributed, t-tests were used to compare means between the two groups, and mean and standard deviations were used to summarise the variables. Non-parametric Mann-Whitney tests were used if data was not normally distributed, while median and interquartile range (percentile 25 to 75) were used to summarise the variables. Categorical variables between groups were compared using Chi-squared tests, and Pearson's correlation coefficient was used to assess linear relationships between continuous variables.

Multiple linear regression analysis was used to assess relationships between several predictor variables and each angle measurement. In each case, the angle was the dependent variable (separate models for C-flex, T-flex, T-Cobb, L-Flex, and L-Cobb were presented). For each model, the independent variables used were main activity (kayaking versus non-kayaking), BMI, posture number, and activity years. The independent variables were chosen based on the specific focus in this study on kayaking, and known confounders such as BMI, posture and length of time performing the activity. The model forced all predictors in the final model since we were interested in the estimates for all variables, even if not statistically significant.

CHAPTER FOUR: RESULTS

This chapter presents the key findings of the study in the form of a manuscript. The manuscript has been submitted to the Journal of Pain, Joints and Spine on 11 December 2024 and is currently under review.

A comparison of spinal curvatures and posture between active kayakers and physically active non-kayakers

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Abstract

Background: Kayaking is a sport that places repetitive demands on the spinal column and upper body musculature to propel the body and kayak forward. There is significant potential for curvature changes attributed to sustained periods of the kayaking posture as well as the effect of ageing on spinal curvatures. The study aimed to investigate the association between kayaking and spinal curvature anomalies (cervical lordosis, thoracic kyphosis, and lumbar lordosis) in males between the ages of 40 to 60 years.

Materials and Methods: Fifty-two male participants were included in this study, with two groups – Kayaking (K) and Non-kayaking (NK) - comprising 26 participants respectively. Full-body photographs were taken and analysed using PosturePro™. Spinal curvatures were measured using a Flexicurve ruler and angles were then calculated using BiomechFlex software.

Results: There was no significant difference in mean spinal angles between the groups. T-Flex and T-Cobb angles showed trends toward differences between the groups, with the K group having larger values than the NK group. There were statistically significant positive correlations between activity years and T-angles (T-Flex: p=0.015 and T-Cobb: p=0.014) seen in the sample population. In the K group, a moderate negative correlation between activity years and L-angles (L-Flex: p=0.028 and L-Cobb: p=0.023) was noted.

Conclusion: Spinal alignment changes can be affected through exposure to specific postural states. The activity of kayaking has a specific postural pattern and although not all results were of statistically significant value, a clinically significant value of altered spinal curvature associated with kayaking was found.

Keywords: Kayaking, spinal curvature, posture, physical activity.

Introduction

The spine is a key element of human anatomy that serves as a major structural foundation for posture and locomotion [1]. Spinal curves appear as one grows and are well established when walking and standing are achieved [2]. Viewed from the sagittal plane, spinal curvatures with an anterior concavity are named kyphosis, and curvatures with a posterior concavity are referred to as lordosis [2]. Therefore, according to anatomical segmentation, spinal curvatures are divided into cervical lordosis (C1-C7), thoracic kyphosis (T1-T12), and lumbar lordosis (L1-L5) [2,3]. Spinal curvatures undergo progressive change through one's lifespan as general trends indicate a deterioration of sagittal spinal alignment and posture as age increases past the fourth to fifth decade of life [4]. The spinal column is designed to assume a wide range of positions in response to different stimuli, therefore being adaptable and dynamic by design [5]. Changes in spinal curvature associated with increased age include increases in cervical lordosis and thoracic kyphosis, as well as decreased lumbar lordosis [6,7,8,9,10]. Posture is described as proper alignment of body segments to gravity [11]. Regular exercise and sporting activity have positive effects according to the exercise-specific features on body posture [12]. However, chronic poor postures because of bad habits or repeated postural positions can lead to various detrimental effects on muscles, increase load and strain on passive structures, and ultimately increase the risk of hyperkyphosis [13].

Each sporting discipline is unique in its specific postural and movement patterns and repeated exposure to these postures may induce specific modifications in spinal curvatures when training for long periods [14]. Therefore, the long-term effects of repetitive movements and sustained postures adopted during a specific sporting activity, as seen in kayaking, may pose a risk for altered postural states. Kayaking is a sport that places repetitive demands on the spinal column and upper body musculature to propel the body and kayak forward. By the nature of the activity of kayaking, it is difficult to maintain a neutral lumbar spine alignment in the seated position [15]. Therefore, the prolonged seated position seen in kayaking may lead to poor movement patterns and postural trends. There is significant potential for curvature changes attributed to sustained periods of this seated posture over years of kayaking as well as the effect of aging on spinal curvatures.

Fisher (2015) found that when changing from a slouched to an erect posture while kayaking, there is reduced stability and therefore makes the activity more difficult [16]. This indicates that if poor postural positions are assumed, the kayaker is less likely to change their posture and will maintain a poor postural position while kayaking. Research has extensively documented the advantages of physical activity and the significance of good posture in relieving back and neck pain [13,15]. However, poor postures that are assumed while kayaking may have adverse effects on spinal curvatures.

This study aimed to investigate the association between kayaking and spinal curvature anomalies (cervical lordosis, thoracic kyphosis, and lumbar lordosis) in males between the ages of 40 to 60 years. Additionally, the study aimed to establish the association, if any, between factors such as age, activity, sitting time, and the selected spinal curvatures. In doing so, the study provides insight into postures seen in kayaking and postural patterns observed because of the activity of kayaking.

Materials and Methods

Study Design

This study followed a quantitative design to compare spinal curvatures and posture between the Kayaking (K) and Non-kayaking (NK) groups.

Study Population

This study consisted of two groups: Individuals who actively participate in the sport of kayaking (K) and physically active non-kayakers (NK). For sample homogeneity, the sample group was limited to males between the ages of 40 and 60 years old. Male participants were chosen, as most of the kayaking population in KwaZulu-Natal consists of males [17]. Additionally, the effect of spinal alignment also differs between males and females [13], and therefore, females were not included in this study.

Sample Size

Using a two-sample T-test with a 5% level of significance, a power of 80% and an effect size of 0.8 (which was regarded as a large effect size) the sample size for each group was calculated to be 26. GPower version 3.1 was used to calculate the sample size [18].

Measurement Tools

Participant demographics and additional information such as anthropometric variables, primary activity, activity frequency, and hours spent participating in their activity as well as activity years were recorded. Standing anterior and lateral photographs were taken and analysed by PosturePro™ software. Markers were placed in specific anatomical positions which the software interprets and provides the examiner with a postural number that corresponds to a scale that describes the posture. Cervical and thoracolumbar curvatures were measured using a Flexicurve ruler and subsequent C, T, and L angles were calculated. A Flexicurve ruler is a flexible ruler that can be manipulated to mould and replicate its contact surface. Once the ruler adopted the relevant spinal curvatures, it was placed onto graph paper and the curvatures were traced onto graph paper for further evaluation. By using Biomech Flex software, C, T, and L angles were calculated.

Ethical Considerations

The study received ethical clearance from the institutional research ethics committee (IREC 158/23) at Durban University of Technology (DUT). The study participants were provided with a letter of information and each participant signed a letter of informed consent before participating.

Statistical Analysis

IBM SPSS version 28 was used to analyse the data. A p-value <0.05 was considered statistically significant, and testing was two-tailed. Continuous variables were checked for normality of distribution using Shapiro-Wilk's tests and if normally distributed, t-tests were used to compare means between the two groups, and mean and standard deviations were used to summarise the variables. If not normally distributed, non-parametric Mann-Whitney tests were used, while median and interquartile range (percentile 25 to 75) were used to summarise the variables. Chi-squared tests were used to compare categorical variables between the groups, and Pearson's correlation coefficient was used to assess linear relationships between continuous variables. Multiple linear regression analysis was used to assess relationships between several predictor variables and each angle measurement.

Results

A total of 52 males between the ages of 40–60 agreed to participate in the study. Participants were allocated into kayaking (K) and non-kayaking (NK) groups. A summary of the statistics for age, height, weight, and BMI for each group as well as the comparison of these values between the groups is shown in Table 1. There was a significantly higher average age in the K group (p=0.008), but the other parameters were the same between the groups.

Table 1. Comparison of age and anthropometric variables (n= 26 per group)

		Mean	Std. Dev	Min	Max	t-value	2-sided p-value
Age	Kayaking	51.5	5.2	40	60	2.759	0.008
	Non-kayaking	47.0	6.5	40	59		
Height (cm)	Kayaking	178.2	7.4	165	195	0.158	0.875
	Non-kayaking	177.8	8.4	160	192		
Weight (kg)	Kayaking	86.4	10.0	69	109	1.132	0.263
	Non-kayaking	82.5	14.4	55	103		
BMI	Kayaking	27.3	3.5	21.4	34.2	1.357	0.181
	Non-kayaking	26.0	3.5	21.0	31.9		

There were no significant differences between the mean angles between the groups as seen in Table 2. T-Flex and T-Cobb angles showed trends towards differences between the groups (p=0.091 and p=0.089 respectively), with the K group having larger values than the NK group, but the differences were not significant.

Table 2. Summary of measures for C, T, and L spinal angles

		Mean	Std. Dev	Min	Max	t-value	p-value
C-Flex (˚)	Kayaking	36.1	14.8	4.6	61.6	-0.643	0.523
	Non-kayaking	38.5	12.7	11.2	59.8		
T-Flex (˚)	Kayaking	31.9	9.5	15.2	57.0	1.722	0.091
	Non-kayaking	27.3	9.7	11.8	46.3		
T-Cobb (˚)	Kayaking	34.3	8.1	19.9	55.8	1.734	0.089
	Non-kayaking	30.4	8.3	17.1	46.7		
L-Flex (˚)	Kayaking	17.3	10.1	4.0	36.0	-0.196	0.845
	Non-kayaking	17.9	13.2	1.1	45.3		

L-Cobb (˚)	Kayaking Non-kayaking	23.1 23.5	7.7 10.2	12.8 10.5	37.4 44.6	-0.154	0.878

Hours spent participating in activity, activity years, and posture number values are shown in Table 3. Maximum hours of activity showed a non-significant trend of more hours spent in the NK group (*p*=0.087). The time spent in years participating in the selected activity was significantly longer in the K group, with a median of 23 years versus 12 years (*p*=0.002). This may be related to the fact that the average age of participants in the K group was older than that of the NK group.

Table 3. Comparison of hours, activity years, and posture numbers[1]

		Median	Minimum	Maximum	P25	P75	p-value
Minimum Hours	Kayaking	4	3	8	3	5	0.269
	Non-kayaking	4	3	8	3	6	
Maximum Hours	Kayaking	6	6	15	6	9	0.087
	Non-kayaking	8	6	12	6	10	
Activity Years	Kayaking	23	4	40	15	30	0.002
	Non-kayaking	12	4	40	7	20	
Posture number	Kayaking	13	1	31	8	20	0.209
	Non-kayaking	11	3	24	5	18	

Table 4 shows statistically significant positive correlations between activity years and T-angles (T-Flex: *p*=0.015 and T-Cobb: *p*=0.014), although the correlation coefficients were low (r=0.335 and 0.338 respectively). This suggests a low to moderate linear relationship between those variables. The scatterplot shows the wide variation in the linear relationship, although it remains a positive trend such, that as the years of doing the activity increases, so does the thoracic curvature angle (Figure 1- A).

The association between activity years and increased thoracic curvature is true of the entire sample, however, when looking at the groups individually, neither group showed statistically significant associations. Table 4 shows that a greater

[1] P25 = 25th percentile, P75 = 75th percentile

significance was found in the K group alone (T-Flex: *p*=0.011, T-Cobb: *p*=0.106), when compared to the NK group (T-Flex: *p*=0.321, T-Cobb: *p*=0.321). Although not achieving statistical significance, this shows a greater level of association between activity years and an increasing thoracic curvature in the K group when compared to the NK group. In the K group, a moderate negative correlation between activity years and L-angles (L-Flex and L-Cobb) was found, indicating that as activity years increased, the lumbar curvature values decreased, i.e. the lumbar curvature flattened. There was a significant negative association between activity years and L-Flex (*p*=0.028) and L-Cobb (*p*=0.023) in the K group. This is shown in Table 4 and Figure 1-B.

A trend towards a moderate negative correlation between time spent sitting and L-angles (L-Flex: *p*=0.074, L-Cobb: *p*=0.075) was identified. As time spent sitting increased, the L-angles decreased. The sample size was lower in this subgroup as not all participants reported sitting for long periods, thus the correlation did not achieve statistical significance. This relationship is shown in Table 4 and Figure 2.

Table 4. Comparison of spinal angles with activity years and time spent sitting

Total Sample		C-Flex	T-Flex	T-Cobb	L-Flex	L-Cobb
Activity Years	Pearson Correlation	-0.117	0.335	0.338	-0.207	-0.209
	Sig. (2-tailed)	0.409	0.015	0.014	0.140	0.137
Time Spent Sitting (*n*=18)	Pearson Correlation	0.078	-0.298	-0.298	-0.432	-0.430
	Sig. (2-tailed)	0.760	0.230	0.233	0.074	0.075
Kayaking (K)						
Activity Years	Pearson Correlation	-0.040	0.320	0.325	-0.430	-0.445
	Sig. (2-tailed)	0.848	0.111	0.106	0.028	0.023
Time Spent Sitting (*n*=9)	Pearson Correlation	0.290	-0.032	-0.018	0.204	0.208
	Sig. (2-tailed)	0.449	0.935	0.936	0.598	0.592
Non-Kayaking (NK)						
Activity Years	Pearson Correlation	-0.149	0.206	0.206	-0.038	-0.038
	Sig. (2-tailed)	0.467	0.312	0.312	0.852	0.855
Time Spent Sitting (*n*=9)	Pearson Correlation	-0.264	-0.380	-0.382	-0.739	-0.739
	Sig. (2-tailed)	0.493	0.314	0.310	0.023	0.023

Figure 11- Thoracic curvature (A) and lumbar curvature (B) versus activity years

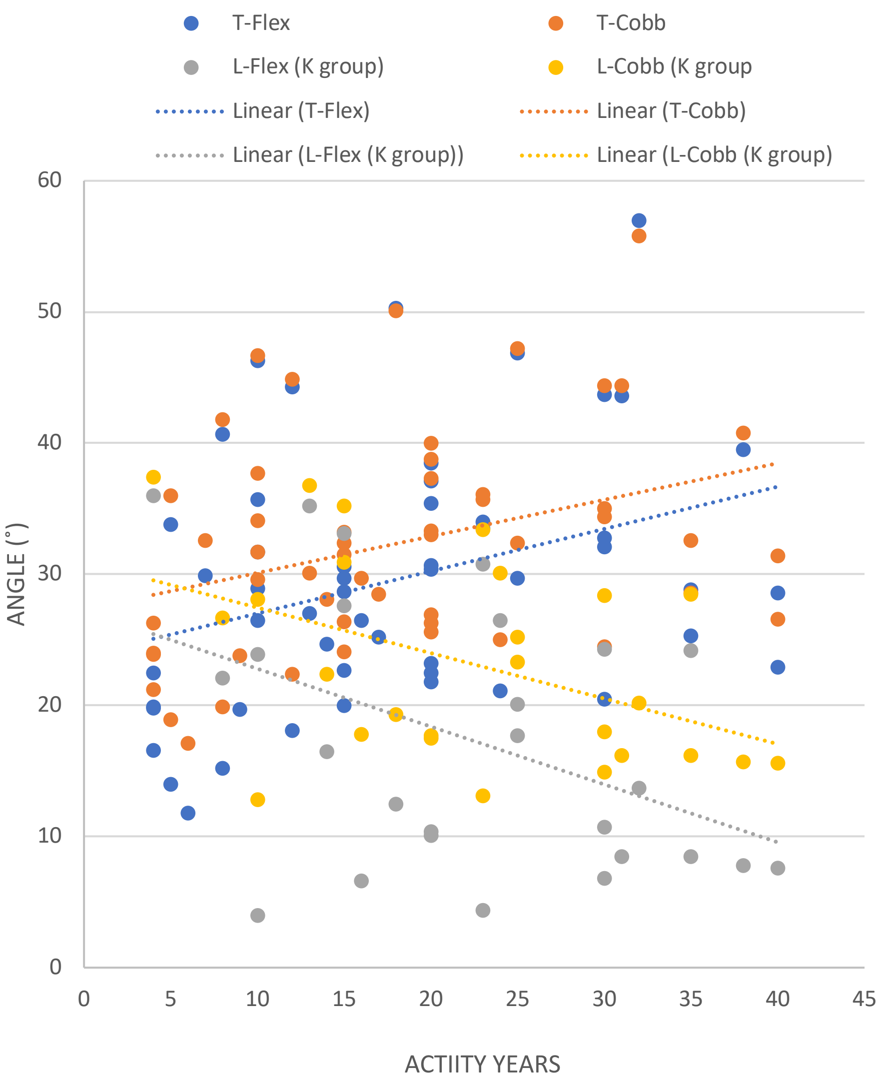
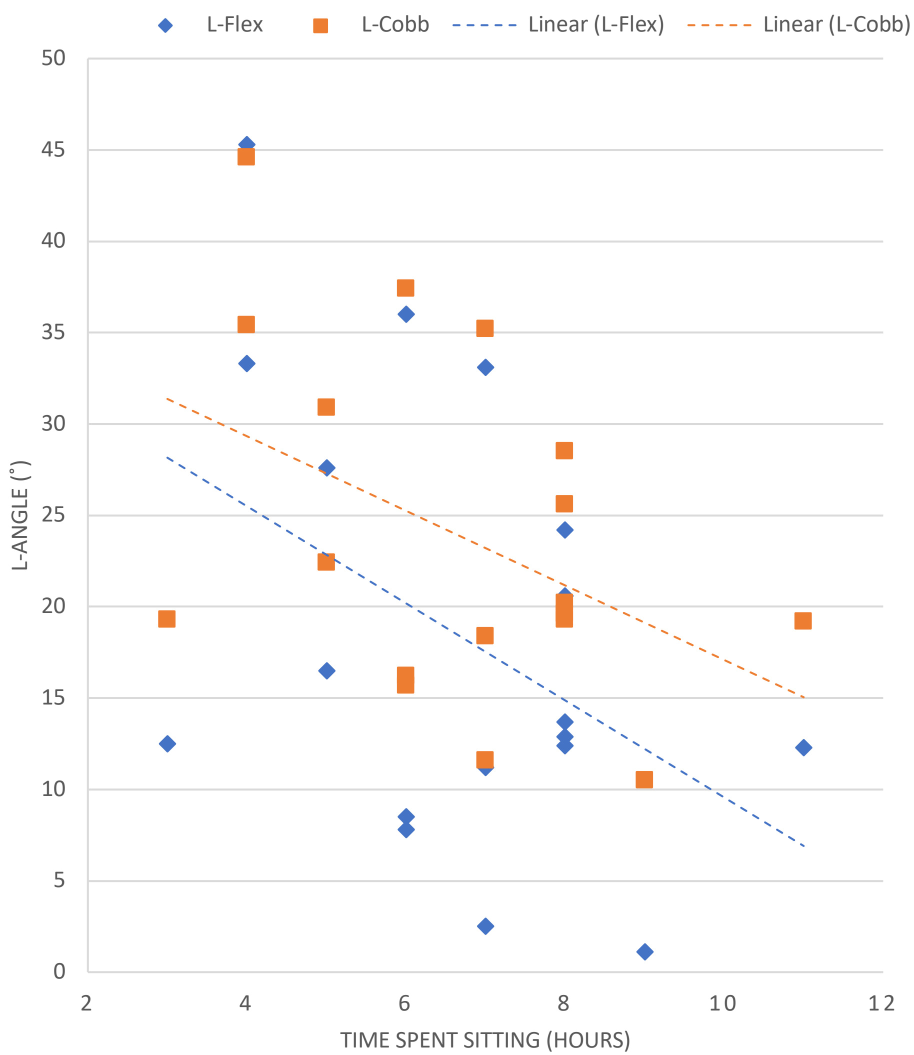


Figure 12- L-angle versus time spent sitting



The five multiple linear regression models were fitted, each with one of the spinal angles as the dependent variable, and a set of predictor variables including main activity (K or NK), BMI, posture number and activity years. The following was deduced from the five models:

None of the variables were significant predictors of C-Flex. Posture number and activity years were significantly associated with T-Flex after adjusting for the other variables in the regression model (*p*=0.042 and 0.035 respectively). The coefficient (slope) for posture number was 0.379, which means that for every one unit increase in posture number, the increase in the T-Flex angle was on average 0.379 degrees. The coefficient for activity years was 0.303, which means that for every one-year increase in activity years, the expected increase in the T-Flex angle was on average 0.303 degrees after holding all other variables constant. T-Cobb also showed similar results as posture number and activity years were significantly associated with T-Cobb (*p*=0.043 and *p*=0.034 respectively). The coefficient for posture number was 0.324, again meaning that for every one unit increase in posture number, the increase in T-Cobb was on average 0.324 degrees. The coefficient for activity years was 0.262 which means for every one-year increase in activity years, the expected increase in the T-Cobb angle was 0.262 after holding all other variables constant.

Regarding L-angles (L-Flex and L-Cobb), BMI showed to have a significant association with L-Flex and L-Cobb (both had a *p*-value of 0.007). The coefficient for L-Flex was 1.297 and for L-Cobb was 0.994, which means that for every one unit increase in BMI, the L-Flex and L-Cobb angles are expected to increase by 1.297 and 0.994 degrees, respectively.

Discussion

Anthropometric and Activity Variables

There was a similar age distribution between the two groups, however, there was a significantly higher (*p*=0.008) average age in the K group. The other anthropometric variables were similar between the two groups. According to WHO guidelines, the mean BMI values in both groups of participants were categorised as the overweight range.

The primary activity participation varied among the NK group. It was found that each group participated in their primary activity for a minimum of three hours per week. A non-significant trend of the maximum time spent in primary activity per week was noted in the NK group (*p*=0.087), which was greater than that of the K group's maximum reported time per week. This may be influenced by varied weather conditions experienced [17] and greater options to participate in activities that are practised indoors. Considering the longer time spent in primary activity per week in the NK group, activity years in the K group were significantly higher (*p*=0.002) with an average of 22.46 years in the K group and 13.77 years in the NK group. This may be related to the fact that participants in the K group were on average older than the NK group.

The regression analysis found that BMI was significantly associated with L-angles (L-flex and L-Cobb: *p*=0.007) while holding all other variables constant. The coefficient for L-Flex was 1.297 and for L-Cobb was 0.994, which means that as BMI values increase, the lumbar curvature increases as well. This is in line with the literature [1, 24] that explores the influence of BMI on thoracic and lumbar curvatures. In the study by Miranda *et al.* (2022), BMI was significantly associated with lumbar lordotic curvature and increased lumbar lordotic curvatures were seen in individuals with higher BMI values and obesity [24].

Stretching and Sitting Time

Questions relating to time spent stretching and sitting were also answered by all participants. There was no significant difference found for stretching practices (*p*=0.095), time spent per stretching day (*p*=0.238), or number of days spent stretching (*p*=0.640) between the two groups. Literature has shown that stretching practices may influence musculoskeletal disorders [19, 20], however, the extent and specificity of stretching practices vary and further investigation into the type of stretching is needed to better understand the effect on spinal curvature alignment and posture.

With regards to sitting time, 34.6% (*n*=18) of the total sample said that they sit for extended periods, which, according to literature, can have musculoskeletal effects and ultimately affect spinal curvatures and posture [21, 22]. Issues relating to reliability do occur as underreporting has been noted as a limitation in this regard [22]. It is worth mentioning a trend towards a moderate negative correlation between time spent sitting and L-angles (L-Flex: *p*=0.074, r= -0.432 and L-Cobb: *p*=0.075, r = -0.430). As time spent sitting increased, the lumbar curvature angles decreased. The sample size is lower in this subgroup as not all participants said that they sit for extended periods of time. In the NK group, a significant finding of a strong negative correlation between time spent sitting and lumbar curvature angles was identified (L-Flex and L-Cobb: *p*=0.023, r= -0.739). This agrees with other studies, which found lumbar curvatures to decrease as sitting time increased [23]. Some degree of limitation, however, is found here, as the sample size in this comparison is low (*n=9*), one cannot assume that correlation implies causation. Just because two variables are correlated, it does not mean one causes the other.

Spinal Angles (Cervical, Thoracic and Lumbar)

Mean spinal angles were recorded and compared between the K and NK groups. It needs to be noted that when calculating and evaluating spinal angles, the Biomech-Flex computer software was unable to calculate C-Cobb values in individuals who had a BMI value of >25. Due to 63.46% of the total sample having a BMI of >25, this would significantly reduce the statistical power of accurate C-Cobb angles that were able to be calculated (participants in the normal BMI range), thus the C-Cobb angle was not included in the analysis. Therefore, a comparison of cervical spine curvatures was done using C-Flex values.

With respect to spinal curvatures and posture, the study found that when comparing kayaking to other physical activities, no significant differences were found between mean spinal angels (C-Flex, T-Flex, T-Cobb, L-Flex and L-Cobb) and posture numbers. There was, however, a trend towards differences between the two groups in terms of mean T-angles (T-Flex: *p*=0.091 and T-Cobb: *p*= 0.089), with the K group having larger T-angles than the NK group, although the difference was not significant. These results are consistent with López-Miñarro *et al.* (2017), who found that there were no significant differences seen in spinal curvature variables during relaxed standing among male athletes in different sporting disciplines (kayaking, canoeing and tennis). There were slight increases in thoracic kyphosis angles when compared to a normal thoracic kyphosis range but this was in an adolescent age group [14]. The study by López-Miñarro *et al.* (2017), recognised a limitation in that their assessment of spinal curvatures was limited to an adolescent population and acknowledged that differences in spinal curvatures do exist between adults and adolescent groups [14].

A significant positive correlation between primary activity years and T-angles (T-Flex: *p*=0.015 and T-Cobb: *p*=0.014) was found, which suggests that as primary activity years increased, the thoracic kyphotic curvature values increased as well. This was found to be significant in the total sample, although when looking at the groups individually, neither group showed statistically significant associations. It was noted that a greater significance was seen in the K group (T-Flex *p*=0.011 and T-Cobb *p*=0.106) when compared to the NK group (T-Flex *p*=0.321 and T-Cobb *p*=0.321). The interpretation of these findings highlights the limitation of the sample size. The sample population shows a significant association between activity years and an increase in thoracic curvatures, and no significant correlation can be made when K and NK groups are studied individually. This links to a phenomenon called the Simpsons Paradox, as described by Pearl (2013), where significant findings can be found in a population group, but disappear or reverse when split into subgroups [25].

Regarding the lumbar spine, a significant negative correlation was found between L-angles and activity years in the K group (L-Flex *p*=0.028 and L-Cobb *p*=0.023). This means that as participants spent more time (in years) kayaking, lumbar curvatures flattened. A similar finding was seen in a study by López-Miñarro (2010), where reduced lumbar curvatures were found in a kayaking population when compared to a control group [26]. Again, this study population consisted of a young age group and recommendations for long-term studies were made as spinal curvatures are known to change as one grows [26]. From the results of this study, it can be deduced that trends towards increased thoracic spine curvatures and significantly decreased lumbar curvatures associated with increased activity years were seen in the K group when compared to the NK group.

These correlations identified between activity years and increased thoracic curvatures (of which the K group had a greater level of significance) and decreased lumbar curvatures seen in the K group, lead us to understand that spinal curvature change associated with kayaking exists. The extent of the curvature change is limited as when comparing mean angles of spinal curvatures between K and NK groups, no significant findings can be deduced. However, the fact that lumbar curvatures were significantly flattened in the K group as activity years increased, there may be some degree of spinal curvature change associated with the activity of kayaking.

Conclusion

Posture and spinal curvature alignment are adaptable and can be influenced by various factors. Ageing plays a major role in the change seen in spinal curvatures over time and resultant postures observed, which is notably seen around the fourth to fifth decade of life. Specific sporting activity and exercise can modify the degree and extent of the changes seen. Kayaking is an activity where specific postures are assumed for extended periods and have the potential to influence postural change and spinal curvature alignment. The results of the study show significant associations between flattened lumbar curvatures and increased kayaking activity years, with trends relating to increased thoracic curvatures associated with increased activity years in the kayaking population studied. The results, therefore, suggest that some degree of spinal curvature change associated with kayaking exists. These results indicate the need for further research, with larger sample sizes in this field of research.

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CHAPTER FIVE: DISCUSSION

5.1 INTRODUCTION

Chapter 5 discusses the study results and how they relate to the available literature on the effects of ageing and physical activity, specifically, kayaking, on posture and spinal curvatures. This chapter draws a comparison between the results of this study and the findings of similar studies, to better understand the effect of kayaking on spinal curvatures and posture.

5.2 AGE AND ANTHROPOMETRIC VARIABLES

All study participants were males between the ages of 40 to 60 years, in keeping with the study's objectives. This study was limited to males as studies suggest that differences in spinal curvatures between males and females exist (Katzman *et al.* 2017b: 2; Roghani *et al.* 2017: 568; Tang *et al.* 2022: 7). Another contributing factor, was that the majority of the kayakers from Durban male (Kruger & Saayman 2013: 1163). Study participants were assigned to two groups based on their activity, K or NK.

The age range between the groups were similar. The mean age of the K group was 51.5 (±5.2) years old, and the mean age of the NK group was 47 (±6.5) years old. This resulted in the K group's mean age being significantly higher (p=0.008) than that of the NK group. This may be due to the relatively small sample size. Unfortunately, having a significant age difference between the two groups does confound the findings and does not assist when comparing the spinal curvatures between the two groups. Either a narrower age margin for the inclusion criteria or a larger sample size need to be considered as there is a need for control with respect to the variable of age in the study. This would ensure any differences found would be attributed to kayaking rather than age.

The other anthropometric study variables were similar between the groups. There were no significant differences in height (p=0.875), weight (p=0.263) and subsequent BMI calculations (p=0.181) between the two groups. In the K group, the BMI ranged from 21.4 to 34.2 kg/m^2, with a mean BMI of 27.3 kg/m^2. The BMI in the NK group ranged from 21 to 31.9 kg/m^2, with a mean BMI of 26 kg/m^2. According to

WHO guidelines (WHO 1995: 312; Nuttall 2015: 119), the groups have a mean BMI that is classified as ‘overweight’.

A study by González-Sánchez *et al.* (2014: 7) explained that when comparing individuals with a normal BMI to participants with obesity, significant differences in thoracic kyphosis angles were noted (González-Sánchez *et al.* 2014: 7). The hypothesis that spinal curvatures are affected by obesity is supported by a study by Miranda *et al.* (2022: 511), which determined that adolescents with obesity had greater angles of lumbar lordosis (Miranda *et al.* 2022: 511). This was seen in this study, as the regression analysis showed that BMI was significantly associated with increased L-angles (L-Flex and L-Cobb: p=0.007). As BMI values increase by 1 unit, the lumbar spine curvature increases by 1.297 degrees for L-Flex and 0.994 degrees for L-Cobb, whilst holding other variables constant. This is consistent with the literature. Mirzashahi *et al.* (2023: 4) and Holzgreve *et al.* (2024: 2), found that higher BMI values were associated with greater lumbar spine lordotic curvatures and higher risk of lower back pain (Mirzashahi *et al.* 2023: 4; Holzgreve *et al.* 2024: 2).

5.3 ACTIVITY PARTICIPATION

Since participants were likely to participate in more than one activity, other activities that participants regularly participated in were recorded. In the K group, kayaking was the primary activity, while in the NK group, the primary activity varied. The most frequently reported activities in the NK group included running (65.4%), gym (50%), cycling/mountain biking (30.8%), walking (23.1%), surfing (11.5%), and swimming (11.5%). Second to kayaking, frequently reported activities by the K group included running (61.5%), gym (38.5%), cycling/mountain biking (23.1%), surfing (15.4%), and walking (7.7%). In a paper by Rpehl and Strand (2017: 55), burnout and overuse injuries are among some of the reasons linked to the negative effects of sport specialisation and only participating in one sport (Rpehl & Strand 2017: 55). Cross-training and participation in a range of sporting codes are generally well understood for the maintenance of general fitness and athletic performance. This may explain why study participants reported participation in multiple sporting activities. Lim *et al.* (2011: 203) explains that in older individuals, motivation to participate in physical activity includes a sense of challenge, physical health benefits and the opportunity to socialise (Lim *et al.* 2011: 203). This may also be a reason for the multiple sporting activities reported by participants.

5.4 ACTIVITY FREQUENCY

In this study, hours spent participating in primary activities, per week, ranged from three to fifteen hours in the K group, and ranged from three to twelve hours in the NK group. The mean minimum hours per week was slightly higher in the NK group (4.65 hours) than in the K group (4.19 hours). This indicated that the groups participated for at least four hours per week, on average, in their primary activity. The mean maximum hours per week was slightly higher in the NK group (8.19 hours) when compared to the K group (7.23 hours). As the sport of kayaking takes place in many outdoor settings (Kruger & Saayman 2013: 1158), the inconsistent nature of weather and environmental conditions may influence the time participants reported having spent kayaking. Weather and outdoor conditions are known to heavily influence the amount of time one can be outside participating in kayaking or other outdoor physical exercise.

The number of years participating in the primary activity was significantly longer (p=0.002) in the K group, with a mean of 22.46 years, versus 13.77 years in the NK group. This might be because participants in the K group had a greater mean age than the NK group. According to Molanorouzi, Khoo and Morris (2015: 8), motivation for participation in physical activity varies, and is dependent on the type of activity, age group and gender (Molanorouzi, Khoo & Morris 2015: 8). Compared to people who are typically physically active, participants are likely to have engaged in kayaking for longer periods of time because it was the specific activity that was studied.

A study by López-Miñarro, Alacid and Rodriguez-Garcia (2010: 301) investigated spinal curvatures and hamstring muscle extensibility among young elite kayakers and non-athletes (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 301). As this study investigated elite kayakers, time spent on the activity was greater than that of the current study. The study was also limited in the sense that the sample group of kayakers only participated in kayaking and no other physical activity (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 303). The main finding in the study was that the spinal curvature measurements found were considered normal. It was explained that because the sample group was young, there was insufficient duration and years of training to be associated with spinal curvature adaptions (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 308). This is where the current study may display some effect of spinal curvature change associated with kayaking as the sample consists of an older population.

5.5 TIME SPENT STRETCHING AND SITTING

Participants were asked questions regarding stretching practices, the amount of time spent stretching and the number of days per week the participant stretched. K group participants (36%) said that they followed a stretching regime, with stretching time ranging from five to twenty minutes per day, with an average of 11.67 minutes of stretching per day. NK group participants (57.7%) followed a stretching regime, with stretching time ranging from five to thirty minutes per day, with an average of 15 minutes of stretching per day. Studies have shown that stretching practices may reduce musculoskeletal disorders, mainly related to back pain (Hartfiel *et al.* 2017: 687; Holzgreve *et al.* 2018: 6). There was no significant difference found for stretching practices (p=0.095); time spent per day (p=0.238), or number of days spent stretching (p=0.640) between the two groups.

Questions relating to time spent sitting were also answered by the participants. In the K and NK groups, 34.6% of participants said that they sit for extended periods, for five days a week. Time spent sitting ranged from three to eleven hours per day, with an average of 6.67 hours per day. This average is lower that the recommended time spent sitting according to the Canadian movement guidelines, which was less than eight hours per day (Ross *et al.* 2020: 70). The majority of the reported sitting time was linked to occupation, and this is consistent with current literature that investigates time, related to occupational sitting. Coenen *et al.* (2018: 1187) explained that many workers spend most of their working hours sitting, and this highlights the correlation between occupational sitting and the prevalence of musculoskeletal symptoms (Coenen *et al.* 2018: 1187). This is consistent with Mclaughlin *et al.* (2020: 9), who collected data over 10 years from 62 countries, and found that self-reported sitting time averaged 4.7 hours per day (Mclaughlin *et al.* 2020: 9). It was, however, noted that the study was limited by underreporting

(Mclaughlin *et al.* 2020: 9) and the calculation of total sitting time is heavily dependent on the line of work of the individual. In this study the mean time sitting was, therefore, higher than that in the study by Mclaughlin *et al.* (2020: 9), which shows that occupational sitting times can vary, and due to the noted relationship between sitting and prevalence of musculoskeletal symptoms, the spinal curvatures have the potential to be influenced by time spent sitting.

5.6 SPINAL CURVATURE AND POSTURE

We draw attention to the fact that the BiomechFlex computer software was unable to accurately calculate the C-Cobb angle for participants with a BMI >25 (overweight classification), and therefore, C-Cobb was excluded from the statistical analysis. This is due to the build-up of subcutaneous tissue of the cervical spine, which may impact the C-flex angle measurement (Raupp *et al.* 2017: 502). In this study, 63.46% of the sample population (K and NK groups) were classified in the overweight BMI range (BMI >25). This significantly reduced the statistical power of accurate C-Cobb angles that were calculated (participants in the normal BMI range), and thus the C-Cobb angle was not included in the analysis, and C-Flex angles between the two groups were explored for cervical spine curvature comparison.

There were no significant differences between mean spinal angles between the K and NK groups as all *p*-values were above 0.05. The mean values of C-Flex (p=0.523), T-angles (T-Flex p=0.091 and T-Cobb p=0.089), and L-angles (L-Flex p=0.845 and L-Cobb p=0.878) did not show any significant differences between the two groups. The T-angles showed trends towards differences between the groups, with the K group having larger values than the NK group, but the differences were not significant (T-Flex p=0.091 and T-Cobb p=0.089). This indicates that kayaking did not have a greater effect on spinal curvatures than other forms of physical activity included in the study for mean spinal angles. These results are consistent with López-Miñarro *et al.* (2017: 113), who found that there were no significant differences seen in spinal curvature variables during relaxed standing among male athletes (kayaking, canoeing and tennis). There were slight increases in thoracic kyphosis angles when compared to a normal thoracic kyphosis range, which was also seen in the current study as thoracic curvatures in the K group were greater than those seen in the NK group. A limitation was recognised by López-Miñarro *et* *al.* (2017), in that their assessment of spinal curvatures was limited to an adolescent population and differences in spinal curvatures between adults and adolescent groups were acknowledged (López-Miñarro *et al.* 2017: 114). Although each study investigated spinal curvatures in different selected age-groups, the results of the studies were consistent. This adds to the validity of the results of this current study.

López-Miñarro, Alacid and Rodriguez-Garcia (2010: 308) also observed no significant differences in the standing thoracic curvature angle in all age groups studied. The study results were not in agreement with other studies investigating other sporting disciplines but they were consistent with the results of this current study, in that there were no significant differences found in thoracic curvature angles between the K and NK groups (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 308).

The lack of difference found between mean spinal angles of the K and NK groups might be related to the fact that the study was underpowered. There was a significant difference in age between the two groups and there were a few findings that were close to producing a significant value but these were not considered significant as the study was underpowered. This highlights the limitations of and a need for careful consideration of inclusion and exclusion criteria to produce results of greater significance and draw meaningful findings for the data.

The interpretation of the finding of no significant difference in mean spinal angles between the two groups may suggest that kayaking had no greater influence on spinal curvatures when compared to other physical activity. It may be argued that through the activity of kayaking and recruitment of major muscles groups, posture can improve and normal spinal curvatures may be maintained. Katzman *et al.* (2017a: 8) highlights the intervention of targeted spinal strengthening exercise in order to reduce hyperkyphosis and improve postures (Katzman *et al.* 2017a: 8). Another study by Çelenay and Kaya (2017: 507) found that a thoracic spine exercise programme improved back pain and spinal alignment (Çelenay & Kaya 2017: 507). Therefore, the fact that kayaking may promote normal and better postures seen in activity is a possibility. This current study did assess this in an ageing population, of which it was expected that spinal curvatures and posture would not be in parameters that are considered normal.

This study included posture as one of the parameters, where posture numbers calculated by PosturePro™ were used to compare posture between the K and NK groups. A better standing posture is indicated by a low posture number. The distribution of posture numbers between the K and NK groups was similar (p=0.209), with a large range of posture numbers found in K (minimum=1, maximum=31) and NK (minimum=3, maximum=24) groups. The mean posture number in K and NK groups were similar (14.54 and 12 respectively) and showed no significant difference between the two groups. These results suggest that kayaking did not have a greater impact on posture when compared to other forms of physical activity included in the study.

After a regression analysis of the data was done, it was found that posture number was significantly associated with increased T-angles (T-Flex: p=0.042 and T-Cobb: p= 0.043). For every one unit increase in posture number, the thoracic spine curvature increased by 0.379 degrees for T-Flex and 0.324 degrees for T-Cobb, whilst holding other variables constant. This agrees with the literature in that poorer postures are related to increased or hyperkyphotic thoracic curvatures. A study by Katzman *et al.* (2010: 354) explains that functional limitations, musculoskeletal alteration and decreases in quality of life are among the consequences of hyperkyphosis (Katzman *et al.* 2010: 354). This highlights the importance of posture and the role that posture plays in one's overall well-being.

The clinical implications of hyperkyphosis and associated poor posture are described by Roghani *et al.* (2017: 3-4). These include impaired respiratory function with associated increased risk of early mortality due to pulmonary complications, lowered physical function and greater difficulty performing day to day activities, and increased risk of falling due to impaired balance, which in turn increases the risk of fractures and other injuries (Roghani *et al.* 2017: 3-4). These are very serious health implications and highlight the clinical importance of maintaining spinal health.

5.6.1 Spinal curvature and posture: correlation with age

In this study, the parameter of age showed no significant correlation with the spinal curvature measures. Previous research has highlighted that advancing age affects spinal curvatures, with emphasis on the thoracic curvature showing the most change as one ages (Katzman *et al.* 2010: 358; Norasteh *et al.* 2019: 184). This was seen in the current study when comparing the spinal curvatures measured. The thoracic spine curvature showed the greatest trend associated with age; however, this was an insignificant statistic (T-Flex and T-Cobb *p*=0.169). According to Norasteh *et al.* (2019: 187), the cervical spine lordotic curvature and thoracic spine kyphotic curvature tend to increase with ageing, while the lumbar lordotic spinal curvature tends to decrease with age (Norasteh *et al.* 2019: 187). This was seen in the current study, when looking at correlations with age and spinal curvatures, whereby the thoracic curvature increased, and the lumbar curvature decreased. This was an unexpected finding in terms of the correlation with increasing age, as the cervical spine curvature did not increase but decreased. This was not of significant value but does go against what was explained in the study by Norasteh *et al.* (2019). An article by Liu *et al.* (2019), suggests that changes in cervical spine curvatures may differ depending on pathological conditions (Liu *et al.* 2019: 1). Liu *et al.* (2019: 1) further explained that the changes in thoracic and lumbar curvatures are well understood and documented, and studies show that the changes seen in the cervical spine are inconsistent (Liu *et al.* 2019: 1). This may explain the change seen in the cervical spine in this current study.

A moderate negative correlation between age and posture number in the NK group was found (*p*=0.035, r= -0.415). This indicates that as age increased, the posture number decreased. The mean posture number in the study sample was 13.27, with a mean of 14.5 and 12 in the K and NK groups, respectively. A study conducted by Senthil *et al.* (2018: 2) explored the reliability of PosturePro™ software, with study participants aged 35 to 55 years. Between three investigators, the mean posture numbers collected in this age group ranged from 19.3 (with a standard deviation of 4.8) and 20.1 (with a standard deviation of 4.2) (Senthil *et al.* 2018: 2). When looking at the study by Senthil *et al.* (2018: 2) and the current study, similar ranges of posture numbers are seen in similar age groups. Despite a moderate negative correlation between the two parameters seen in the NK group, it is noted that age and posture are linked and affected by several other factors.

5.6.2 Spinal curvature and posture: correlation with activity years

There were statistically significant positive correlations between years participating in the primary activity and T-Flex (*p*=0.015) and T-Cobb (*p*=0.014) although the correlation coefficients were low (r=0.335 and r=0.338 respectively). This suggests a low to moderate linear relationship, but a positive trend that shows that as primary activity increases over the years, so does the thoracic curvature angle. This is true of the total sample size. Although T-Flex and T-Cobb angles were not significantly correlated with activity years in the K group alone (*p*=0.111 and *p*=0.106, respectively), the significance was greater than that of the NK group T-angles (T-Flex and T-Cobb: *p*=0.312). The interpretation of these findings draws attention to the limitation of the sample size, as the study may have been underpowered. According to Pearl (2014: 8), this is related to a phenomenon known as Simpsons Paradox, where significant findings may exist in a population group, but disappear or reverse when divided into subgroups (Pearl 2014: 8). This is observed in this current study as when looking at the entire sample, there is a significant correlation between activity years and thoracic curvatures measured. But when looking at the K and NK groups separately, no significant correlation is seen. It can be noted that the K group did have a greater level of significance (T-Flex: *p*=0.111, T-Cobb: *p*=0.106) versus that seen in the NK group (T-Flex and T-Cobb: *p*=0.312).

In the K group, a significant negative correlation between activity years and L-angles (L-Flex *p*=0.028 and L-Cobb *p*=0.023) was found. This suggests a moderate negative linear relationship between years of kayaking and the flattening of the lumbar lordotic curvature. The correlation coefficient for L-Flex and L-Cobb angles were -0.430 and -0.445, respectively, which indicates that as activity years increased, the lumbar curvature in the K group flattened. In a study by López-Miñarro, Alacid and Rodriguez-Garcia (2010: 306) it was found that the standing lumbar curvature angle was greater in control groups when compared to a kayaking group (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 306). This can be interpreted as a flattening or a reduced lumbar curvature in the kayaking group observed. It is important to note this study consisted of an adolescent sample size. In another study by López-Miñarro *et al.* (2017: 114), it was hypothesised that differences in lumbar curvatures would only be identified if the sample population studied had longer training periods, for adaptations in spinal curvatures to occur (López-Miñarro *et al.* 2017: 114). This could explain the significant correlation seen in this study, as it is understood that in the K group, as years of kayaking training increase, the L-angle decreases at a rate that is more significant than the decrease that was seen in the NK group.

A regression analysis found that activity years were also significantly associated with T-angles (T-Flex: p=0.035 and T-Cobb: p= 0.034). For every one-year increase in activity years, the thoracic spine curvature increased by 0.303 degrees for T-Flex and 0.262 degrees for T-Cobb, whilst holding other variables constant. This further reiterates the finding of increased thoracic curvatures related to activity years.

There was no significant correlation between posture number and activity years (p=0.741) in the sample population. This was seen in the total sample and well as the K and NK groups individually. These results suggest no association between kayaking and/or physical activity and altered posture in the study population exist. In contrast, Katzman *et al.* (2017a: 11) and Ponzano *et al.* (2021: 140) have demonstrated that spine-strengthening exercise interventions and posture training over time can correct age-related hyperkyphosis and improve posture (Katzman *et al.* 2017a: 11; Ponzano *et al.* 2021: 140). Spine strengthening exercises and posture training mentioned by Katzman *et al.* (2017a: 3) and Ponzano *et al.* (2021: 11) were very specific and targeted individuals with diagnosed hyperkyphosis, unlike participants in this current study sample.

5.6.3 Spinal curvature and posture: association with stretching and sitting time

There was no statistical significance between time spent stretching and the spinal curvatures measured. It was reported that 46.2% of the total sample population followed a stretching routine, with an average of 13.75 minutes of stretching for an average of 5.9 days per week. There is a significant variety in stretching methods and intensity. According to Thomas *et al.* (2018: 252), stretching a muscle group for five minutes, five times per week, will show a gain in range of motion for that muscle (Thomas *et al.* 2018: 252). We are, however, unable to relate the time stretching to posture and spinal curvatures in this study as the reported time spent stretching was not specified to spinal extensors or muscles specifically related to maintaining posture. Therefore, no association or correlation between posture and spinal curvature is seen.

Drawing on multiple studies (Anwary *et al.* 2021: 1; Kett, Sichting & Milani 2021: 214), time spent sitting is linked with lower back pain, as poor spinal postures assumed for long periods result in spinal and postural asymmetry. As noted by Anwary *et al.* (2021: 1), assumed poor sitting postures can result in a non-neutral spine positioning leading to anomalies, such as changes in kyphotic and lordotic curvatures (Anwary *et al.* 2021: 1). In the current study, 34.6% (n=18) of the sample population reported sitting for extended periods. The average amount of time spent sitting by participants was 6.67 hours per day, on an average of five days per week. According to a study by De Carvalho *et al.* (2020: 8), it was found that sitting for one hour to 6.96 hours, per day, for five days per week, was associated with immediate increases in lower back pain (De Carvalho *et al.* 2020: 8). Although the literature has noted the association between back pain and sitting, this current study investigated sitting time but did not investigate back pain related to sitting. There was no significant correlation between sitting and C-Flex or T-angles (T-Flex and T-Cobb) in the sample population (K and NK); however, it is worth mentioning that a trend towards a moderate negative correlation between time spent sitting and L-angles (L-Flex r=-0.432 and L-Cobb r=-0.430) was identified. As time spent sitting increased, the L-angles decreased. The sample size is lower in this subgroup thus the correlation did not achieve statistical significance (L-Flex p=0.074 and L-Cobb p=0.075).

In the NK group, a significant negative correlation was found between time spent sitting and the L-angles (L-Flex and L-Cobb, p=0.023, r= -0.739). These results suggest a strong relationship between the lumbar curvature and time spent sitting, showing that as time spent sitting increased, the lumbar curvature flattened. Although the sample size involved in this statistic is low (n=9), this is in line with current literature that explores prolonged sitting effects on lumbar spinal curvatures. In a study by Hey *et al.* (2017: 804), it was found that when an individual transitions from a standing to a sitting posture, there is a reduction in the lumbar lordosis as the body's centre of gravity moves forward (Hey *et al.* 2017: 804). This is seen in sitting posture and the kayaking posture, and possibly explains why lumbar curvatures associated with activity years were significantly flattened in the K group. The literature mentioned explains the link between sitting time, changes to spinal curvature and posture; however, in this study, there was no significant correlation between posture number and reported time spent sitting.

5.7 SUMMARY

Kayaking showed no difference when compared to other physical activities on spinal curvatures and posture as no significant differences were found between mean spinal angels as well as posture numbers. There was a trend towards differences between the two groups, with the K group having larger T-angles (T-Flex and T-Cobb) than the NK group, although the difference was not significant. A significant positive correlation between primary activity years and T-angles (T-Flex and T-Cobb) was found, which suggests that as primary activity years increased, the thoracic kyphotic curvature values increased as well. This was found to be significant in the total sample, although not a significant value when assessing the groups individually; however, the K group did have a greater significance compared to the NK group. With reference to the lumbar spine, a significant negative correlation was found between L-angles and activity years in the K group. This means that as participants spent more time (in years) kayaking, lumbar curvatures flattened.

These results suggest that trends towards increased thoracic spine curvatures and significantly decreased lumbar curvature are associated with increased activity years as seen in the K group when compared to the NK group. These correlations lead us to somewhat agree with the hypothesis and suggest that spinal curvature change associated with kayaking exists. As no significant differences were seen in mean angles between the K and NK groups, the extent of curvature change is limited. However, the fact that with increasing activity years the lumbar curvatures in the K group were significantly decreased when compared to the NK group, there may be some degree of spinal curvature change that is associated with kayaking.

CHAPTER SIX: CONCLUSION

Chapter 6 highlights the key findings of the study and provides some strengths and limitations. This chapter also presents some recommendations for future research and provides a conclusion for the study.

6.1 KEY FINDINGS

- There were no significant differences in mean spinal curvature angles found between the K and NK groups.
- Thoracic curvatures measured (T-Flex and T-Cobb) showed trends towards differences between K and NK groups, with the K group having larger thoracic curvature values than that of the NK group, but the differences were not significant.
- Statistically significant positive correlations between years of activity and T-angles (T-Flex and T-Cobb) were identified. This suggests a low to moderate linear relationship between these variables. This means that as years of activity increases, the thoracic curvature increases. This is true of the entire sample; however, it is noted that a greater significance was seen in the K group alone.
- In the K group, a moderate negative correlation between activity years and L-angles (L-Flex and L-Cobb) was found. This indicates that as activity years in the K group increased, lumbar curvature decreased, i.e. the lumbar lordotic curve flattened.

6.2 STRENGTHS

To our knowledge, this is the first study to investigate spinal curvature alignment and posture in the selected age group of kayakers. Studies have been done which explored spinal curvature alignment in younger individuals and it was noted that studies in older populations were recommended (López-Miñarro, Alacid & Rodriguez-Garcia 2010: 310; López-Miñarro *et al.* 2017: 114). This study adds information to existing literature regarding age and spinal curvature changes, as well as the influence of physical activity, specifically, the activity of kayaking on spinal curvatures and posture in an ageing population. Another notable strength of this study is the agreement of results with other literature that explores the association between variables such as BMI and sitting time with spinal curvatures, specifically, how the lumbar lordosis is affected. Findings in this regard are consistent with that of the literature explored (Been, Gómez-Olivencia & Kramer 2019: 343; Tsagkaris *et al.* 2022: 6).

6.3 LIMITATIONS AND RECOMMENDATIONS

In this study, participants were between the ages of 40 to 60 years, which limits the correlations between age and the variables investigated (posture and spinal curvature values). The study also only included male participants; thus results do not necessarily represent kayakers as an entire population, and generalisations to female populations are not valid. Some limitations exist with regard to participants reporting hours spent on activity per week and activity years. Literature shows that people tend to underreport time spent sitting (Mclaughlin *et al.* 2020: 2), and this may be seen in the reporting of time spent in activity. The variables fall into the category of single-item, self-reported time measures, and have poor accuracy and a potential lack of validity (Mclaughlin *et al.* 2020: 9). This study was unable to produce C-Cobb values, as BMI values greater than 25 made the calculation unreliable, therefore, inclusion would comprise result significance.

It is recommended that future studies include larger sample sizes. Due to the sample size being 52, the study may have been underpowered and larger sample sizes may produce more compelling findings. Future studies can also include investigation into female kayakers, to better represent the kayaking population. Future studies could include more spinal alignment parameters, such as pelvic tilt angles and coronal spinal curvature measurements. It is important to note that a correlation implies a degree of association between two variables, not necessarily that a finding is a result of a variable.

6.4 CONCLUSION

It is well understood that a musculoskeletal consequence of ageing is associated with the deterioration of spinal curvature alignment. Many factors can influence the degree and extent of spinal curvature change, with exposure to postural states having a direct effect on the development of altered spinal curvatures. The results of this study do, to some degree, find an association between the activity of kayaking and a change in spinal curvature alignment. As kayaking activity years increased, there was a significantly flattened lumbar lordosis association. Due to the anatomical association between the thoracic and lumbar spine, any change experienced in the lumbar spine curvature may have a direct influence on the thoracic spine curvature. These findings indicate the need for further research in this regard, with a focus on long-term spinal curvature consequences associated with kayaking. The study was limited in the sample size and cross-sectional design, which caused the study to be underpowered. Although associations and trends were seen, it cannot be deduced that kayaking causes poor posture or clinically significant alterations to spinal curvatures. Longitudinal studies are needed to understand how spinal curvatures and posture are influenced with the prolonged participation in kayaking.

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APPENDICES

Appendix A: Request for Permission to Conduct Research (Clinic Director)

[1/09/2023]
Clinic Director: Chiropractic Day Clinic
Dr Desiree Varatharajullu
desireev@dut.ac.za

Request for Permission to Conduct Research

Dear Dr Varatharajullu,

My name is Matthew Tasker, an MHSc Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves assessing spinal curvatures and posture in active kayakers versus physically active non-kayakers in healthy males between the ages of 40-60 years old.

The study is set to take place in the DUT Chiropractic Day Clinic, and I hereby am seeking your consent to use the clinic for the purposes of this research.

I have attached a copy of my proposal, which includes copies of the data collection tools and consent forms as well as a copy of the approval letter received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (0825279489; taskermatthew@gmail.com). Thank you for your time and consideration.

Yours sincerely,
Matthew Tasker
Durban University of Technology

Appendix B: Request for Permission to Conduct Research (DRPS)

[1/09/2023]
Directorate for Research and Postgraduate Support
Ms Vaneshree Govender
vanesh@dut.ac.za

Request for Permission to Conduct Research

Dear Ms Govender,

My name is Matthew Tasker, an MHSc Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves assessing spinal curvatures and posture in active kayakers versus physically active non-kayakers in healthy males between the ages of 40-60 years old.

The study is set to take place in the DUT Chiropractic Day Clinic, and I hereby am seeking your consent to use the Chiropractic Day Clinic as the premises for this research to take place on. Participants will not be recruited from the DUT campus nor from patients attending to the Chiropractic Day clinic. The Chiropractic Day Clinic will merely be used to perform the necessary data collection.

I have attached a copy of my proposal, which includes copies of the data collection tools and consent forms as well as a copy of the approval letter received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (0825279489; taskermatthew@gmail.com). Thank you for your time and consideration.

Yours sincerely,
Matthew Tasker
Durban University of Technology

Appendix C: Request for Permission to Conduct Research (Gatekeeper)

[1/09/2023]
Gatekeeper
Ms. Lebo Ramakatsa
gatekeeper@dut.ac.za

Request for Permission to Conduct Research

Dear Ms Ramakatsa,

My name is Matthew Tasker, an MHSc Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves assessing spinal curvatures and posture in active kayakers versus physically active non-kayakers in healthy males between the ages of 40-60 years old.

The study is set to take place in the DUT Chiropractic Day Clinic, and I hereby am seeking your consent to use the Chiropractic Day Clinic as the premises for this research to take place on. Participants will not be recruited from the DUT campus nor from patients attending to the Chiropractic Day clinic. The Chiropractic Day Clinic will merely be used to perform the necessary data collection.

I have attached a copy of my proposal, which includes copies of the data collection tools and consent forms as well as a copy of the approval letter received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (0825279489; taskermatthew@gmail.com). Thank you for your time and consideration.

Yours sincerely,
Matthew Tasker
Durban University of Technology

Appendix D: Advertisement

DUT DURBAN UNIVERSITY OF TECHNOLOGY

Attention:
Male kayakers between the ages of **40-60 years old**.

Do you want to be involved in an interesting research study?
(A research study at the Durban University of Technology)

Are you an active kayaker? Have you been kayaking for 3 or more years? We want to assess the curves in your back and compare them to non-kayakers.

Participation will include:
-Medical history
-Postural examination
-Photographic documentation and analysis, front and side views
-Spinal curvature measurement with a flexible ruler

Participation is anonymous and should not take more than 1 hour.

Contact:
Matthew Tasker – 082 527 9489
taskermatthew@gmail.com
OR
DUT Chiropractic Clinic – 031 373 2205
for more information.

<u>**Attention**</u>:
Male non-kayakers between the ages of **40-60 years old**.

Do you want to be involved in an interesting research study?
(A research study at the Durban University of Technology)

Are you physically active? Do you participate in 3 hours of physical activity per week? We want to assess the curves in your back and compare them to kayakers.

<u>Participation will include:</u>
-Medical history
-Postural examination
-Photographic documentation and analysis, front and side views
-Spinal curvature measurement with a flexible ruler

Participation is anonymous and should not take more than 1 hour.

<u>Contact:</u>
Matthew Tasker – 082 527 9489
taskermatthew@gmail.com
OR
DUT Chiropractic Clinic - 031 373 2205
for more information.

Appendix E: Request for Permission to Place Advertisements

[1/09/2023]

Request for Permission to Place Advertisements

To whom it may concern,

My name is Matthew Tasker, an MHSc Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves assessing spinal curvatures and posture in active kayakers versus physically active non-kayakers in healthy males between the ages of 40-60 years old.

I am hereby seeking your consent to place an advertisement, which is attached, on your premises to recruit participants for my research.

I have attached a copy of my proposal, which includes copies of the data collection tools and consent forms as well as a copy of the approval letter received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (0825279489; taskermatthew@gmail.com). Thank you for your time and consideration.

Yours sincerely,
Matthew Tasker
Durban University of Technology

Appendix F: Screening Consultation

Kayaking participants

Questions to ask potential participants	Expected answers
May I ask you a few questions in order to determine your eligibility for the study?	Yes
What is your sex?	Male
Are you between the ages of 40-60 years old?	Yes
Is kayaking your primary form of exercise?	Yes
Have you actively been kayaking for the last 3 years?	Yes
How often do you kayak per week?	At least 3 days/week, or 3 hours/week
Have you been diagnosed with any spinal anomalies (i.e. scoliosis, block vertebrae, hemi-vertebrae etc.)? (Chaturvedi *et al.* 2018: 343)	No
Any history of spinal trauma or surgery? (Li *et al.* 2022: 8; Liebsch & Wilke 2022: 137)	No
Are you currently receiving treatment for back pain? (Wong, Cheung & Cheung 2022: 424-425)	No
Have you been diagnosed with any chronic respiratory condition/s (i.e. chronic bronchitis, emphysema)? (Gonçalves *et al.* 2017: 246)	No

Non-kayaking participants

Questions to ask potential participants	Expected answers
May I ask you a few questions in order to determine your eligibility for the study?	Yes
What is your sex?	Male
Are you between the ages of 40-60 years old?	Yes
Are you involved in any kayaking training?	No
How many hours of physical exercise do you do per week?	At least 3 hours / week.
Have you been diagnosed with any spinal anomalies (i.e. scoliosis, block vertebrae, hemi-vertebrae etc.)? (Chaturvedi *et al.* 2018: 343)	No
Any history of spinal trauma or surgery? (Li *et al.* 2022: 8; Liebsch & Wilke 2022: 137)	No
Are you currently receiving treatment for back pain? (Wong, Cheung & Cheung 2022: 424-425)	No
Have you been diagnosed with any chronic respiratory condition/s (i.e. chronic bronchitis, emphysema)? (Gonçalves *et al.* 2017: 246)	No

Appendix G: Case History

DUT DURBAN UNIVERSITY OF TECHNOLOGY — DEPARTMENT OF CHIROPRACTIC

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________________ Date: __________

File #: __________ Age: __________

Gender: __________ Occupation: ______________________

Student: ______________________ Signature ______________________

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

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

Case Summary signed off: Date:

Student's Case History:

Page 1 of 4

1. **Source of History:**

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

3. **Present Illness:**

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

4. **Other Complaints:**

5. **Past Medical History:**

General Health Status

Childhood Illnesses

Adult Illnesses

Psychiatric Illnesses

Accidents/Injuries

Surgery

Hospitalizations

6. Current health status and life-style:

Allergies

Immunizations

Screening Tests incl. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

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

Tobacco
Alcohol
Social Drugs

7. Immediate Family Medical History:

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

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

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

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

General

Skin

Head

Eyes

Ears

Nose/Sinuses

Mouth/Throat

Neck

Breasts

Respiratory

Cardiac

Gastro-intestinal

Urinary

Genital

Vascular

Musculoskeletal

Neurologic

Haematological

Endocrine

Psychiatric

Appendix H: Posture Evaluation

DUT DURBAN UNIVERSITY OF TECHNOLOGY INSTITUTIONAL RESEARCH ETHICS COMMITTEE

Name: ________________________________

POSTURE EVALUATION		
NAME: AGE: SEX: HEIGHT: WEIGHT: DATE:		
Body type: Ectomorph / Mesomorph / Endomorph / Slight Build / Medium Build / Heavy Build		
Uncorrected Standing A Corrected (Talus in Neutral) Standing B Postural Deformity Corrected C		
ANTERIOR VIEW	Comments:	
Head (aligned, forward, flexed, extended)		
Mandible (resting position, retracted)		
Shoulders (level, uneven)		
Rib cage (symmetric, asymmetric)		
Scoliosis (left, right, lumbar, thoracic, cervical)		
Pelvis (level, anterior/posterior tilt)		
Hips (coxa vara, coxa valga, anteversion, retroversion)		
Femurs (alignment, torsion)		
Knees (level, genu varum, genu valgum)		
Patellar position		
Tibias (alignment, torsions)		
Ankles (inversion, eversion)		
Rearfoot/forefoot alignment		
Feet (pes cavus, pes planus, supination/pronation)		
Toes (alignment, deformities)		
Leg length		
LATERAL VIEW	Comments:	
Head (forward, flexed/extended)		
Mandible (resting, protracted/retracted)		
Scapulae (winging, elevation/depression)		
Thoracic kyphosis (increased/decreased)		
Lumbar lordosis (increased/decreased)		
Pelvis (anterior/posterior tilt)		
Knees (hyperextension/flexion)		
Feet (longitudinal arch)		
POSTERIOR VIEW	Comments:	
Head (alignment, tilt)		
Shoulders (level)		
Scapulae (bilateral symmetry)		
Spine C-1 to sacrum (rotations, deviations)		
Pelvis (level, tilt)		
Sacrum (level at base and inferior lateral angles)		
Hips (level, uneven)		
Knees (creases level/uneven)		
Leg (rearfoot alignment)		
Ankles (inversion/eversion)		
Calcaneal position (inverted/everted)		
Pertinent Medical History:		
Pertinent Radiographic Findings / Other Tests:		

(Magee 2014)

Appendix I: Letter of Information and Consent

LETTER OF INFORMATION

Title of the Research Study: A comparison of spinal curvatures and posture between active kayakers and physically active non-kayakers.

Principal Investigator/s/researcher: Matthew Tasker, BHSc (Chiropractic)

Co-Investigator/s/supervisor/s: Professor JD Pillay, PhD (Physiology); Dr Adelle K Bhundoo, MTech (Chiropractic)

Brief Introduction and Purpose of the Study: The effects of a prolonged kayaking posture on spinal curvatures and postural patterns that arise from the activity of kayaking are not well documented. The purpose of the study is to investigate whether an association exists between the activity of kayaking and spinal curvatures anomalies (cervical lordosis, thoracic kyphosis and lumbar lordosis) in healthy males between the ages of 40-60 years old in the eThekwini municipality. If an association is found, this may form a basis for an understanding of spinal curvature changes associated with kayaking and influence practitioner intervention strategies.

Greeting
Hello, I hope you are well today. Thank you for showing interest in my study.

Introduce yourself to the participant
My name is Matthew Tasker, I am a 6th year student at DUT doing research for my Master's degree in Chiropractic.

Invitation to the potential participant
I would like to invite you to participate in the research.

What is Research
Research is a systematic search or enquiry for generalized new knowledge. My research is investigating whether the activity of kayaking has an effect on posture and spinal curvature changes. You are under no obligation to participate in the study and if you have any questions regarding the study, please feel free to ask as it is important that you understand the study.

Outline of the Procedures:
My research is an observational study, meaning no intervention will be done. You will have to a booked appointment at the Durban University of Technology Chiropractic Day Clinic (Venue - 8 Ritson Road, Musgrave, Berea) or a location that is more convenient to you. For this observational study, you will either fall into the kayaking group or non-kayaking group. You will have one consultation estimated to last one hour long. A case history and postural exam will be done followed by placement of markers (for the use and evaluation of Posture

Pro software) and the taking of lateral and anterior full body photographs. Your spinal curvatures will then be measured using a Flexicurve ruler which is placed along the spine and held by Velcro straps. The Flexicurve ruler will then be used to map out spinal curvatures onto graph paper to be evaluated.

Inclusion criteria for the kayaking group of the study includes the following: Participant being male and between the ages of 40-60 years of age, kayaking is the participants primary form of exercise, kayak training history of at least 3 years, participant actively kayaks for a minimum of 3 days per week or at least 4 hours per week.

Inclusion criteria for the non-kayaking group of the study includes the following: Participant being male and between the ages of 40-60 years of age, participation in at least 3 hours of physical exercise (purposeful exercise) per week.

Exclusion criteria for the study includes the following (both kayaking and non-kayaking groups): Identified structural spinal anomalies (i.e. structural scoliosis, block vertebrae, hemi-vertebrae), musculoskeletal deformities as determined by the postural exam, history of spinal surgery (i.e. spinal vertebral fusion), history of spinal trauma (i.e. intervertebral disc bulge / herniation, compression fractures), ongoing treatment for back pain (i.e. chiropractic, physiotherapy), chronic respiratory conditions (i.e. chronic bronchitis / emphysema).

Specific exclusion criteria for the non-kayaking group of the study includes the following: Participation in kayaking training.

Risks or Discomforts to the Participant:
Due to the study being observational, there are no risks or risk of discomfort to you during this study.

Explain to the participant the reasons he/she may be withdraw from the Study:
You are entitled to withdraw from the study at any time should you wish to do so. There will be no adverse consequences for you should you choose to withdraw from the study. If during the postural exam, factors mentioned in the exclusion criteria are found, you will be unable to take part in the study.

Benefits:
The results of this study may assist in understanding the long-term posture effects as a result of kayaking which may aid in practitioner intervention strategies.

Remuneration:
Participation in this study will be entirely voluntary and without remuneration. You are free to leave the research at any time.

Costs of the Study:
There is no cost to you for your participation in this research.

Confidentiality:
Your information will remain confidential, and no personal information will be published in the final dissertation, therefore you will not be able to be identified. Persons who will have access to your information will include the researcher, supervisor, research head of department and the chiropractic head of department.

Results:
Results of the study will be made available in the form of a dissertation at the Durban University of Technology library.
Research-related Injury:
Due to the study being observational, research-related injuries should not occur.

Storage of all electronic and hard copies including tape recordings:
All research data will be submitted to the chiropractic program for storage and disposal, after 5 years will be shredded. During the duration of the study all information will be stored in the Durban University of Technology Chiropractic Clinic in a locked room and kept safe. All electronic data will be password-secured and stored in the Chiropractic Day Clinic for 5 years, after which it will be deleted as well. The information will be accessible to the researcher, supervisor, research head of department and the chiropractic head of department.

Persons to contact in the Event of Any Problems or Queries: Please contact the researcher (Matthew – 082 527 9489), my supervisor (031 373 2398) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the Acting Director: Research and Postgraduate Support on researchdirector@dut.ac.za

Thank you for participating in my study,
Matthew Tasker

CONSENT

Full Title of the Study: A comparison of spinal curvatures and posture between active kayakers and physically active non-kayakers.

Names of Researcher/s: Matthew Tasker

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, ________________ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ _______ ____________________________

Full Name of Participant **Date** **Time** **Signature/Right Thumbprint**

I, __________ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

____________________ ____________ ______________________

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

____________________ ____________ ______________________

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

__________________ ___________ ____________________

Full Name of Legal Guardian Date **Signature**
(If applicable)

Appendix J: Letter of Information and Consent (Afrikaans)

INLIGTINGSBRIEF

Titel van die Navorsingstudie: 'n Vergelyking van spinale krommings en postuur tussen aktiewe kajakvaarders en fisies aktiewe nie-kajakvaarders.

Hoofondersoeker/s/navorser: Matthew Tasker, BHSc (Chiropraktyk)

Mede-ondersoeker(s)/Toesighouer(s): Professor JD Pillay, PhD (Fisiologie); Dr Adelle K Bhundoo, Mtech (Chiropraktyk)

Kort Inleiding en Doel van die Studie: Die uitwerking van 'n langdurige kajak-houding op sagitale ruggraatbelyning en posturale patrone wat voortspruit uit die aktiwiteite van kajak is nie goed gedokumenteer nie. Navorsing is nodig om te bepaal of kajakvaarders die risiko loop om veranderde ruggraatkrommings te ontwikkel voordat aanbevelings of intervensiestrategieë vir jonger kajakvaarders voorgestel word om die omvang van krommingsveranderinge in die toekoms te beperk. Die doel van die studie is om vas te stel of daar 'n verband bestaan tussen die aktiwiteit van kajak en sagitale ruggraatbelyning/krommingsafwykings (servikale lordose, torakale kifose en lumbale lordose) by gesonde mans tussen die ouderdomme van 40-60 jaar oud in die eThekwini munisipaliteit. Indien 'n assosiasie gevind word, kan dit 'n basis vorm vir 'n begrip van spinale krommingsveranderinge wat verband hou met kajak en praktyk-intervensiestrategieë beïnvloed.

Groete
Hallo, ek hoop dit gaan vandag goed met U. Dankie dat U in my studie belangstel.

Stel jouself aan die deelnemer voor
My naam is Matthew Tasker. Ek is 'n sesdejaar student by DUT waar ek besig is met my Meesters Graad in Chiropraktyk.

Uitnodiging aan die Potensiële Deelnemer
Ek nooi U uit om deel te wees van die navorsing.

Wat is Navorsing
Navorsing is 'n sistematiese soeke of navraag na algemene nuwe kennis. My navorsing ondersoek of die aktiwiteit van kajak 'n effek het op postuur en spinale krommingsverandering. Jy is onder geen verpligting om aan die studie deel te neem nie en as jy enige vrae oor die studie het, vra gerus, want dit is belangrik dat jy die studie verstaan.

Uiteensetting van die Prosedures:
My navorsing is 'n waarnemingstudie en geen ingryping sal gedoen word nie. Jy sal 'n afspraak van die Durbanse Universiteit van Tegnologie se Chiropraktiese Dagkliniek (lokaal 8, Ritsonweg, Musgrave, Berea) ontvang. Jy sal een konsultasie van ongeveer 'n uur bywoon. 'n Gevallegeskiedenis en posturale eksamen sal gedoen word, gevolg deur die plasing van merkers (vir die gebruik van evaluering van Posture Pro-sagteware) en die

neem van laterale en anteriore volle liggaamfoto's. Jou spinalekrommings sal gemeet word deur die gebruik van 'n Fleksikurwe-liniaal wat langs die ruggraat geplaas word, vasgehou deur klittenbandbande. Die Fleksiekurwe-liniaal sal dan gebruik word om die ruggraatkrommings op grafiekpaper uit te teken om geëvalueer te word.

Die inligtingsbrief sal aan jou verskaf word en die ingeligte toestemming sal deur U onderteken moet word voor die aanvang van die studie. Vir hierdie waarnemingstudie sal jy óf in die kajakgroep, óf die nie-kajakgroep val. Insluitingskriteria vir die kajakgroep van die studie sluit die volgende in:

Deelnemers moet van die manlike geslag wees, tussen die ouderdomme van 40-60 jaar oud. Kajak is die deelnemers se primêre vorm van oefening, kajakopleiding van ten minste 3 jaar. Deelnemers moet vir 'n minimum van 3 dae per week of ten minste 4 uur per week, aktief met kajak besig wees.

Insluitingskriteria vir die nie-kajakgroep van die studie sluit die volgende in: Deelnemers synde manlik en tussen die ouderdomme van 40-60 jaar oud. Deelnemers moet blootgestel wees aan ten minste 3 uur fisiese oefening per week (doelgerigte oefening).

Uitsluitingskriteria vir die studie sluit die volgende in (beide kajakgroep en nie-kajakgroep): Geïdentifiseerde strukturele ruggraatafwykings (dit is strukturele skolioseblokwerwels, blokeerwerwels, hemi-werwels), miskulosketale misvorming soos bepaal deur die posturale ondersoek, geskiedenis van rugraatchirurgie (dit is spinale werwelversmelting), geskiedenis van spinale trauma (dit is intervertebrale skyfbult/herniasie, kompressiefakture), deurlopende behandeling vir rugpyn (dit is chiroprakties, fisioterapie), kroniese respiratoriese toestande (dit is chroniese brongitis/emfiseem).

Spesifieke uitsluitingskriteria vir die nie-kajakgroep van die studie sluit die volgende in: Deelname aan kajakopleiding.

Risiko's of Ongemak vir die Deelnemers
Aangesien die studie 'n waarneming is, is daar geen risiko of ongemak vir die deelnemer gedurende die studie nie.

Verduidelik aan die Deelnemer waarom hy/sy dalk aan die Studie onttrek mag word:
Jy mag enige tyd aan die studie onttrek word as jy dit verkies. Daar sal geen nadelige gevolge vir jou wees as dit jou wens is om jou van die studie te onttrek nie. Indien faktore wat in die uitsluitingskriteria genoem word tydens die posturale eksamen gevind word, sal jy nie aan die studie kan deelneem nie.

Voordele:
Die resultate van hierdie studie kan help om die langtermyn postuureffekte as gevolg van kajak te verstaan, wat kan help met praktisyn-intervensiestrategieë.

Vergoeding:
Deelname aan hierdie studie sal heeltemal vrywillig en sonder vegoeding wees. Jy is vry om die ondersoek enige tyd te verlaat.

Koste verbonde aan die Studie:
Daar is geen koste verbonde aan die deelname aan hierdie studie nie.

Vertroulikheid:
Jou inligting sal vertroulik bly en geen persoonlike inligting sal in die finale proefskrif gepubliseer word nie, daarom sal jy nie geïdentifiseer kan word nie. Persone wat toegang tot inligting sal hê sal die ondersoeker insluit asook die toesighouer, hoof van die navorsingsdepartement en die chiropraktiese departementshoof.

Resultate:
Resultate van die studie sal in die vorm van 'n verhandeling by die Durban Universiteit van Tegnologie-biblioteek beskikbaar gestel word.

Navorsingsverwante besering:
Aangesien die studie waarneming is, behoort navorsingsverwante beserings nie te voorkom nie.

Berging van alle elektroniese en harde kopieë, insluitend bandopnames:
Alle navorsingsdata sal na 5 jaar by die chiropraktiese program ingedien word vir berging en wegdoening, sal versnipper word. Gedurende die duur van die studie sal alle inligting in die Durban Universiteit van Tegnologie Chiropraktiese Kliniek in 'n geslote kamer gestoor word en veilig bewaar word. Alle elektroniese data sal met 'n wagwoord beveilig word en vir 5 jaar in die Chiropraktiese Dagkliniek gestoor word, waarna dit ook uitgevee sal word. Die inligting sal toeganklik wees vir die navorser, studieleier, navorsingsdepartementshoof en die chiropraktiese departementshoof.

Persone om te kontak in die geval van enige probleme of navrae: Kontak asseblief die navorser (Matthew – 082 527 9489), my studieleier (031 373 2398) of die Institusionele Navorsingsetiek-administrateur by 031 373 2375. Klagtes kan by die Waarnemende Direkteur aangemeld word. : Navorsing en Nagraadse Ondersteuning op researchdirector@dut.ac.za

Dankie vir jou deelname aan my studie,
Matthew Tasker

DUT DURBAN UNIVERSITY OF TECHNOLOGY INSTITUTIONAL RESEARCH ETHICS COMMITTEE

TOESTEMMING

Volle Titel van die Studie:
'n Vergelyking van spinale krommings en postuur tussen aktiewe kajakvaarders en fisies aktiewe nie-kajakvaarders.

Naam van Navorser: Matthew Tasker

Verklaring van Ooreenkoms om aan die Navorsingstudie deel te neem:

- Hiermee bevestig ek dat ek ingelig is deur die navorser, ________________ (naam van die navorser) aangaande die aard, gedrag, voordele en risiko's van die Studie - Navorsingsetiekverklaring Nommer ___________________
- Ek het ook die bo-gaande geskrewe inligting (Deelnemersbrief met inligting aangaande die Studie) ontvang, gelees en verstaan.
- Ek is daarvan bewus dat die resultate van die studie, insluitend persoonlike inligting aangaande my geslag, ouderdom, geboortedatum, voorletters en diagnose anoniem in 'n studieverslag verwerk sal word.
- In die lig van die vereistes van navorsing stem ek saam dat die data wat tydens hierdie studie ingesamel is, in 'n gerekenariseerde stelsel, deur die navorser verwerk mag word.
- Ek mag ter enigertyd sonder vooroordeel, my toestemming en deelname aan die studie onttrek.
- Ek het genoeg geleentheid gehad om vrae te vra en (uit my eie vrye wil) verklaar ek myself bereid om aan die studie deel te neem.
- Ek verstaan dat beduidende nuwe bevindinge wat in die loop van hierdie navorsing ontwikkel is, en wat verband hou met my deelname, aan my beskikbaar gestel sal word.

_____________________ _____________ _____ ______________________
Volle Name van Deelnemer **Datum** **Tyd** **Handtekening / Regter Duimafdruk**

Ek, _______________ (naam van navorser) verklaar hiermee dat die bogenoemde deelnemer ingelig is oor die aard en deelname en risiko's van bogenoemde studie.

___________________ ________________ ___________________________
Volle Name van Navorser **Datum** **Handtekening / Regter Duimafdruk**

__________________ _________________ ___________________________
Volle Name van Getuie **Datum** **Handtekening (indien van toepassing)**

_______________________ ________________ __________________________
Volle Name van Wettige Voog. **Datum** **Hantekening (indien van toepassing)**

Appendix K: Letter of Information and Consent (isiZulu)

INCWADI YOLWAZI

Isihloko socwaningo: Ukuqhathanisa: Ukuqhathaniswa kokugoba komgogodla kanye nokuma phakathi kwama-kayaker asebenzayo nabangewona ama-kayaker abakhuthele ngokomzimba.

Umcwaningi oyinhloko: Matthew Tasker **(**Bachelors of Health Science ku-Chiropractic)

Ababambisene nomcwaningi oyinhloko: Profesa JD Pillay (PhD Physiology)**,** Dokotela Adelle K Bhundoo (MTech ku-Chiropractic)

Isethulo esifushane kanye nenjongo yoncwaningo
Imiphumela yesikhathi eside sendlela umgogodla oma ngayo uma kwenziwa i-kayaking kanye namaphethini endlela yokuma edalwa i-kayaking akubhaliwe kahle. Inhloso yocwaningo ukuphenya ukuthi ingabe ikhona yini inhlangano phakathi komsebenzi we-kayaking kanye nokuqonda komgogodla noma okungaqondakali kahle emajika omgogodla (ijika lentamo ngemuva, umgogodla weqolo langenhla, kanye nomgogodla weqolo elisezansi) kwabesilisa abaphilile abaphakathi kweminyaka engama-40 kuya kuma-60 kumasipala waseThekwini. Uma inhlangano itholakala, lokhu kungase kube isisekelo sokuqonda izinguquko emajikeni omgogodla ezihambisana ne-kayaking kanye nomthelela wamasu okungenelela kochwepheshe

Isibingelelo
Sawubona, ngithemba ukuthi uphilile namuhla. Ngiyabonga ngokubonisa isithakaselo ocwaningweni lami.

Ukuzethula kumhlanganyeli
Igama lami ngingu-Matthew Tasker, ngingumfundi wonyaka wesi-6 e-DUT ngenza ucwaningo ngeziqu zami ze-Master's kuChiropractic.

Isimemo esiya kongaba umhlanganyeli
Ngithanda ukukumema ukuba ubambe iqhaza ocwaningweni.

Yini ucwaningo?
Ucwaningo uphenyo oluhlelekile noma uphenyo lokuthola ulwazi olusha olujwayelekile. Ucwaningo lwami luphenya ukuthi ngabe umsebenzi we-kayaking unomphumela ekushintsheni kokuma nokugoba komgogodla. Awuphoqelekile ukuthi ubambe iqhaza ocwaningweni futhi uma unemibuzo mayelana nocwaningo, sicela ukhululeke ukubuza ngoba kubalulekile ukuthi uluqonde lolucwaningo.

Uhlaka Lwezinqubo
Ucwaningo lwami luwucwaningo lokubheka, okusho ukuthi akukho kungenelela okuzokwenziwa. Kuzodingeka ufike emtholampilo wasemini we-chiropractic osenyuvesi yezobuchwepheshe yaseThekwini ngesikhathi obhukelwe sona (indawo - 8 Ritson Road, Musgrave, Berea).. Kulolu cwaningo lokubheka, uzowela eqenjini le-kayaking noma eqenjini okungelona ele-kayaking. Umlando wempilo kanye nokuhlolwa kwendlela yokuma kuzokwenziwa kulandelwe ukubekwa kwabamaka (ukuze kusetshenziswe futhi kuhlolwe

ubuchwepheshe be-Posture Pro) kanye nokuthathwa kwezithombe zomzimba ezigcwele zangemuva nezingaphambili. Amajika omgogodla azobe eselinganiswa ngokusebenzisa isiqondisi i-Flexicurve esibekwa eceleni komgogodla futhi sibanjwe yizintambo ze-Velcro. Isiqondisi i-Flexicurve sizobe sesisetshenziswa ukwenza imephu yokugoba komgogodla ephepheni legrafu ukuze lihlolwe.

Imibandela yokufakwa eqenjini le-kayaking kulolucwaningo ihlanganisa lokhu okulandelayo:
Umhlanganyeli ongowesilisa futhi uphakathi kweminyaka yobudala engama-40 kuya kuma-60, I- kayaking iwuhlobo lokuqala lokuzivocavoca lwabahlanganyeli, umlando wokuqeqeshwa kwe-kayak okungenani kweminyaka emithathu, abahlanganyeli kumele benze ngenkuthalo i-kayak okungenani izinsuku ezi-3 ngesonto noma okungenani amahora ama-4 ngesonto.

Imibandela yokufakwa eqenjini okungelona ele-kayaking kulolucwaningo ihlanganisa lokhu okulandelayo:
Umhlanganyeli ongowesilisa futhi uphakathi kweminyaka yobudala engama-40 kuya kuma-60, ukubamba iqhaza ekuzivocavoceni umzimba okungenani amahoreni angu-3 (ukuzivocavoca okunenjongo) ngesonto.

Imibandela yokungafakwa ocwaningweni ihlanganisa lokhu okulandelayo (womabili amaqembu ele-kayaking kanye nokungelona ele-kayaking):
Umgogodla owakheke ngendlela engaqondakali kahle (njengomgogodla owakhekhe ngendlela etshekile, umgogodla ovimbekile, ukukhubazeka kwemisipha namathambo njengoba kunqunywe ukuhlolwa kwendlela yokuma, umlando wokuhlinzwa komgogodla (ukuhlanganiswa komgogodla), umlando wokuhlukumezeka komgogodla (okungukuthi ukuqumba kwediski yomgogodla noma ukuphutshuka, ukuphuka komgogodla ngenxa yokucindezeleka), ukwelashwa okuqhubekayo kobuhlungu beqolo (okungukuthi i-chiropractic, i-physiotherapy), izimo ezingapheli zokuphefumula (ukuvuvuka kwemigudu yokuphefumula okungapheli / i-emphysema).

Imibandela eqondile yokukhishwa ocwaningweni yeqembu elingenzi i-kayaking ihlanganisa lokhu okulandelayo:
Ukubamba iqhaza ekuqeqesheleni i-kayaking. Uzoba nokubonisana okukodwa okulinganiselwe ukuba ihora elilodwa ubude.

Ubungozi noma ukungakhululeki okungahle kuvelele obambe iqhaza:
Ngenxa yokuthi lolu cwaningo luyaqaphelisisa, azikho izingcuphe noma ingozi yokungakhululeki kuwe phakathi nalolu cwaningo.

Chazela umhlanganyeli izizathu zokuthi angahoxa Ocwaningweni:
Unelungelo lokuhoxa ocwaningweni nganoma yisiphi isikhathi uma ufisa ukwenza njalo. Ngeke kube nemiphumela emibi uma ukhetha ukuhoxa ocwaningweni. Uma ngesikhathi sokuhlolwa kwendlela yokuma, izici ezishiwo kwimibandela yokukhishwa zitholakala, ngeke ukwazi ukuba ingxenye yocwaningweni.

Izinzuzo:
Imiphumela yalolu cwaningo ingasiza ekuqondeni imiphumela yesikhathi eside yokuma ngenxa ye-kayaking engasiza ochwepheshe kumasu okungenelela.

Inkokhelo:
Ukubamba iqhaza kulolu cwaningo kuzoba ngokuzithandela futhi ngaphandle kweholo. Ukhululekile ukushiya ucwaningo noma kunini.

Izindleko Zocwaningo:
Azikho izindleko ozobhekana nazo ngokubamba iqhaza kwakho kulolu cwaningo.

Ukugcinwa kuyimfihlo:
Ulwazi lwakho luzohlala luyimfihlo, futhi alukho ulwazi lomuntu siqu oluzoshicilelwa ku-dissertation yokugcina, ngakho-ke ngeke ukwazi ukukhonjwa. Abantu abazokwazi ukufinyelela olwazini lwakho bazobandakanya umcwaningi, umphathi, inhloko yocwaningo kanye nenhloko yomnyango we-chiropractic.

Imiphumela:
Imiphumela yalolu cwaningo izotholakala ngohlobo lwe-dissertation kumtapo wolwazi wasenyuvesi yezobuchwepheshe yaseThekwini.

Ukulimala okuhlobene nocwaningo:
Ngenxa yokuthi lolu cwaningo luyabhekisisa kuphela, akumele kwenzeke ukulimala okuhlobene nocwaningo.

Ukugcinwa kwawo wonke amakhophi asemshinini kanye namakhophi aqinile okuhlanganisa nokuqoshiwe:
Lonke ulwazi locwaningo luzothunyelwa ohlelweni lwe-chiropractic ukuze lugcinwe futhi luphinde lulahlwe, ngemva kweminyaka engu-5. Ngesikhathi socwaningo lonke ulwazi luzogcinwa emtholampilo we-chiropractic enyuvesi yezobuchwepheshe yaseThekwini, egunjini elikhiyiwe futhi eligcinwe liphephile. Lonke ulwazi olusemshinini luzovikelwa ngephasiwedi futhi lugcinwe emtholampilo we-Chiropractic iminyaka engu-5, ngemva kwalokho luzobe selususwa. Ulwazi luzofinyeleleka kumcwaningi, umphathi, inhloko yocwaningo kanye nenhloko yomnyango we-chiropractic.

Abantu ongathintana nabo uma kunezinkinga noma imibuzo: Sicela uthinte umcwaningi (uMatthew - 082 527 9489), umphathi wami (031 373 2398) noma uMqondisi Wezimiso Zocwaningo Lwesikhungo ku-031 373 2375. Izikhalazo zingabikwa kuMqondisi Osabambile: Ucwaningo kanye Nokwesekwa Kwabaneziqu ku researchdirector@dut.ac.za.

Ngiyabonga ngokubamba iqhaza ocwaningweni lwami,
Matthew Tasker

INCWADI YOKUVUMA

Isihloko socwaningo: Ukuqhathaniswa kokugoba komgogodla kanye nokuma phakathi kwama-kayaker asebenzayo nabangewona ama-kayaker abakhuthele ngokomzimba.

Amagama omcwaningi: Matthew Tasker

Isitatimende sesivumelwano sokubamba iqhaza ocwaningweni:

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

___________________	____________	__________	___________________
Amagama agcwele	**usuku**	**isikhathi**	**isiginesha omhlanganyeli**

Mina Mnumzane Matthew Tasker, ngiyaqinisekisa ukuthi umhlanganyeli ongenhla waziswe ngokugcwele mayelana nesimo, ukuziphatha kanye nobungozi bocwaningo oluhlongozwayo.

__________________	___________	____________________
Amagama agcwele omcwaningi	usuku	isiginesha
__________________	___________	____________________
Amagama agcwele kafakazi	usuku	isiginesha (Uma ekhona)
__________________	___________	____________________
Amagama agcwele omnakekeli	usuku	isiginesha (Uma ekhona)

Appendix L: Template of Measures

Template of Measures

Participant name: ________________________________

Group: Kayaking Non-kayaking

Age		
Height		
Weight		
Main activity		
Hours spent per week in activity (Min and Max)	Min	Max
Activity years		
Other activities include		
Occupation		
Participant meets inclusion and exclusion criteria		

Notes for Case History
Notes for Postural Exam
Additional Notes

Measures for Spinal Angles (C, T and L)	
C-angle (˚)	
T-angle (˚)	
L-angle (˚)	

Posture Pro Number:	

Hours of physical activity per week:

0-1	1-2	2-3	3-4	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12+

Days per week physically active:

0	1	2	3	4	5	6	7

Participant follows a stretching routine:

Yes		No
Time spent stretching		
Number of days per week		

Does the participant sit at work or drive for extended periods of time:

Yes		No
Approximate time spent sitting /day		
Number of days per week		

Appendix M: Ethics Training

Zertifikat Certificat Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Matthew Tasker

a complété avec succès - has successfully completed

Introduction to Research Ethics

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/05/05

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

Ce programme est soutenu par - This program is supported by :

Zertifikat Certificat Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Matthew Tasker

a complété avec succès - has successfully completed

Research Ethics Evaluation

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/05/05

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

Ce programme est soutenu par - This program is supported by :

Zertifikat Certificat Certificado Certificate

Promouvoir les plus hauts standards éthiques dans la protection des participants à la recherche biomédicale
Promoting the highest ethical standards in the protection of biomedical research participants

Certificat de formation - Training Certificate

Ce document atteste que - this document certifies that

Matthew Tasker

a complété avec succès - has successfully completed

Informed Consent

du programme de formation TRREE en évaluation éthique de la recherche
of the TRREE training programme in research ethics evaluation

Release Date: 2021/05/05

Professeur Dominique Sprumont
Coordinateur TRREE Coordinator

Ce programme est soutenu par - This program is supported by :

Appendix N: Permission (off-site data collection)

chiropractic collective

12 March 2024

To Whom It May

I, Dr Tyren Naidoo, hereby give permission for Mr. Mathew Tasker, to make use of the room at Chiropractic Collective in Kloof.

Kind Regards

Dr Tyren Naidoo

065 801 6868 admin@chiropracticcollective.com

Appendix O: IREC full approval

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

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

www.dut.ac.za

10 October 2023

Mr M B Tasker
Suit 62
Private bag X3019
Paarl
7640

Dear Mr Tasker

A comparison of spinal curvatures and posture between active kayakers and physically active non-kayakers
Ethical Clearance number IREC 158/23

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

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

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

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

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

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

Yours Sincerely

Prof J K Adam
Chairperson: DUT-IREC

Appendix P: IREC approval

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

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

www.dut.ac.za

10 April 2024

Mr M B Tasker
Suit 62
Private bag X3019
Paarl
7640

Dear Mr Tasker

A comparison of spinal curvatures and posture between active kayakers and physically active non-kayakers
Ethical Clearance number IREC 158/23

I am pleased to inform you that your application for amendment to include an additional site for data collection has been approved.

Yours Sincerely

Prof J K Adam
Chairperson: DUT-IREC

Appendix Q: Proof reader certificate

Helen Bond

IMPELA EDITING SERVICES

impelaediting@gmail.com

079 395 5873

10 December 2024

CERTIFICATE

Matthew Tasker

Dear Matthew

Thank you for using Impela Editing Services to edit your Master's dissertation entitled "A COMPARISON OF SPINAL CURVATURES AND POSTURE BETWEEN ACTIVE KAYAKERS AND PHYSICALLY ACTIVE NON-KAYAKERS".

I have proofread for errors of grammar, punctuation, spelling, syntax and typing mistakes. I have formatted your work and checked the references (this means checking the formatting) according to the DUT Harvard guideline.

Please note that Impela Editing accepts no fault for work changed after issuing this certificate.

Kind regards

Helen Bond (Bachelor of Arts, HDE)

Appendix R: Plagiarism Report

M.Tasker (21719334) Turnitin.docx

ORIGINALITY REPORT

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