THE EFFECT OF VARIOUS PILLOW TYPES ON CERVICO-THORACIC AND FORWARD HEAD POSTURE IN YOUNG ADULTS

By

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

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DEDICATION

I dedicate this dissertation to:

My husband, Omar Khayyam Karim. Thank you for the love, encouragement, care and support that you have provided me with over the years.

My parents, Nisar Ahmed and Zubeda Khan, thank you for all the inspiration, love and sacrifices you have made throughout the years so that I could achieve my goals

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ABSTRACT

Correct neck support is required during sleep to align the spine and maintain neutral posture, and to immobilise the joints in the neck which would allow the cervical paraspinal muscles to relax (De Laittre, 1974; Ambrogio et al., 1998; Erfanian et al., 1998). Poor spinal posture during sleep however, has been hypothesized to result in lateral bending and uneven loading on the intervertebral discs and cervical facet joints, and compression of pain-sensitive structures in the neck (Leilnahari et al., 2011). The pillow is a significant contributing factor to sleep quality and the development of symptoms on waking (Gordon et al., 2011). This should theoretically reduce pressure on the pain-sensitive structures and allow the intervertebral discs to be unloaded and rehydrated (Leilnahari et al., 2011).

Aim:

To determine and compare the effect of the Simmons' Beautyrest pillow, a polyester foam pillow, a latex pillow, and no pillow, on cervico-thoracic and forward head posture in the supine and recumbent supine positions in asymptomatic individuals.

Methods:

Forty asymptomatic subjects between the ages of 20 and 30 years were recruited using convenience sampling. The study was a double-blinded comparative investigation where all participants underwent a case history, physical examination and an orthopaedic examination of the cervical spine. Thereafter, digital photographic images of the participants lying without a pillow and on three different pillows (Simmons Beautyrest® pillow, a polyester foam pillow and a latex pillow) in the supine and recumbent positions were captured. These images were then uploaded onto a computer, and using the linear co-ordinates of each anatomical landmark (which was determined by the researcher using CorelDraw Graphics Suite 12), the cervico-thoracic and craniocervical postures were determined. The cervico-thoracic posture was determined by calculating the gradients of the intersegmental slopes, relative to the horizontal plane, using the formula $(y2 - y1)/(x2 - x1)$. The craniocervical posture was determined by calculating the craniocervical angle. This angle was determined by constructing lines between the anatomical landmarks and measuring the angle produced at C7. At the end of the objective data collection, participants were asked verbally which pillow they found most comfortable. All data was collected by the researcher. Statistical analysis was done using IBM SPSS version 21.0. Repeated measures ANOVA test was used to compare the mean slope measurements in the four conditions. Inferential techniques included Wilcoxon Signed-Rank test and t-tests. A p-value of < 0.05 indicated statistical significance.

Results:

The mean (± SD) age of the participants was 24.3 (± 2.57) years. In terms of pillow preference, 15 participants preferred the latex pillow, 8 preferred the polyester pillow and 17 preferred the Simmons Beautyrest® pillow. In the recumbent position for the C2-EOP slope the latex and Simmons Beautyrest® pillows supported the neck in a similar manner (p= 0.480) and closer to neutral than no pillow and the latex pillow. For the C4-C2 and the C7-C4 slopes, the latex pillow produced the least extreme slope. For the T3-C7 slope, the polyester pillow produced the slope closest to neutral. Overall, for the entire cervical spine, the latex pillow produced the least extreme slopes, but at the cervico-thoracic junction, the polyester pillow produced the most neutral slope. In all segments, the condition without a pillow produced the most extreme slopes. When comparing the slopes themselves, it can be seen that the most extreme deviations from neutral occurred at the C2-EOP segment. The mid-cervical spine deviated least from neutral. In the supine position, there were no significant differences (p> 0.05) in the sagittal angular displacement between the pillows.

Conclusion:

The results of this study support the view that there is no one particular pillow that is better than the others for providing optimal support to the head and neck. Furthermore, practitioners should be aware that it is the craniocervical and cervico-thoracic slopes, which are determined with the patient in the recumbent position, that provide significant information regarding support provided by the pillow rather than the sagittal angular displacement assessed in the supine position.

LIST OF SYMBOLS AND ABBREVIATIONS

®:	Registered Trademark
°:	Degree
C1:	First cervical vertebra
C2:	Second cervical vertebra
C3:	Third cervical vertebra
C4:	Fourth cervical vertebra
C5:	Fifth cervical vertebra
C6:	Sixth cervical vertebra
C7:	Seventh cervical vertebra
CDC:	Chiropractic Day Clinic
cm:	Centimetres
CROM:	Cervical range of motion
DUT:	Durban University of Technology
EOP:	External occipital protuberance
L1:	First lumbar vertebra
L2:	Second lumbar vertebra
L3:	Third lumbar vertebra
L4:	Fourth lumbar vertebra
L5:	Fifth lumbar vertebra
mm:	Millimetres
n:	Sample size or count
NDI:	Neck Disability Index

NRS:	Numerical Rating Scale
SPSS:	Statistical Package for the Social Sciences
T1:	First thoracic vertebra
T2:	Second thoracic vertebra
T3:	Third thoracic vertebra
T4:	Fourth thoracic vertebra
T5:	Fifth thoracic vertebra
T6:	Sixth thoracic vertebra
T7:	Seventh thoracic vertebra
T8:	Eighth thoracic vertebra
T9:	Ninth thoracic vertebra
T10:	Tenth thoracic vertebra
T11:	Eleventh thoracic vertebra
T12:	Twelfth thoracic vertebra

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Patients with cervical or thoracic spine symptoms who present to healthcare professionals may include poor sleep quality and low pillow comfort amongst their complaints (Gordon et al., 2002; Gordon et al., 2011). The pillow is a significant contributing factor to sleep quality and the development of symptoms on waking (Gordon et al., 2011). It is hypothesised that poor cervical posture during sleep results in lateral bending and uneven loading on the intervertebral discs and cervical facet joints, and compression of pain-sensitive structures in the neck (Leilnahari et al., 2011). This often results in neck, scapular or arm pain, and headaches when the individual is awake (Gordon et al., 2002). Several authors suggest that correct neck support during sleep is required to align the spine and maintain neutral posture, and to immobilise the joints in the neck which would allow the cervical paraspinal muscles to relax (De Laittre, 1974; Ambrogio et al., 1998; Erfanian et al., 1998). This should theoretically reduce pressure on the pain-sensitive structures and allow the intervertebral discs to be unloaded and rehydrated (Leilnahari et al., 2011).

Cervical support and neck pillows are frequently used to decrease pain and improve neck symptoms (Persson, 2006) although the evidence regarding their efficacy is contradictory (Shields et al., 2006). A well-designed pillow should support and maintain the head and neck in almost the same position that the head and neck assumes when the person is sitting or standing (De Laittre, 1974; Gordon et al., 2010) as well as prevent the neck from assuming extreme postures (Gordon et al., 2010). Although several studies have examined the effect of cervical pillows on subjective measures related to neck pain (Shields et al., 2006), headaches (Erfanian et al., 2004), sleep quality (Gordon et al., 2009), waking symptoms, and scapular and arm stiffness (Gordon et al., 2010), there have been very few studies that have investigated objective outcome measures related to the efficacy of cervical pillows (Lin and Huang, 2007; Gordon et al., 2011). Healthcare practitioners, including chiropractors, are frequently requested by their patients for information regarding choice of an appropriate pillow (Gordon et al, 2011). The plethora of contradictory information regarding pillow choice is based on subjective assessments and anecdotal evidence regarding pillows and this becomes disconcerting for both healthcare practitioners as well as patients. It is the opinion of this researcher that both subjective and objective evidence should be taken into account in order to provide suitable recommendations on pillow choice. However, additional data such as changes in spinal posture in response to different pillows is required, to demonstrate how the cervical spine responds to different pillows.

The Simmons Beautyrest® pillow which has been recently introduced to the South African market, is a specifically-designed pillow made up of inner coils which are separately wrapped in order to adjust to individual movements. Its manufacturer's claim that it is able to provide proper neck support irrespective of an individual's sleeping position (Simmons South Africa, 2012; Jagarnath, 2012). A recent study by Jagarnath (2012) reported that the Simmons Beautyrest® pillow is effective in decreasing non-specific neck pain when compared to the patient's own standard pillow. The author recommended that further investigation should be carried out in order to compare the Simmons Beautyrest® pillow to other types of pillows so as to determine the effect of selected biomechanical parameters to provide more objective data to support the findings.

1.2 AIMS AND OBJECTIVES

1.2.1 The aim of this study was:

To determine the effect of the Simmons' Beautyrest pillow on craniocervical and cervico-thoracic posture in the supine and recumbent positions compared to no pillow, a polyester foam pillow and a latex pillow in asymptomatic participants.

1.2.2 The objectives of this study were:

Objective One:
To determine the effect of no pillow on craniocervical and cervico-thoracic posture in the supine and recumbent positions in order to achieve a base-line measurement.

Objective Two:
To determine the effect of the polyester foam pillow on craniocervical and cervico-thoracic posture in the supine and recumbent positions.

Objective Three:

To determine the effect of the latex pillow on craniocervical and cervico-thoracic posture in the supine and recumbent positions.

Objective Four:

To determine the effect of the Simmons Beautyrest pillow on craniocervical and cervico-thoracic posture in the supine and recumbent positions.

Objective Five:

To compare the results of Objectives 1-4 in order to determine if there were significant differences between the groups.

1.3. THE HYPOTHESIS

An alternate hypothesis (H_a) was set which stated that:

- There will be a significant difference in the craniocervical and cervico-thoracic and forward head postures in the supine and recumbent positions between the three pillows

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Poor neck posture during sleep results in lateral bending and uneven loading of the cervical intervertebral discs and facet joints and causes compression of pain-sensitive structures in the neck (Leilnahari et al., 2011). This often results in neck, scapular or arm pain, and headaches when the individual is awake. Correct neck support during sleep immobilises the facet joints, allowing the cervical paraspinal muscles to relax, and maintains the cervical lordosis (De Laittre, 1974; Ambrogio et al., 1998; Erfanian et al., 1998). This reduces pressure on the pain-sensitive structures, leading to pain-relief for prolonged periods (Ambrogio et al., 1998). Healthcare practitioners, including chiropractors, are frequently requested for recommendations regarding pillow choice. A variety of advice is given, often based on anecdotal evidence, because there is limited research regarding the effect of different pillow types on the neck posture.

2.2 A SUMMARY OF THE RELEVANT ANATOMY OF THE CERVICAL SPINE

The seven vertebrae which are found between the skull and thorax form the cervical spine (Moore and Dalley, 1999). These vertebrae are the smallest vertebrae in the body (Standring, 2008) due to the fact that they are exposed to less weight-bearing force than any other vertebrae in the entire spine (Moore and Dalley, 1999). The following features are found in every cervical vertebra:

- An oval foramen in the transverse process, which allows the passage of the vertebral artery from C1 to C6 (Moore and Dalley, 1999).
- The transverse processes terminate in two lateral projections that are termed the anterior and posterior tubercles (Moore and Dalley, 1999).

2.2.1 Typical Cervical Vertebra

The third to seventh cervical vertebrae are referred to as the ‘typical’ cervical vertebrae (Standring, 2008) and have the following in common:

- Broad vertebral bodies which are concave superiorly and convex inferiorly. The superior borders are raised posteriorly to form the uncinate processes (Moore and Dalley, 1999).
- Large, triangular vertebral foramina (Standring, 2008). The boundary of each vertebral foramen is formed by two pedicles and two laminae (Moore and Dalley, 1999). The pedicles are stump-like processes which are posteriorly orientated. They join with the laminae, which are wider and flatter, to make up the vertebral arch (Moore and Dalley, 1999).
- Superior articular facets that face superoposteriorly and inferior articular facets that face inferoanteriorly (Standring, 2008).
- Short, bifid spinous processes in C3 to C5 (Moore and Dalley, 1999). The spinous process of C6 and C7 is long (Standring, 2008).
- Transverse foramina which admit the passage of neurovascular structures (Moore and Dalley, 1999).

2.2.2 Atypical Vertebrae

2.2.2.1 The Atlas (C1)

The atlas is made up of the anterior and posterior arches that replace the vertebral body and spinous process. Each arch has a tubercle and a lateral mass. The superior surface of the posterior arch has a groove for the vertebral artery. The superior articular surfaces of the atlas are concave and kidney-shaped to articulate with the occipital condyles (Standring, 2008).

2.2.2.2 The Axis (C2)

The axis, which is the strongest cervical vertebra because it has to carry the skull, supports the atlas on its superior articular facets (Moore and Dalley, 1999). It is unique due to two distinguishing characteristics; a large bifid spinous process (Moore and Dalley, 1999), and the odontoid process, or dens, which protrudes from the superior aspect of the body (Standring, 2008). The dens functions as a pivot around which the atlas rotates, and is secured by the transverse ligament that prevents horizontal movement (Standring, 2008).

2.2.2.3 The C7 Vertebra

The seventh cervical vertebra is often called the *vertebra prominens* because it has a long spinous process compared to the other cervical vertebrae (Standring, 2008). The oval foramen of the transverse process of C7 is smaller, and only contains small accessory vertebral veins (Moore and Dalley, 1999).

2.2.3 Intervertebral Discs

The intervertebral joints have a significant weight-bearing function and are, therefore, designed to function as shock absorbers (Moore and Dalley, 1999). Each intervertebral disc is composed of an outer annulus fibrosis and an inner nucleus pulposis (Standring, 2008). The fibrocartilaginous annulus fibrosis forms a tough circumferential ring that bonds two adjacent vertebrae together (Standring, 2008). The elastic nucleus pulposis is located at the centre of the intervertebral disc. It responds to axial forces by acting as a shock absorber, and to movement by acting as a ball bearing. Intervertebral discs are found throughout the cervical spine, except between C1 and C2 (Moore and Dalley, 1999).

2.2.4 Cervical Joints

The following joints are found in the cervical spine (Moore and Dalley, 1999):

- Intervertebral joints are secondary cartilaginous joints, the articulating surfaces of which are joined by ligaments and the intervertebral discs.
- Zygopophyseal or facet joints are plane-type synovial joints between the superior and inferior articular processes of adjacent vertebrae and permit gliding motion between the vertebrae.
- Uncovertebral "joints" are joint-like structures between the uncinate processes of C3 to C6 and the vertebral bodies superior to them.
- Atlantoaxial joints which are made up of three articulations between C1 and C2. There are two lateral joints and one median joint (i.e. the atlanto-dental joint). These are synovial joints between the superior articular facets of the axis and the inferior articular facets of the atlas.
- Atlanto-occipital joints comprise of the articulations of the occipital condyles with the lateral masses of C1.

2.2.5 Intervertebral Foramina

- The intervertebral foramina of the cervical spine, which contain the spinal nerve roots, ganglia and blood vessels, are formed by the superior and inferior vertebral notches (Moore and Dalley, 1999).

2.2.6 Muscles of the Cervical Spine

The muscles of the cervical region are divided into two categories viz. the extrinsic and intrinsic muscles. The anatomy and actions of these muscles are shown in **Tables 2.1** and **2.2** respectively.

- The **extrinsic muscles** of the neck comprise of the superficial and intermediate layers of muscles (Standring, 2008). They are responsible for generating movements of the upper limb, and controlling breathing movements. The sternocleidomastoid and trapezius muscles fall in this group.

Table 2.1 Attachments, innervation and action of the extrinsic cervical muscles

Muscle	Attachments	Innervation	Action
Sternocleidomastoid	**Origin:** From the manubrium and superior surface of the medial 1/3 of the clavicle. **Insertion:** Mastoid process and the superior uncial line	Spinal root of cranial nerve IX and C2-C3	Unilateral: lateral flexion and rotation Bilateral: flexion of the neck
Trapezius	**Origin:** Medial 1/3 of superior nuchal line and external occipital protuberance. **Insertion:** Lateral 1/3 of clavicle, acromion and spine of scapula.	Spinal root of cranial nerve IX and C3-C4	Elevation, retraction and rotation of the scapula

Adapted from Moore and Dalley (1999)

- The **intrinsic** muscles of the neck are comprised of the deep cervical muscles (Standring, 2008). These muscles are responsible for maintaining posture as well as producing the movements of the spine. The posterior cervical and suboccipital muscles fall into this category.

Table 2.2 Attachments, innervation and actions of the intrinsic cervical muscles

Muscle	Attachment	Innervation	Action
Semispinalis capitis	**Origin:** Spinous processes of C3-T4 and nuchal ligament. **Insertion:** Mastoid process and superior nuchal line.	Dorsal rami of spinal nerves	Stabilizes vertebrae during local movement.
Semispinalis cervicis	**Origin:** Spinous processes of T3-T6. **Insertion:** Transverse processes of C1-C3.	Dorsal rami of spinal nerves	Stabilizes vertebrae during local movement.
Multifidus	**Origin:** Articular processes of C4-C7. **Insertion:** Spinous process of vertebra above.	Dorsal rami of spinal nerves	Stabilizes vertebrae; assists with local rotation and extension.
Rectus capitis	**Origin:** Spinous process of C2. **Insertion:** Lateral part of inferior nuchal line and occipital bone.	Dorsal rami of C1	Unilateral: Rotation, lateral flexion Bilateral: Extension
Rectus capitis posterior minor	**Origin:** Posterior tubercle of C1. **Insertion:** Medial aspect of inferior nuchal line.	Dorsal rami of C1	Unilateral: Lateral flexion of the head. Bilateral: Extension
Obliquus capitis inferior	**Origin:** Spinous process of C2. **Insertion:** Transverse process of C1.	Dorsal rami of C1	Unilateral: Rotation of the head Bilateral: Extension
Obliquus capitis superior	**Origin:** Transverse process of C1. **Insertion:** Occipital bone between superior and inferior nuchal lines.	Dorsal rami of C1	Unilateral: Rotation, lateral flexion Bilateral: Extension

Adapted from Moore and Dalley (1999)

2.2.7 Innervations of the Cervical Spine

The innervation of the neck is presented in **Table 2.3**. The suboccipital triangle refers to the area inferior to the occiput and includes the posterior aspects of the atlas and axis (Moore and Dalley, 1999).

Table 2.3 Innervation of the neck and back

Nerve	Origin	Distribution
Suboccipital	Dorsal ramus of C1 nerve	Muscles of suboccipital triangle
Greater occipital	Dorsal ramus of C2 nerve	Skin of the neck, and the occipital bone
Lesser occipital	Ventral ramus of C2 and C3 nerves	Skin of the neck and scalp
Dorsal rami of C3-C0	Spinal nerves of C3-C0	Skin over the vertebral column and intrinsic muscles of the back

Adapted from Moore and Dalley (1999)

2.2.8 Ligaments of the Cervical Spine

Several ligaments attach to the vertebral bodies and the posterior elements of the cervical vertebrae and may cross either one or several segments (Yoganandan et al., 2001). They include the following:

- The anterior longitudinal ligament extends from the sacrum to the anterior tubercle of C1 and the anterior aspect of the foramen magnum (Standring, 2008). It provides stability by attaching to the anterolateral aspects of the vertebral bodies and intervertebral discs, and prevents hyperextension of the vertebral column to some extent (Moore and Dalley, 1999).
- Hyperflexion of the vertebral column is prevented by the posterior longitudinal ligament, which attaches to the posterior aspect of the vertebral bodies and the intervertebral discs of C2 to the sacrum (Moore and Dalley, 1999; Standring, 2008).
- Abrupt flexion of the vertebral column is prevented by the ligamentum flava, which extend from the lamina of one vertebra to the lamina of the vertebra below. The ligaments assist in maintaining the normal cervical lordosis and help the vertebrae to return to the neutral position after flexion (Standring, 2008).
- The spinous processes of adjacent vertebrae are connected via the interspinous ligaments, which attach from the root to the apex of each process (Standring, 2008).
- The apices of all the spinous processes from C7 to L3 or L4 are connected via the supraspinous ligament (Standring, 2008). The supraspinous ligament joins the nuchal ligament.
- The nuchal ligament arises from the external occipital protuberance and the posterior aspect of the foramen magnum and attaches onto the spinous processes of the cervical vertebrae. Apart from providing stability, the nuchal ligament also serves as an area for muscle attachment (Moore and Dalley, 1999).

- The transverse processes of adjoining vertebrae are connected via the intertransverse ligaments (Standring, 2008).
- The transverse ligament of the atlas runs between the lateral masses of the atlas and prevents the dens from moving away from the anterior arch of the atlas (Moore and Dalley, 1999).
- The alar ligaments extend from the foramen magnum and attach to the sides of the dens, thereby restricting rotation and lateral flexion of the head (Moore and Dalley, 1999).

2.3 A SUMMARY OF THE BIOMECHANICS OF THE CERVICAL SPINE

2.3.1 Curve of the Cervical Spine

The spine displays four distinct curves when viewed from the lateral aspect. These are divided into primary and secondary curves. The thoracic and sacral curves are the primary curves and are concave anteriorly (kyphosis). The cervical and lumbar curves are the secondary curves and are concave posteriorly (Drake et al., 2005). The least prominent curve of the adult spine is the cervical lordosis (Standring, 2008).The curve arises at the atlas and terminates at T2, with the apex between C4 and C5 (Bergmann and Peterson, 2011). It develops at the end of the embryonic period (Erfanian et al., 2004), but becomes more marked at approximately two months of age (Moore and Dalley, 1999). The function of the cervical lordosis is to respond to axial compression forces as well as to maintain the centre of gravity of the head over the spine (Bergmann and Peterson, 2011). The occiput, atlas and axis form the superior segment of the cervical lordosis, while the lower cervical vertebrae form the inferior segment (Middleditch and Oliver, 2005). Although the inferior segment is longer, the extent of the curvature is larger in the superior segment (Middleditch and Oliver, 2005). The degree of the curve is mainly determined by the facet joints and intervertebral discs (Bergmann and Peterson, 2011).

There have been numerous reported values of the normal cervical lordosis in the literature. Yochum and Rowe (2005) provided a range of 35° to 45°, with the average being 40°. McAviney et al. (2005) observed that the clinically 'normal' range for the cervical lordosis was 31° to 42°. Age has been shown to be a factor that affects cervical lordosis, as there is an increase in lordosis with an increase in age (McAviney et al., 2005). Recent studies by Naicker (2011) and Roopnarian (2011) (both currently unpublished), examined the differences in cervical lordosis, between gender and race in the adult population of Durban, South Africa. The results of their studies are tabulated in **Table 2.4** below.

Table 2.4 Comparison of the mean cervical lordosis between males and females from four racial groups

Race	Females (°)	Males (°)
Black	16.3	15.1
Coloured	12.1	18.1
Indian	6.9	13.1
White	9.9	17.4

Adapted from Naicker (2011), Roopnarian (2011)

The data in **Table 2.4** shows that when assessing the cervical lordosis there is a difference between the sexes. In all race groups the mean cervical lordosis is larger in males, except Blacks (Roopnarian, 2011); where females had a larger mean cervical lordosis value (Naicker, 2011).

2.3.2 Range of Motion of the Cervical Spine

2.3.2.1 Flexion/Extension

There is an average of 15° of combined flexion and extension at each cervical segment (Bogduk and Mercer, 2000). Globally, there is 65° of flexion and 57° of extension (Feipel et al., 1999). The greatest degree of flexion and extension occurs at the C5-C6 segment. During flexion there is separation of the articular surfaces which results in distraction of the posterior components and compression of the anterior components. The reverse occurs during extension, with approximation of the posterior elements and distraction of the anterior elements (Bergmann and Peterson, 2011).

2.3.2.2 Lateral flexion

Lateral flexion occurs to a lesser degree than flexion and extension in the cervical spine (Bogduk and Mercer, 2000). The greatest lateral flexion occurs in the mid-cervical region where there is approximately 10° of movement to each side. This decreases in the inferior segments (Bergmann and Peterson, 2011). In the lower cervical spine, lateral flexion is coupled with rotation. Therefore, when the neck is laterally-flexed and the ipsilateral facets and intervertebral discs are compressed, the inferior facets slide infero-medially. On the contralateral side, there is stretching of the facets and intervertebral discs and the inferior facets slide antero-superiorly (Bland, 1994; Bergmann and Peterson, 2011).

2.3.2.3 Rotation

Axial rotation occurs most optimally in the facet joint plane with an average global rotation in the cervical spine of 72° (Feipel et al., 1999). The most amount of rotation occurs in the upper segments of the cervical spine. In the lower cervical spine, rotation in the horizontal plane is always coupled with ipsilateral lateral flexion (Bogduk and Mercer, 2000). This results in the postero-inferior displacement of the ipsilateral facet joint and antero-superior displacement of the contralateral facet joint (Bland, 1994; Bergmann and Peterson, 2011). Feipel et al. (1999) established a database of normal active cervical spine motion ranges by analysing 250 asymptomatic participants of a wide age range, using a goniometer **(Table 2.5)**. The results provide a useful reference for clinical applications. The global motion ranges found were comparable to other reports in the literature (Bergmann and Peterson, 2011).

Table 2.5 Range of motion of the cervical spine

Motion	14-19 yrs.	20-29 yrs.	30-70 yrs.	Mean ROM (14-70 years)
Flexion	70°	66°	57°	65°
Extension	61°	57°	50°	57°
Lateral flexion (left)	47°	44°	38°	44°
Lateral flexion (right)	48°	45°	39°	44°
Rotation (left)	75°	72°	68°	72°
Rotation (right)	75°	71°	68°	72°

Adapted from Feipel et al. (1999)

2.3.3 Posture

Spinal posture is defined as the interconnection between spinal segments to each other and to gravity (Klaus et al, 2009). Normal posture is "believed to be the state of musculoskeletal balance that involves a minimal amount of stress and strain on the body" (Kendall, 2005) and is vital for musculoskeletal health (McEvoy and Grimmer, 2005). It is constructed from the synergy between the biomechanics of the spine and the neuromuscular system (Klaus et al., 2009).

"Normal" posture is defined in the sagittal plane when a plumb line from the external auditory meatus passes through the shoulder joint, posterior to the centre of the hip joint, through the knee joint and anterior to the ankle joint (Yip et al., 2006). When describing neutral erect posture in terms of spinal curves, "normal" posture is defined as a slight lumbar lordosis, a slight thoracic kyphosis and a slight cervical lordosis (Klaus et al., 2009). Ideal cervical posture reduces the effect of the antigravity load on cervical structures and, therefore, lessens the stress on the cervical structures by decreasing the amount of energy needed to balance head (Grimmer-Sommers et al., 2008).

2.3.3.1 Anterior head carriage

Age and postural displacements are major contributors to degeneration of the cervical spine (Diab and Moustafa, 2011). Anterior head carriage, or forward head posture is one of the most common postural deviations and has been linked to altered cervico-thoracic curves (Talbot, 2005); cervicogenic, migraine (Diab and Moustafa, 2011), and post-concussion (Fernández-de-las-Peñas et al., 2005) headaches; myofascial pain (Diab and Moustafa, 2011); temporomandibular joint disorders (Fernández-de-las-Peñas et al., 2005); and altered scapular movement (Diab and Moustafa, 2005).

In forward head posture, the head is rotated posteriorly due to hyperextension of the cervical spine. This creates torque at the base of the spine, and increases the amount of stress placed on the surrounding structures. These supporting structures, if placed under strain for prolonged periods, can lead to the production and perpetuation of pain. The osseous structures are also affected because the altered posture leads to compression of the posterior aspects of the vertebral bodies and on the facet joints (Talbot, 2005).

2.3.3.2 Sleep posture

The vertebral column and surrounding structures are restored from the activities of the day during sleep (Hysmans et al., 2006). Growth, restoration and hydration of the intervertebral discs are based on the amount of pressure and its manner of application on them. With the change in the direction of the gravity vector during sleep, the intervertebral discs are unloaded and can rehydrate to restore their elasticity (Leilnahari et al., 2011). The pressure in the lower cervical facet joints is decreased, allowing the articular cartilage to be restored (Hysmans et al., 2006).

Non-neutral postures that are adopted during sleep increase the biomechanical stress placed on the spine and its supporting structures (Gordon et al., 2011) by loading the intervertebral discs and facet joints unevenly (Leilnahari et al., 2011). Due to the complex structure of intervertebral discs, there is only about 6˚ of axial rotation at each level. Increased rotation increases the intra-nuclear pressure and prolonged stress results in tissue damage (Leilnahari et al., 2011). On very firm surfaces in the lateral recumbent position, only the wider areas of the body (e.g. the shoulders and pelvis) are supported, leading to lateral flexion away from the bed (Normand et al., 2005). On very soft surfaces, the heavier areas of the body (e.g. the pelvis) sag, leading to lateral flexion toward the bed (Normand et al., 2005). This leads to compression of pain-sensitive structures such as muscles and joints causing symptoms on awakening such as neck pain, headaches and arm pain (Gordon et al., 2011). In the supine position, the lower thoracic spine and pelvis are supported optimally, but the lumbar spine is minimally supported. Furthermore, there is minimal loading on the spine when compared to standing. However, due to the legs being in the neutral position, the psoas muscle is fully lengthened. This increases the lordosis and load on the lumbar spine (Normand et al., 2005).

In order to load the spine evenly while sleeping in the supine position, the vertebral column should retain the same curvatures that are present when standing. In the lateral sleeping position, which is the most common sleeping position (Gordon et al., 2011), the spine should be supported in a straight line, while retaining the normal spinal curves (Hysmans et al., 2006). The studies investigating posture during supine or recumbent positions may be divided into those that investigated the effects of the mattress and those that investigated the effect of pillows. The details of the studies that investigated the effect of pillows are presented in **Table 2.8** and discussed in **Section 2.5**.

Lahm and Iaizzo (2002) determined the effect of a mattress with three different degrees of firmness on the physiologic responses of 22 asymptomatic participants. The EMG activity, heart rate and blood pressure of each participant was recorded with the patient standing up. The participant was then made to lie in the recumbent position on the mattress which was inflated to one of three pressure settings (827.4, 2413.2 or 3999.0 Pa). After lying on the bed for 30 minutes, the participant was then allowed to stand up for five minutes. Thereafter, the EMG, heart rate and blood pressure were recorded. The procedure was repeated with the mattress inflated to the remaining two pressure settings. Spine alignment was determined in the lateral position using video image analysis. Using these images, the researchers aimed to determine the relationship between the most proximal and distal landmarks, as well as the relationship between the spine and the horizontal axis. The results show insignificant changes in EMG activity, heart rate and blood pressure. However, there were significant changes in spine alignment between the three pressure settings. In order to analyse the spinal alignment from the images, a region shading process was employed. Two regions were identified viz. Region 1 represented the area between the line drawn from the two furthermost points of the spinal region of interest, and the curve of the spine itself and Region 2 represented the area between the curve of the spine and the horizontal axis. The results are shown in the **Table 2.6**. These findings indicate that the alignment of the spine was optimal at the mid and higher ranges. The statistical analysis of Region 1 did not yield significant results ($p = 0.1125$), but in Region 2, significant results were observed ($p < 0.01$).

Table 2.6 Summarised findings of comparing changes in spine alignment under different pressure conditions

Pressure	827.4Pa	2413Pa	3999.0Pa
Region 1	2903.2±1509.7mm²	2290.3±1206.5mm²	2116.1±1135.5mm²
Region 2	8871.0±3632.3mm²	6632.3±3109.7mm²	5703.2±3180.6mm²

Results from Lahm and Iaizzo (2002)

A study examining the biomechanical effect of four different mattresses was conducted by De Vocht et al. (2006). Eighteen normal adult males of similar heights, but in three different weight groups participated. Photographs were taken of the participants lying in the lateral recumbent position and the co-ordinates of the spinous processes of T1, T4, T6, T8, T12, L1, L4, and S1 were derived in order to calculate the segmental slopes. In order to test pressure distribution, two pressure-sensitive pads were placed on top of the mattress i.e. one pad for the thoracic region and another for the pelvic region. The participants were instructed to lie flat on their backs with their legs separated slightly and arms resting on the chest. The pressure distribution over the entire area of both pads was recorded. The results of this study suggest participants' weight was directly related to pressure, but did not influence spinal distortion. There were significant differences in pressure distribution and spine alignment between the mattresses. Interestingly, it also demonstrated minimal pressure might not lead to minimal spinal distortion.

Another study which investigated mattress firmness was carried out by Leilnahari et al. (2011) who attempted to determine the effect of body dimensions, and weight in 25 men during lateral sleep position on soft and firm mattresses. The anthropometric measurements of each participant were used to create a model of each patient and their spine. The dimensions, girth, height and depth of thorax, shoulder, belly and pelvis of each participant was measured. In order to determine spine alignment, an optical tracking method was used to determine the co-ordinates of the spinous process of each vertebra from C7 to L5. The relevant angles were determined and then compared. In the second phase, the data from phase one was used to develop the models. The results illustrated that the custom mattress was most appropriate choice for all body types. The researchers concluded that the firmness of the sleeping surface has an effect on spine alignment.

2.4 DIGITAL IMAGING

There are various methods used to assess spine alignment and head posture. These are described in **Table 2.7**.

Table 2.7 Reported methods described in the literature to evaluate posture

Assessment	Reference	Description	Mechanism	Advantages	Disadvantages	Values	Reliability/Validity
Photography	Chansurinikor et al. (2001); De Vocht et al. (2006); McEvoy and Grimmer (2005); Talbot (2005); Yip et al. (2006); Klaus et al. (2009); Gordon et al. (2011)	Digital photography used to determine forward head posture and spine alignment.	Relevant anatomical landmarks were marked off. A digital image was captured. The linear co-ordinates of each landmark was determined and used to determine the angle/slope.	Easy to perform, inexpensive, non-invasive	Patient position must be standardised to ensure reproducibility Time consuming Requires operator training	Angle in degrees. If measuring spinal segments, the gradient of the slope with a + or - sign indicating the direction of the slope.	Digitisation techniques were highly reliable on repeated occasions of measurement on the same slides (Chansurinikor, 2001).
Plain-film radiographs	Talbot (2005); Klaus et al. (2009)	Use of radiographs to visualise the skeletal system.	Emission of x-rays	Accurate	Exposure to radiation Time consuming Expensive	Use of angles measured in degrees and distances measured in mm.	Gold standard for determining cervical lordosis.
Video-raster stereography	Hysmans et al. (2006)	White light raster line triangulation.	Scanned the back surface by projecting raster lines on it and by capturing them with a camera.	Short measurement and processing	Time consuming Requires	Calculates shapes, obtained from surface measurements (measured in mm).	The accuracy of the measured surface points is of the order of a magnitude of 0.5mm.

				time Non-invasive	operator training		
Linear excursion movement device	Grimmer (1996)	Device that measured the excursion of 2 anatomical landmarks when the patient moved from their normal posture to neutral posture.	The positions of the anatomical landmarks were marked with the subjects in a neutral posture. Subjects then assumed usual resting posture. The new positions of the landmarks were marked. The distances through which the points travel were recorded and converted to angles.	Highly reproducible and simple	Time consuming Requires operator training	Angles (measured in degrees).	Measurements from the device were shown to be reproducible and accurate.
Skin surface tracking	Klaus (2008)	Markers/sensors adhered to skin overlying spinous processes.	Tracking device recorded 3-D position of sensors relative to the source.	High reproducibility	Requires operator training Time consuming	Spinal curves are represented by angles (measured in degrees).	It has been validated against radiography.
Electronic Head Posture Instrument	Lau et al. (2010)	To clinically assess and evaluate cervical posture.	Identified and digitally displayed degrees/per cent slope.	Non-invasive Simple Inexpensive Accurate to one decimal place.	Requires operator training Time consuming	Angles (measured in degrees).	Reliability was assessed and showed a high intra-rater and inter-rater reliability.

2.5. PILLOWS

Although sleep posture is a continually developing area of interest, the amount of available research is still limited (Van Deon et al., 2012). One of the most important functions of sleep is to support the human body in a way that allows the muscles and intervertebral discs to recover from nearly continuous loading during the day (Hysmans et al., 2006; Earhart et al., 2011) as well as maintaining the same neutral posture that is evident during standing (Leilnahari et al., 2011; Earhart et al., 2011; Van Deon et al., 2012). This is due to the fact that the body is unable to actively control the spine while sleeping (Hysmans et al., 2006). Another function of sleep systems is the adaptability to the various sleeping postures which apply varying loads on the vertebral column (Overheard et al., 2011).

The pillow is a significant contributing element which affects sleep quality and waking symptoms (Gordon et al., 2011). Various authors suggest that the use of a cervical pillow or support during sleep may benefit people with chronic neck pain, cervical intervertebral disc disease, whiplash (Persson and Moritz, 1998) and waking pain (Gordon et al., 2010). This is achieved by relaxing and reloading the natural cervical lordosis (Persson, 2006), immobilizing the joints, allowing the muscles to relax, maintaining the cervical lordosis, or providing joint protection (Ambrogio et al., 1998).

The variety of pillow types that is accessible on the market, each with the manufacturers claiming that these could produce reduce the symptoms related to pillows and, and improve sleep quality (Gordon et al., 2002) is confusing for consumers, who consequently seek advice from their healthcare practitioners (Gordon et al., 2011).

A systematic review was conducted by Shields et al. (2006) to determine whether cervical pillows have any effect on neck pain. Only five articles of low quality met the inclusion criteria of the study and the authors thus concluded that there was not enough information to determine whether cervical pillows have any effect on neck pain. The paucity of research on pillows has led many of these practitioners, including chiropractors, to recommend neck support based on anecdotal evidence or personal experience. These recommendations include the use of flexible pillows consistency provide support for the head, but avoid extreme postures and mould to the spinal contours of the individual. Cervical roll pillows, contoured pillows and firm pillows, which are not malleable to the body contours, have been advised against. A summary of the studies that have investigated the various pillow types is shown in **Table 2.8** and is discussed below.

In 1997, Lavin et al. reported the effect of two pillows (a cervical roll pillow and a water-based pillow) on 46 subjects with chronic neck pain and cervicogenic headaches. They investigated the effect of the patients’ own pillow on pain, sleep quality, and medication consumption over one week. The subjects used one of the test pillows for two weeks and data was recorded. This was repeated with the remaining test pillow. The results showed that the participants preferred the water pillow to their own. Most of the participants found the roll pillow uncomfortable, with a few patients dropping out of the study completely. The researchers hypothesized that this was due to the fact that the water-based pillow was malleable, while the roll pillow exaggerated the neck posture and did not adequately support the head.

Persson and Moritz (1998) compared the responses of 55 participants to six pillows of varying firmness, shape and content. The soft polyurethane pillow with two firm supporting cores was reported to be the most comfortable. The roll-type pillow was reported to be the least comfortable. The researchers concluded that in order to reduce neck pain and improve sleep quality, a soft pillow of medium height with a firm core should be utilized. Another study that investigated a roll-type pillow was undertaken by Hagino et al. (1998). They recorded the pain rating in 30 patients with chronic neck pain in order to determine a baseline. Participants then used the Align Right pillow for four weeks and the pain rating was recorded again. Most of the participants found the pillow to be uncomfortable, but eventually had a decrease in neck pain. Three of the participants reported an increase in neck pain while two participants dropped out of the study.

Lin and Huang (2007) investigated the effect on neck muscle activity and craniocervical posture when using a neck support pillow, a standard pillow, and no pillow. Thirty participants were observed in the seated and supine positions for 30 minutes. Electromyography readings of the sternocleidomastoid and upper trapezius muscles were recorded after three-minute intervals. The craniocervical postures were assessed using a universal goniometer. The researchers found significant differences in the craniocervical posture between each condition ($p<0.05$). There was a decrease in the sternocleidomastoid muscle activity only from the seated to the supine posture. There was also a decrease in both the sternocleidomastoid and upper trapezius activity between conditions. The lowest muscle activity was recorded with the neck support pillow (-2% on EMG), and the most activity without a pillow (2.5%). This indicated that good neck support was associated with decreased muscle activity and neck flexion.

Gordon et al. (2010) investigated the link between different pillow content and shape on waking symptoms such as stiffness, headache and scapular or arm pain. The results indicated people with waking symptoms should not use feather pillows. Polyester and contoured foam pillows should not be used in people with waking stiffness, but should be recommended to those who suffered with waking headache and scapular and arm pain. No significant difference was found between the contour and regular-shaped pillows.

Gordon et al. (2011) undertook a study to examine the effect of various pillows on cervico-thoracic posture in the recumbent position over time. Digital images of ninety five participants were recorded at zero minutes and at ten minutes. The participants each rested on all of the five pillows (polyester, foam regular, foam contour, feather and latex). Using the linear co-ordinates of the external occipital protuberance, C2, C4, C7 and T3, the slope between each landmark was calculated. There were no significant changes in the slope with each pillow over time. The regular and contoured foam pillows produced similar slopes, which indicated that the shape of the pillow did not affect the spinal support. Significant differences were noted when comparing the feather pillow with the latex, regular and contour foam pillows, and when comparing the polyester and foam contour pillows.

Jagarnath (2012) investigated the effectiveness of the Simmons Beautyrest® pillow when compared to the participant's own pillow in the management of chronic non-specific neck pain. Forty participants between the ages of 18-45 years of age were divided into two groups. One group continued to use their own pillow and the other used the Simmons Beautyrest® pillow. At the end of two weeks, the participants who were using their own pillows then changed to using the Simmons' Beautyrest® pillow, while those using the Simmons Beautyrest® pillow returned to using their own pillow. This was also done for two weeks. Subjective outcome measures of Neck Disability Index (NDI), Numerical Pain Rating Scale (NRS) and sleep and pain diary were used while objective measures included Cervical Range of Motion (CROM) and algometer readings. The results indicate an improvement in algometer readings and CROM (right lateral flexion) outcome measures for the Simmons Beautyrest® pillow. The pillow was regarded as comfortable and provided significant relief of non-specific chronic neck pain. The researcher concluded that the Simmons Beautyrest® pillow is effective in reducing non-specific neck pain.

Pillow efficacy has been assessed in a number of studies. However it is difficult to compare the studies to each other since none of the studies utilized the same methodology or similar sample populations. The majority of these studies have examined the efficacy of pillows in reducing neck pain and improving sleep quality comparatively few studies have analysed the effect of the pillows on biomechanical parameters of the head and spine (Lin and Huang 2007; Gordon et al., 2011). Therefore, much of the available data surrounding the efficacy of pillows is based on subjective information. A further point to note is the diversity of pillows that have been tested **(Table 2.8)**. The biomechanical studies testing pillows also have varying methodologies. Some have examined the effect of the pillows on muscle and posture (Lin and Huang, 2007), while others have examined the effect of pillows on the spine and posture (Gordon et al., 2011). Due to the fact that a large portion of the research that examined the effect of sleep surfaces (pillows and mattresses) utilised spinal posture and alignment, the researcher has opted to employ this method of objectively assessing the effect of pillows with a focus on the craniocervical and cervico-thoracic regions.

Table 2.8 The types of pillows utilised in previous research

Reference	Sample Characteristics	Pillow	Description
Lavin et al. (1997)	Age Mean: 48 years; Range: 26-76years Sex Male: 20 Female: 21 M:F 1: 1.1	Water-based pillow	The pillow consisted of soft polyester fibre over a 3.8-cm water base at the bottom of the pillow which could be adjusted to change the firmness of the pillow.
		Roll pillow	A cylindrical polyester fibre-filled roll pillow which was 43cm in length and 17cm in diameter.
		Standard pillow	Participants' own pillow made of down or foam.
Persson and Moritz (1998)	Age Mean: 38 years Range: 20-55 years Sex Male:17 Female: 38 M:F 1:2.2	Pillow 1	Polyether filling with two neck shapes and heights and uniform firmness.
		Pillow 2	Shaped polyurethane pillow with uniform firmness.
		Pillow 3	Soft polyurethane pillow with two firmer cores and two different heights on either side.
		Pillow 4	Thin polyurethane core surrounded by soft padding.
		Pillow 5	Large pillow comprising of three shaped sections.
		Pillow 6	Inelastic foam plastic filling.
Hagino et al. (1998)	Age Mean: 39 years Range: 25-45years Sex M:F 2:3	Align Right cervical pillow	A roll type pillow filled with a trade-marked polyester fibre.
		Standard pillow	No description available.
Gordon et al. (2010)	Age Age clusters of: <40; 40-59; >60. Sex Male: 33 Female:73 M:F 1:2.2	Polyester pillows	Polyester filled pillow of 118mm length.
		Comfort Classic pillow	Regular foam, non-contoured pillow of 120mm depth.
		Medirest pillow	Foam, contoured pillow of 120-142mm in depth.
		Dunlopillo pillow	Latex pillow of 115mm depth.
		Feather pillow	Feather-filled pillow of 120mm depth.

Gordon et al. (2011)	Age Age clusters of: <40; 40-59; >60. Sex M:F 1:1	The same pillows that were used in the study by Gordon et al. (2010) as mentioned above	
Jagarnath (2011)	Age Mean:28.8 years Range: 18-45 years Sex M:F 1:3.4	Simmons Beautyrest® pillow	Pocketed coil pillow is a novel design which contains an inner coils system known as the Morpheus spring system. Each coil is individually wrapped in a polyester fibre filling and is capable of adapting to individual movement. This pillow contains approximately 12 litres of air which enables the pillow to create an ideal microclimate by releasing warm air and allowing fresh air to flow in with changes in pressure.
		Participants' own pillow	Participants' current pillow

2.5.1 Pillow Preference

Gordon and Grimmer-Somers (2010) conducted a study which aimed to determine the effect of five pillows on cervico-thoracic symptoms and sleep quality as well as to determine the pillow comfort and compare it to the effects of the participants own pillows. They found that decreased sleep quality was associated with decreased pillow comfort. Surprisingly, high pillow comfort did not always ensure that participants were symptom free, even on waking. Pillow content was associated with pillow comfort and polyester pillows were the most prevalent choice, followed by foam contour, latex, foam regular and feather and wool. The researchers found that differences between sexes and between age groups. This could be an indication that men and women may have different pillow needs in different age groups. However, the researchers did not provide any reason that might explain this finding.

2.6 CONCLUSION

Poor cervical posture during sleep results in lateral bending and compression of pain-sensitive structures in the neck (Leilnahari et al., 2011). Correct neck support during sleep is required to align the spine and maintain neutral posture, immobilise joints, and allow the cervical paraspinal muscles to relax (Ambrogio et al., 1998; Erfanian et al., 1998). This should theoretically reduce pressure on the pain-sensitive structures and allow the intervertebral discs to be unloaded and rehydrated (Leilnahari et al., 2011). Cervical pillows and neck supports are frequently recommended by doctors and chiropractors to patients in order to decrease pain and improve neck symptoms (Persson, 2006).

Although there have been several studies which have examined the effect of cervical pillows, most of them have examined their efficacy on subjective measures while very few studies that have investigated their effect on objective outcome measures (Lin and Huang, 2007; Gordon et al., 2011). Furthermore, the biomechanical studies testing pillows have varying methodologies, either examining the effect of the pillows on muscle and posture (Lin and Huang, 2007), or examining the effect of pillows on the spine and posture (Gordon et al., 2011).

Polyester pillows are widely available and inexpensive and have been shown to produce the same results as participants own pillows when examining pillow comfort, sleep quality, headache and scapular and arm pain and cervico-thoracic support. Latex pillows have been shown to be comfortable, effective in improving sleep quality, decrease waking cervical pain, headache and scapular and arm pain and support the cervico-thoracic spine when compared to a standard pillow. The Simmons Beautyrest® pillow has also been shown to be comfortable and decrease cervical pain. However, there are no published studies to demonstrate the biomechanical effect of the Simmons Beautyrest® on the neck.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY DESIGN

The study was a double-blinded comparative investigation which was conducted at the Durban University of Technology's (DUT) Chiropractic Day Clinic (CDC). This design was modeled around the design of Gordon et al. (2011) as this study was of a good quality and was one of the few studies that examined the biomechanical aspects relating to cervical pillow use.

3.2 PARTICIPANT RECRUITMENT

Participants were recruited through advertisements in the form of flyers (**Appendix B**), which were placed on notice boards at the DUT, health shops and shopping malls. Permission was sought from the respective authorities before any advertisements were put up. Potential participants were required to contact researcher telephonically. The population from which participants were recruited included male and female individuals between the ages of 20 to 30 years from the eThekwini Metropolitan area, in the city of Durban, KwaZulu Natal.

3.3 SAMPLING

Convenience sampling strategy was utilised for this study (Gordon et al., 2009). The sample size was generated by an experienced biostatistician (Van de Linde, 2012). It was calculated that with a sample size of 32 there would be a 80.36% power at alpha-level 5% to detect a moderate (0.25) effect size. A sample size of 40 subjects was recommended. Financial, time and human resources constraints also played a role in determining the final sample size.

3.4 INCLUSION AND EXCLUSION CRITERIA

3.4.1 Inclusion Criteria

a. Participants had to have been between the ages of 20 and 30 years. This age range was chosen to minimise the inclusion of individuals with age-related changes in cervical spine morphometry and alignment (Yukawa et al., 2012).

b. Asymptomatic participants who did not have any current history of neck pain, thoracic pain and headaches (i.e. within four weeks prior to the consultation).

c. Participants had to be within the normal body mass index (BMI) (i.e. 18-26) range. This was done to ensure a homogeneous sample.

3.4.2 Exclusion Criteria

a. Any participant who had a history of neck or thoracic injury/trauma such as whiplash or spinal surgery.

b. Any participant who had a history or features of inflammatory arthritis of the spine such as ankylosing spondylitis or rheumatoid arthritis as determined by the case history and physical examination findings.

c. Participants who reported a history of dizziness or transient ischaemic attacks (TIAs) (during the case history) or who developed dizziness during the clinical assessment.

d. Participants who had a clinically-detectable scoliosis or kyphoscoliosis of the spine.

e. Participants who used more than one pillow to sleep at the time of participating in the study.

f. Participants who had changed their pillow in the month prior to their consultation at the CDC.

g. Participants who were receiving any form of treatment for a cervical, thoracic or shoulder condition at the time of participation.

3.5 PILLOWS UTILISED IN THIS STUDY

The three pillows that were utilised in this study are described in **Table 3.1**.

Table 3.1 A description of the pillows utilised in this study

	Latex	Polyester	Simmons' Beautyrest®
Content	Chipped latex	Polyester and cotton blend	Inner coils which are separately wrapped in polyester fibre to allow for individual movement
Contour	None	None	None
Length	63cm	64cm	64cm
Breadth	38cm	38cm	36cm
Height	14cm	11.5cm	15cm
Advantages	Long lasting Resilient Hypoallergenic	Inexpensive Hypoallergenic Can easily be washed	Hypoallergenic Non-flattening Adapts to individual movement
Disadvantages	Expensive Cannot be washed in a washing machine	Not durable	Expensive Can only be washed in larger washing machines
Previous studies	Gordon et al. (2009) ; Gordon et al. (2010); Gordon et al. (2011)	Gordon et al. (2009); Gordon et al. (2010); Gordon et al. (2011)	Jagarnath (2012)

The most commonly-used pillows are polyester pillows because they are widely available and inexpensive. They have been shown to produce the same results as participants own pillows when examining pillow comfort sleep quality, headache and scapular and arm pain and cervico-thoracic support (Gordon et al., 2009). The latex pillow has been shown to be comfortable, effective in improving sleep quality, decrease waking cervical pain, headache and scapular and arm pain and supports the cervico-thoracic spine when compared to a standard pillow (Gordon et al., 2010). The Simmons Beautyrest® pillow, which has been recently introduced to the South African market, is a specifically designed pillow made up of inner coils which are separately wrapped to adjust to individual movements. Its manufacturer's claim that it is able to provide proper neck support irrespective of an individual's sleeping position (Simmons South Africa, 2012; Jagarnath, 2012). A recently concluded study by Jagarnath (2012) reported that the Simmons Beautyrest® pillow is effective in decreasing non-specific neck pain when compared to the patient's own standard pillow. The author recommended that further investigation should be performed to compare the Simmons Beautyrest® to other pillows to determine its effect on biomechanical parameters to provide more objective data to support the findings. However, to date, there are no published studies to demonstrate the biomechanical effect of the Simmons Beautyrest® on the cervical spine. Therefore, this study aimed to determine the effect of no pillow, a polyester pillow, a latex pillow and the Simmons Beautyrest® pillow on the craniocervical and cervico-thoracic postures.

3.6. RESEARCH PROCEDURE

3.6.1 Telephonic Interview

Potential participants (who had called and left their contact details) were contacted telephonically to determine whether they were eligible to join the study. Verbal permission was sought to interview them telephonically. It was explained to each person that the purpose of the interview was to determine their eligibility to participate in the study. If they did not voluntarily agree, they were excluded from the study. If they provided verbal permission, they were asked the questions shown in **Table 3.2**. If they provided the expected responses, they were provisionally accepted to participate in the study, and an appointment was made at the CDC.

Table 3.2 Questions asked at the telephonic interview, and their expected responses

	Questions asked by researcher	Response required from participant
1.	Are you between 20 and 30 years of age	Yes
2.	Have you had neck or midback pain in the last month?	No
3.	Have you had any headaches in the last month?	No
4.	Have you ever had any injury or surgery to your spine or neck?	No
5.	Do you suffer from any arthritis to your neck?	No
6.	Do you use more than one pillow to sleep?	No
7.	Have you changed your pillow to sleep in the last month?	No

3.6.2 Consultation

At the consultation at the CDC, each participant was provided with a letter of information and informed consent (either Appendix C1 or C2) which they were instructed to read. The researcher also verbally explained the study to the participant. If they voluntarily agreed to participate in the study, they were required to sign the letter of information and informed consent. If they did not agree to sign the letter of information and informed consent, they were excluded from the study. A case history (**Appendix D**), physical examination (**Appendix E**) and cervical orthopaedic examination (**Appendix F**) were performed for each participant. After the case history, physical and cervical spine regional examinations were completed, the objective assessments were done. The same examination plinth in the same room was utilised for all participants. The plinth was placed on a flat surface. This was determined by the researcher using a spirit level.

A senior chiropractic student assisted the researcher in the study with regard to the blinding. The data was captured and processed by the researcher. Before commencing with the study, the research assistant determined the midpoint of the pillow using a tape measure. This was marked with a marker pen. The research assistant then measured the vertical height from the midpoint of each pillow using a tape measure. A record of the measurement was made. Before each participant's objective assessments commenced, the research assistant measured the vertical height of each pillow again using a tape measure. These measurements were then compared to the original measurements:

- If the height of each pillow was within 5mm of the original measurement then that pillow was used.
- If the difference was 5mm or greater, a new pillow was used. The new pillow was also measured to ensure that it was within 5mm of the original measurement.

The research assistant then placed all four pillows in identical-patterned pillow cases. Each pillow case was clearly marked with a number (1-4), which correlated to a specific pillow. Only the research assistant knew which number represented which pillow. This was done to blind the researcher and the participants from determining which pillow was being assessed which reduced measurement bias.

Participants were required to remove any neck chains before the assessments commenced, if possible. Reflective markers made of adhesive paper were placed on the external occipital protuberance (EOP), C2 spinous process, C4 spinous process, C7 spinous process, T3 spinous process, the tragus of the ear, the mental protuberance of the mandible and a point 7cm inferior to the mandible. These landmarks were located by the researcher using static palpation, and verified by the research assistant. The outcome measures are described in **Tables 3.3** and **3.4**.

Recumbent position:

Participants were instructed to lie on an examination plinth. They were then placed in the right recumbent lying position (Verhaert et al., 2011) with the head resting on the plinth and the back perpendicular to the plinth **(Figure 3.1)**. The arms were placed with the shoulders forward flexed to 45^0 in front of the trunk and the elbows flexed to 90°. The lower limbs were placed together with the knees flexed together at 90^0 and the hips flexed to within 60^0 of the trunk (Gordon et al., 2011).In order to prevent torsion of the spine, the patient was placed in such a manner that the markers were aligned in both the sagittal and frontal planes. A digital camera was positioned parallel to and one meter away (determined using a metal tape measure) from the participant's neck at the level of C4on a tripod (Gordon et al., 2011). A spirit level was used to align the camera in both the vertical and horizontal planes. An adhesive marker was placed on the floor to ensure that the camera was in the same position for all participants. The camera placement was checked before each participant's photographs were taken to ensure that the camera was in the same place for all participants. A digital image was recorded. The images were stored on the memory card of the camera and later transferred to a computer to be analysed. This was then repeated with the head resting on the respective pillows. In order to analyse the cervico-thoracic posture, the CorelDraw Graphics Suite 12 was used to determine the *x* and *y* co-ordinates of each anatomical landmark. The gradient of each intersegmental slope was then calculated by using the formula $(y2 - y1)/(x2 - x1)$ (**Table 3.3**).

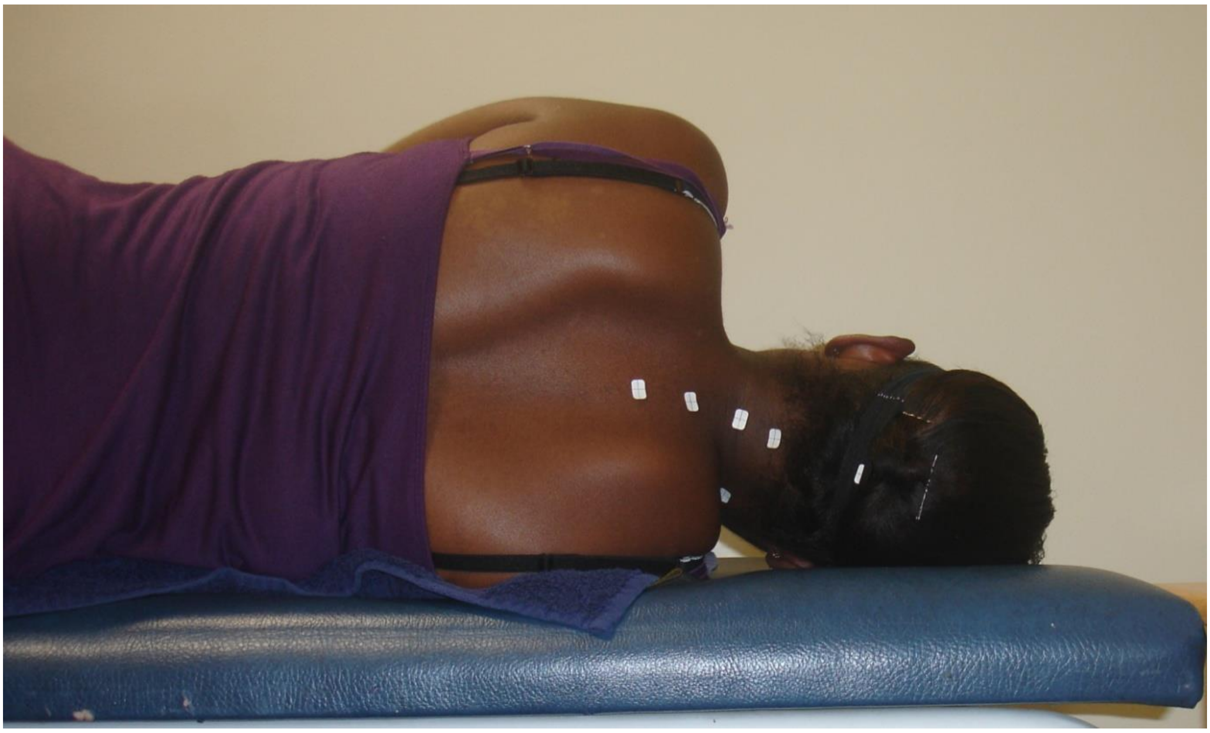

Figure 3.1 Demonstration of lying in the lateral recumbent position without a pillow (Verbal permission to use this photograph was provided from the participant)

Supine position:

The participant was then placed in the supine position, with the head resting on the examination plinth. A blindfold (similar to the one used during sleep to block out light) was used to cover the participant's eyes. This was done to protect their identity **(Figure 3.2)**. The camera was then placed parallel horizontally to the patients head, 80cm away (determined using a metal tape measure), on a tripod. An adhesive marker was placed on the floor to ensure that the camera was in the same position for all participants. A digital image was recorded and stored on the camera. This was then repeated with the head resting on the pillows. The craniocervical posture was determined by calculating the craniocervical angle. This angle was determined by constructing lines between the anatomical landmarks and measuring the angle produced at C7 (**Table 3.4**).

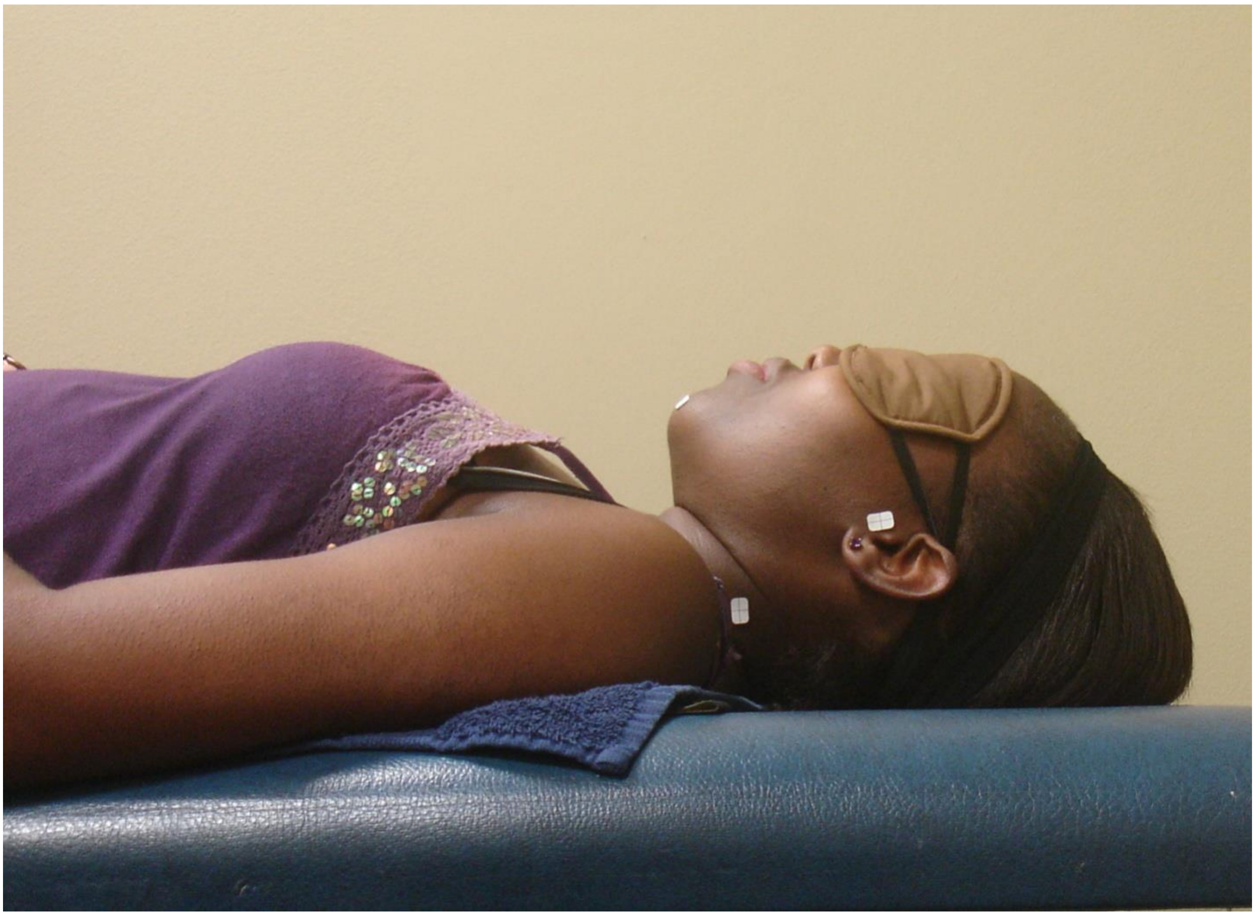

Figure 3.2 Demonstration of lying in a supine position without a pillow (Verbal permission to use this photograph was provided from the participant)

3.7 OUTCOME MEASURES

The outcome measures in the recumbent position are described in **Table 3.3** and the outcome measure for the supine position is described in **Table 3.4**. At the end of the objective data collection, participants were asked verbally which pillow they found most comfortable and this was recorded by the researcher.

Table 3.3 A description of the method for assessing craniocervical and cervico-thoracic slopes in the recumbent position

Outcome measure	Reference	Method	Unit of measurement	What did it indicate?
EOP-C2 slope	Gordon et al. (2011)	Reflective markers were placed on the participant's external occipital protuberance and C2 spinous process by the researcher and verified by the research assistant. A digital image was then recorded. The linear coordinates from each landmark were digitized and used to calculate the intersegmental slopes relative to horizontal using the formula: (y2 − y1)/(x2 − x1).	No unit of measurement as this is a slope. The magnitude of the slope was determined which is either a positive or negative value.	A negative value indicated that the EOP was higher than C2. A positive value indicated that C2 was higher than the EOP.
C2-C4 slope	Gordon et al. (2011)	Reflective markers were placed on the participant's C2 and C4 spinous processes by the researcher and verified by the research assistant. A digital image was then recorded. The linear coordinates from each landmark were digitized and used to calculate the intersegmental slopes relative to horizontal using the formula: (y2 − y1)/(x2 − x1).	No unit of measurement as this is a slope. The magnitude of the slope was determined which was either a positive or negative value.	A negative value indicated that C2 was higher than C4. A positive value indicated that C4 was higher than C2.
C4-C7 slope	Gordon et al. (2011)	Reflective markers were placed on the participant's C4 and C7 spinous processes by the researcher and verified by the research assistant. A digital image was then recorded. The linear coordinates from each landmark were digitized and used to calculate the intersegmental slopes relative to horizontal using the formula: (y2 − y1)/(x2 − x1).	No unit of measurement as this is a slope. The magnitude of the slope was determined which is either a positive or negative value.	A negative value indicated that C4 was higher than C7. A positive value indicated that C7 was higher than C4.
C7-T3 slope	Gordon et al. (2011)	Reflective markers were be placed on the participant's C7 and T3 spinous processes by the researcher and verified by the research assistant. A digital image was then recorded. The linear coordinates from each landmark was digitized and used to calculate the intersegmental slopes relative to horizontal using the formula: (y2 − y1)/(x2 − x1).	No unit of measurement as this is a slope. The magnitude of the slope was determined which is either a positive or negative value.	A negative value indicated that C7 was higher than T3. A positive value indicated that T3 was higher than C7.

EOP= external occipital protuberance; C2=cervical vertebra 2; C4= cervical vertebra 4; C7= cervical vertebra 7; T3= Thoracic vertebra 3; *x*= x axis; *y*=y axis

Table 3.4 A description of the method for assessing sagittal angular displacement of the head

Outcome measure	Reference	Method	Unit of measurement	What did it indicate?
Sagittal angular displacement of the head	Falla et al. (2003)	Reflective markers were placed on the tragus of the ear, the mental protuberance of the mandible and on the lateral aspect of the neck, 7cm inferior to the mastoid process by the researcher and verified by the research assistant. A digital image was then recorded. The digitized linear co-ordinates of each landmark were used to measure the cranio-vertebral angle.	Degrees (˚)	Demonstrated the degree of forward head posture

3.8 ETHICAL CONSIDERATIONS

1. Approval to conduct the study was obtained from the Faculty of Health Sciences Research Committee (FRC) and the Institutional Research Ethics Committee (IREC) **(Ethics Certificate Clearance Number: IREC 013/14, Appendix A).**

2. All participants were required to sign a letter of information and informed consent.

3. Participants had to provide consent to have their photographs taken. This appeared in the letter of informed consent (**Appendix C1** or **C2**). Participants' identities were protected as their names did not appear on the actual photographs. To further protect the identities of the participants, the eyes of all participants were blindfolded in the supine position to prevent them from being identified.

4. Although dizziness has not been reported as an adverse effect of lying on pillows, there was a minimal chance of this occurring if the participant had a history of dizziness or previous episodes of TIAs. However, the study methodology was designed to protect the participant in the following way:
    a. Each participant was required to undertake a detailed case history. Any participant who had a history of dizziness or TIAs was excluded from the study
    b. The participant had to undergo a physical and cervical regional examination. If the researcher found any indicators of dizziness while performing these tests, the participant was excluded from the study.

5. If the participant did report any dizziness during data collection:
    a. Data collection would have ceased immediately and participant would have been automatically excluded from the study.
    b. The participant would have been instructed to remaining lying down until the dizziness subsided.
    c. The participant's airways, breathing and circulation would have been monitored for at least half an hour.
    d. The participant would have been referred to an appropriate health care provider if the symptoms persisted beyond the half hour.

6. The Simmons Beautyrest® pillows used in this study were sponsored by Simmons South Africa. However, the company was not involved in the design or conduction of the study.

3.9 STATISTICAL ANALYSIS

Statistical analysis was done using IBM SPSS version 15.0. Repeated measures ANOVA testing was used to compare the mean slope measurements in the four conditions i.e.no pillow, Simmons Beautyrest® pillow, latex pillow and latex pillow (within-subjects effects since the 4 groups were paired i.e. each participant was measured in all four conditions. An adjusted *p*-value of 0.05 indicated statistical significance. Age, gender, ethnicity and body mass index provided the descriptive data. The descriptive statistics were presented in the form of tables and graphs for the quantitative data that was collected. Inferential techniques included the use of the Wilcoxon Signed-Ranked test, and t-tests. The Wilcoxon-signed rank test was used for non-parametric intra-group analyses while the t-tests were used for pre-post analyses. These were interpreted using the *p*-values (Singh, 2013).

3.10 APPRAISAL OF METHODS USED IN THIS STUDY

There are various methods used to assess spine alignment and head posture **(Table 2.7)**. The method utilised in this study was the digital photography which uses anatomical landmarks which were marked-off. The digital images were used to determine the linear co-ordinates of each landmark and this was used to determine the angle/slope created between the landmarks. The advantages and disadvantages of this method, based on the experience of the researcher, are tabulated in **Table 2.7.** In the researcher's opinion, this method of analysing spinal posture is easy because it does not require complicated equipment (except a laptop or PC installed with appropriate software such as CorelDraw Graphics Suite 12; and a digital camera) or participant positioning as required in other methods such as radiography and video-raster stereography. It is also a relatively inexpensive method. A digital camera, tripod, computer and software are the minimum equipment required. These are much cheaper than radiographic equipment and skin tracking methods. Digitisation techniques are very reliable and repeatable (Chansurinikor et al., 2001). Moreover, there was no danger of radiation exposure and this approach may be safely employed in children and pregnant women. However, the process is quite time-consuming as the co-ordinates of each landmark need to be determined before the actual slope/angle is determined. The process also requires some training as the operator would need to familiarise themselves with the relevant software first. They would also need to have a good understanding of surface anatomy and experience in palpating the landmarks, in order to have reproducibility and accuracy of the results.

Table 3.5 Appraisal of methods used in this study

Advantages	**Disadvantages**
Easy	Time-consuming
Cost-effective	Requires training
Reproducible	Requires experience
No radiation exposure	

CHAPTER FOUR

RESULTS

4.1 DEMOGRAPHIC AND SELECTED ANTHROPOMETRIC CHARACTERISTICS OF THE PARTICIPANTS

The mean age of the forty participants was 24.3 (± 2.57) years. The age ranged between 20 and 29 years. The mean (± SD) of the BMI was 22.6 $kg.m^{-2}$ (± 2.1 $kg.m^{-2}$). The mean, standard deviation and range of the weight and height of the participants are shown in **Table 4.1**. The standard deviations are small implying that there was not much spread from the mean values for the various variables. The race of the participants is indicated by sex in **Table 4.2**. There were more males and females from the Indian race than from any other race, followed by Blacks. The "other" race in **Table 4.2** refers to a participant of Middle Eastern origin. Overall there were slightly more female than male participants. Due to the diverse variety and large number of occupations of the participants, the statistical analysis of the occupation groups could not be undertaken. The distribution of the various occupations is shown in **Table 4.3**. The majority of the participants were students.

Table 4.1 Weight and height of participants

	Weight(kg)	Height(m)
n 40		
Mean	62.0	1.7
Std. deviation	9.6	0.1
Minimum	45.5	1.5
Maximum	83.0	1.8

Table 4.2 Sex distribution across the various races

Race	Males (%)	Females (%)	Total (%)
Black	2 (5.0)	4 (10.0)	6 (15)
Coloured	0(0)	2 (5)	2 (5)
Indian	16 (40)	14 (35)	30 (75)
White	0 (0)	1 (2.5)	1 (2.5)
Other	0 (0)	1 (2.5)	1 (2.5)
Total	**18 (45)**	**22 (55)**	**40 (100)**

Table 4.3 Distribution of occupation of the participants

Occupation	*n*	Percentage (%)
Students	19	47.5
Engineering	3	7.5
Health Care	5	12.5
Law and Finance	8	20.0
Other	5	12.5
Total	**40**	**100**

4.2 SUBJECTIVE OUTCOME MEASURES

4.2.1 Pillow Preference

Pillow preference refers to the pillow that each participant found most comfortable. Overall15 participants preferred the latex pillow, 8 preferred the polyester pillow and 17 preferred the Simmons Beautyrest® pillow. This is depicted graphically in **Figure 4.1**. The pillow preference was then cross tabulated with sex (shown in **Table 4.4**). This indicates that a slightly higher number of female participants preferred the Simmons Beautyrest® pillow than males, but no one pillow stood out as the most preferred pillow.

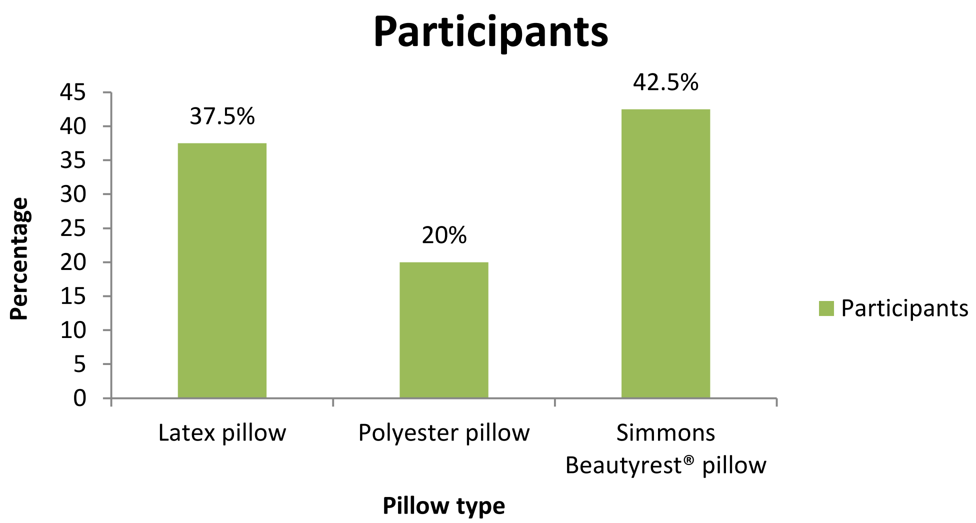

Figure 4.1 Distribution of pillow preference of participants

Table 4.4 Preference of pillows according to sex

Pillow	Male (%)	Female (%)
Latex Pillow	7(38.9)	8 (36.4)
Polyester Pillow	4(22.2)	4(18.2)
Simmons Beautyrest® Pillow	7(38.9)	10(45.5)
Total	**18(100)**	**22(100)**

4.3 OBJECTIVE OUTCOME MEASURES

4.3.1 Cervico-thoracic posture

Comparative analysis of the various pillow types (coded as 0 – 3; 0 indicating no pillow, 1 indicating latex pillow, 2 indicating polyester pillow and 3 indicating Simmons Beautyrest® pillow) and the effects thereof on the cervico-thoracic posture are shown in **Table 4.5**. It should be noted that all values with a minus (-) sign are not negative values. Rather, the sign indicates the direction of the slope. The initial test was to determine the nature of the distributions for the various variables. A One-Sample Kolmogorov-Smirnov Test was performed to determine whether the distributions were normally distributed (**Table 4.5**). Significant values were found at the C2-EOP slope only, in all the conditions.

Table 4.5 Comparative analysis of the 4 conditions on the cervico-thoracic and forward head posture

	n	Normal Parameters		Most Extreme Differences			Kolmogorov -Smirnov Z	Asymp. Sig. (2-tailed)
		Mean	Std. deviation	Absolute	Positive	Negative		
C2EOP-**0**	40	-0.87	0.05	0.37	0.38	-0.25	2.385	0.000
C2EOP-**1**	40	-0.67	0.14	0.22	0.22	-0.16	1.412	0.037
C2EOP-**2**	40	-0.73	0.11	0.24	0.24	-0.17	1.544	0.017
C2EOP-**3**	40	-0.67	0.114	0.23	0.23	-0.13	1.479	0.025
C4C2-**0**	40	-0.57	0.39	0.14	0.09	-0.15	0.922	0.363
C4C2-**1**	40	0.07	0.21	0.20	0.20	-0.10	1.246	0.090
C4C2-**2**	40	-0.09	0.20	0.11	0.10	-0.11	0.697	0.716
C4C2-**3**	40	0.13	0.23	0.13	0.09	-0.14	0.856	0.456
C7C4-**0**	40	-0.49	0.29	0.15	0.15	-0.09	0.97	0.303
C7C4-**1**	40	0.00	0.24	0.15	0.15	-0.09	0.975	0.298
C7C4-**2**	40	-0.20	0.22	0.14	0.10	-0.14	0.88	0.421
C7C4-**3**	40	-0.01	0.21	0.14	0.14	-0.11	0.868	0.438
T3C7-**0**	40	-0.11	0.17	0.13	0.12	-0.13	0.816	0.518
T3C7-**1**	40	0.07	0.14	0.14	0.13	-0.14	0.872	0.433
T3C7-**2**	40	-0.01	0.18	0.20	0.20	-0.15	1.256	0.085
T3C7-**3**	40	0.07	0.15	0.14	0.14	-0.14	0.873	0.430
SAD-**0**	40	62.49	7.74	0.11	0.11	-0.10	0.695	0.719
SAD-**1**	40	63.16	7.43	0.08	0.08	-0.06	0.5	0.964
SAD-**2**	40	63.10	7.87	0.08	0.08	-0.05	0.492	0.969
SAD-**3**	40	63.30	8.17	0.06	0.05	-0.06	0.39	0.998

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest®; EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.1 Comparison of Craniocervical and Cervico-thoracic Slopes between the 4 conditions

4.3.1.1.1 C2-EOP Slope Comparison

The mean slope values for the C2-EOP segment is presented in **Figure 4.2**. To determine if the distribution patterns between the pillow types were the same, the Related Samples Wilcoxon Signed Rank Test was performed. The summarised significance (*p*-values) is shown in **Table 4.6**. The results indicate that none of the pairings have similar distributions, except for C2-EOP slope formed with the latex and Simmons Beautyrest® pillows (*p* = 0.480). The directions of the distributions can be determined from the mean scores. For example, the value of the mean C2-EOP**1** score is greater than that for C2-EOP**0**.

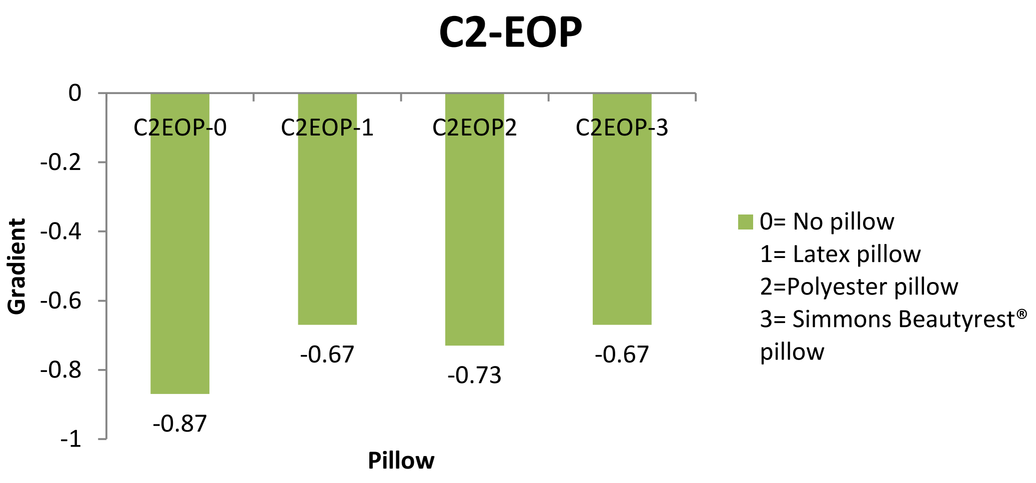

Figure 4.2 Mean slope values for C2-EOP segment in the 4 conditions

Table 4.6 Related Samples Wilcoxon Signed-Rank test distribution patterns between pillows for the C2-EOP segment slope

C2-EOP	***p*-value**
0 and 1	0.000
0 and 2	0.000
0 and 3	0.000
1 and 2	0.000
1 and 3	0.480
2 and 3	0.000

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest®; EOP= External Occipital Protuberance; C2=cervical vertebra 2; yellow highlighted text indicates statistically significant values

4.3.1.1.2 C4-C2 slope comparison

The paired sample descriptive statistics for the slope between C4 and C2 is presented in **Table 4.7**. It is observed that the slopes were positive for the latex and Simmons Beautyrest® pillows indicating that C2 was higher than C4 and negative for the other two indicating that C2 was lower than C4 (**Figure 4.3**). The largest negative slope was observed with the participants not using a pillow. The largest positive slope was observed with the participants using the Simmons Beautyrest® pillow. The latex pillow produced the slope that was closest to neutral. The difference in mean between pairs were significant for all the pairs except for the C4-C2 segment slope whilst using the latex pillow and the C4-C2 segment slope using the Simmons Beautyrest® pillow.

Table 4.7 Paired samples descriptive statistics for C4-C2 segment slope

		Mean	*N*	Std. deviation	Std. error mean
Pair 1	C2C4-**0**	-0.57	40	0.39	0.06
	C2C4-**1**	0.07	40	0.20	0.03
Pair 2	C2C4-**0**	-0.57	40	0.39	0.06
	C2C4-**2**	-0.09	40	0.20	0.03
Pair 3	C2C4-**0**	-0.57	40	0.39	0.06
	C2C4-**3**	0.14	40	0.24	0.04
Pair 4	C2C4-**1**	0.07	40	0.20	0.03
	C2C4-**2**	-0.09	40	0.20	0.03
Pair 5	C2C4-**1**	0.07	40	0.20	0.03
	C2C4-**3**	0.14	40	0.24	0.04
Pair 6	C2C4-**2**	-0.09	40	0.20	0.03
	C2C4-**3**	0.14	40	0.24	0.04

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest® EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3

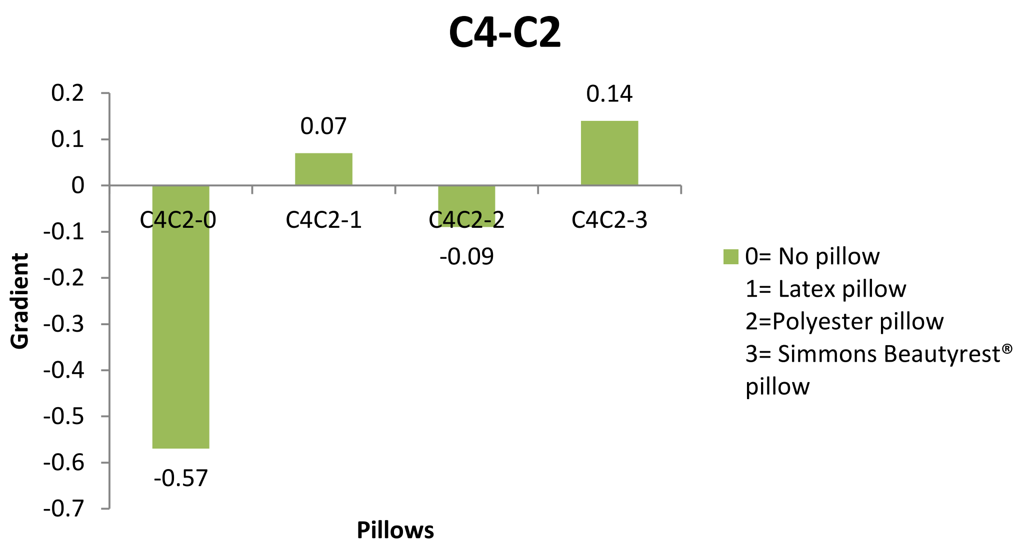

Figure 4.3 Mean slope values for C4-C2 segment in the 4 conditions

Table 4.8 Paired samples t test for C4-C2 segment slope

		Paired Differences					T	Df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% Confidence Interval of the difference lower	upper			
Pair 1	C4C2-**0**–C4C2-**1**	-0.64	0.34	0.05	-0.75	-0.53	-11.84	39	0.000
Pair 2	C4C2-**0**–C4C2-**2**	-0.48	0.36	0.06	-0.59	-0.36	-8.36	39	0.000
Pair 3	C4C2-**0**–C4C2-**3**	-0.70	0.33	0.05	-0.81	-0.60	-13.46	39	0.000
Pair 4	C4C2-**1**–C4C2	0.17	0.18	0.03	0.10	0.22	5.69	39	0.000
Pair 5	C4C2-**1**–C4C2-**3**	-0.06	0.22	0.04	-0.13	0.01	-1.77	39	0.085
Pair 6	C4C2-**2**–C4C2-**3**	-0.23	0.19	0.03	-0.29	-0.17	-7.44	39	0.000

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest® EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.1.3 C7-C4 slope (Lower Cervical spine)

The paired sample descriptive statistics for the C7-C4 segment slope is presented in **Table 4.9**. The mean slope values for segment between C7 and C4 in the four conditions is depicted graphically in **Figure 4.4**. It is noted that the slope was positive for the latex pillow only. This indicates that C4 was higher than C7. The slopes for no pillow, the polyester pillow and the Simmons Beautyrest® pillow were negative indicating that C4 was lower than C7. The largest negative slope was formed when the participants were not using a pillow. The largest positive slope was formed when the participants were using the latex pillow. The latex pillow produced the slope that was closest to neutral. The paired samples t test for the C7-C4 segment slopes is shown in **Table 4.10**. All of the highlighted pairs show significant differences.

Table 4.9 Paired samples descriptive statistics for C7-C4 segment slope

		Mean	*N*	Std. deviation	Std. error mean
Pair 1	C7C4-**0**	-0.49	40	0.29	0.05
	C7C4-**1**	0.00	40	0.24	0.04
Pair 2	C7C4-**0**	-0.50	40	0.29	0.05
	C7C4-**2**	-0.20	40	0.22	0.04
Pair 3	C7C4-**0**	-0.50	40	0.29	0.05
	C7C4-**3**	-0.01	40	0.21	0.03
Pair 4	C7C4-**1**	0.00	40	0.24	0.04
	C7C4-**2**	-0.20	40	0.22	0.04
Pair 5	C7C4-**1**	0.00	40	0.24	0.04
	C7C4-**3**	-0.010	40	0.21	0.03
Pair 6	C7C4-**2**	-0.2	40	0.22	0.04
	C7C4-**3**	-0.01	40	0.21	0.03

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest® EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

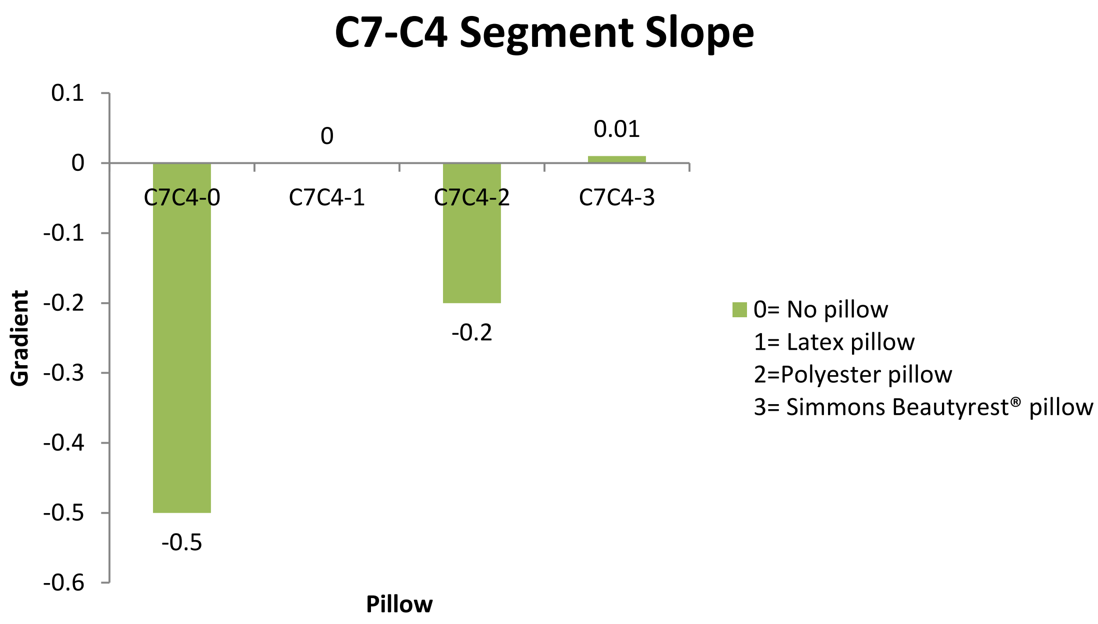

Figure 4.4 Mean slope values for C7-C4 segment in the 4 conditions

Table 4.10 Paired samples t test for C7-C4 segment slopes

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% Confidence Interval of the difference				
					Lower	Upper			
Pair 1	C7C4-**0** – C7C4-**1**	-0.50	0.23	0.03	-0.57	-0.43	-13.50	39	0.000
Pair 2	C7C4-**0**– C7C4-**2**	-0.30	0.23	0.04	-0.38	-0.23	-8.15	39	0.000
Pair 3	C7C4-**0**– C7C4-**3**	-0.49	0.22	0.04	-0.56	-0.41	-13.71	39	0.000
Pair 4	C7C4-**1**– C7C4-**2**	0.20	0.16	0.02	0.15	0.25	8.00	39	0.000
Pair 5	C7C4-**1**– C7C4-**3**	0.02	0.16	0.03	-0.04	0.07	0.58	39	0.567
Pair 6	C7C4-**2**– C7C4-**3**	-0.18	0.16	0.02	-0.23	-0.13	-7.44	39	0.000

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest®; EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.1.4 T3-C7 slope comparison (Cervico-thoracic segment)

The paired sample descriptive statistics for the slope of the T3-C7 segment is given in **Table 4.11**. The mean slope values for the T3-C7 segment in the four conditions is graphically depicted in **Figure 4.5**. It is noted that the slope was positive for the latex and Simmons Beautyrest® pillows indicating that C7 was higher than T3. The slopes for no pillow and the polyester pillow were negative indicating that C7 was lower than T3. The largest negative slope was produced by the participant not utilising a pillow. The largest positive slope was produced by the latex pillow. The polyester pillow produced the slope that was closest to neutral. The paired samples t test for the C7-C4 slopes is shown in **Table 4.12**.

Table 4.11 Paired samples descriptive statistics for T3-C7 segment slope

		Mean	***N***	**Std. deviation**	**Std. error mean**
Pair 1	T3C7-**0**	-0.11	40	0.17	0.03
	T3C7-**1**	0.08	40	0.14	0.02
Pair 2	T3C7-**0**	-0.11	40	0.17	0.03
	C7T3-**2**	-0.01	40	0.19	0.03
Pair 3	T3C7-**0**	-0.11	40	0.17	0.03
	T3C7-**3**	0.07	40	0.16	0.03
Pair 4	T3C7-**1**	0.08	40	0.14	0.02
	T3C7-**2**	-0.01	40	0.19	0.03
Pair 5	T3C7-**1**	0.08	40	0.14	0.02
	T3C7-**3**	0.07	40	0.16	0.03
Pair 6	T3C7-**2**	-0.01	40	0.19	0.03
	T3C7-**3**	0.07	40	0.16	0.03

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest® EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

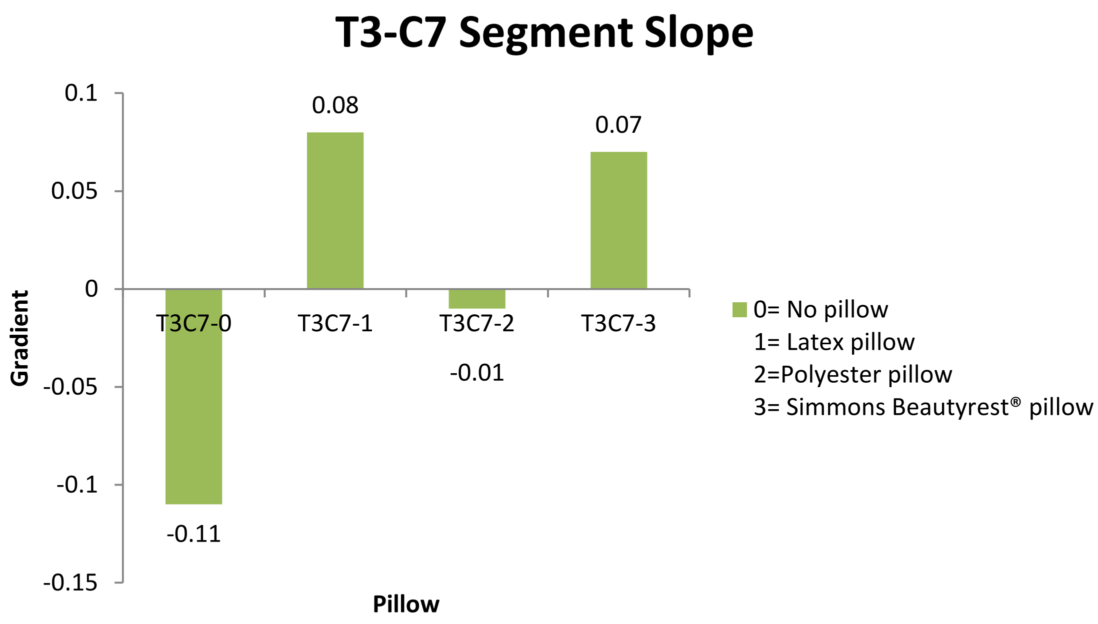

Figure 4.5 Mean slope values for T3-C7 segment in the 4 conditions

Table 4.12 Paired samples t test for T3-C7 segment slopes

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	T3C7-**0**– T3C7-**1**	-0.19	0.17	0.03	-0.25	-0.14	-7.00	39	0.000
Pair 2	T3C7-**0** – T3C7-**2**	-0.10	0.18	0.03	-0.16	-0.04	-3.55	39	0.001
Pair 3	T3C7-**0** – T3C7-**3**	-0.18	0.15	0.02	-0.23	-0.13	-7.35	39	0.000
Pair 4	T3C7-**1** – T3C7-**2**	0.09	0.11	0.02	0.06	0.12	5.26	39	0.000
Pair 5	T3C7-**1** – T3C7-**3**	0.01	0.12	0.02	-0.02	0.05	0.68	39	0.499
Pair 6	T3C7-**2** – T3C7-**3**	-0.08	0.11	0.02	-0.11	-0.04	-4.56	39	0.000

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest® EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.1.5 Summary of the mean craniocervical and cervico-thoracic slopes

A summary of the mean slope values for the four conditions is shown in **Table 4.13.** The overall mean slope gradients of each condition are depicted graphically in **Figure 4.6**. For the C2-EOP slope the latex and Simmons Beautyrest® pillows supported the neck in a similar manner and closer to neutral than the other two conditions. For the C4-C2 and the C7-C4 slopes, the latex pillow produced the least extreme slope. For the T3-C7 slope, the polyester pillow produced the slope closest to neutral. Thus for the entire cervical spine the latex pillow produced the least extreme slopes. However, at the cervico-thoracic junction, the polyester pillow produced the most neutral slope. In all segments, the condition without a pillow produced the largest extreme slopes. When comparing the slopes themselves, it can be seen that the most extreme deviations from neutral occurred at the C2-EOP segment. The mid-cervical spine deviated least from neutral.

Table 4.13 Summary of the mean slope values for each condition

Slope	0	1	2	3
C2-EOP	-0.87	-0.67	-0.73	-0.67
C4-C2	-0.57	0.07	-0.09	-0.14
C7-C4	-0.50	0.00	-0.20	-0.01
T3-C7	-0.11	0.08	-0.01	0.07

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest®; EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3

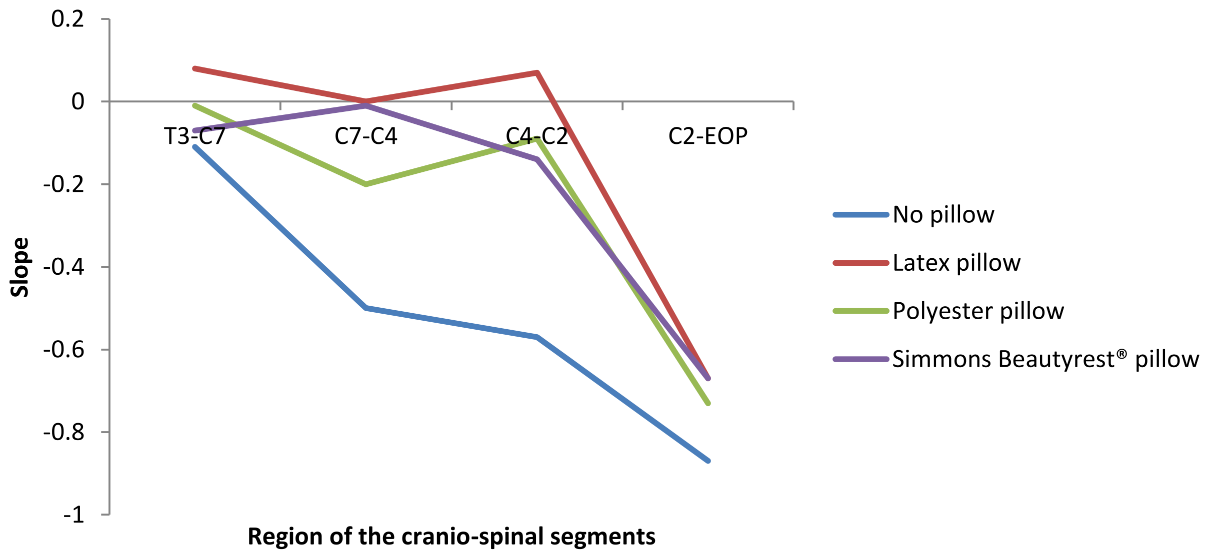

Figure 4.6 Mean slope values for each condition

4.3.1.2 Comparisons of Craniocervical and Cervico-thoracic Slopes within the 4 conditions

The tables below compare the readings by pillow type on the various spinal segments

4.3.1.2.1 No Pillow

The comparison of the slope values of the different spinal segments that were produced without a pillow is shown in **Table 4.14**. There was a statistically significant difference between all the spinal segments except between the C4-C2 slope and the C7-C4 slope indicating that they formed similar slopes when the participants' heads were not supported by a pillow.

Table 4.14 Comparison of the slope of spinal segments without a pillow

0 – comparison	Test	*p*-value
EOP and C2C4	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C4C7	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C7T3	Related Samples Wilcoxon Signed-Rank Tests	0.000
C2C4 and C4C7	Paired t-Test	0.196
C2C4 and C7T3	Paired t-Test	0.000
C4C7 and C7T3	Paired t-Test	0.000

EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.2.2 Latex Pillow

The difference in spinal segment slopes when the participants head were supported by the latex pillow is presented in **Table 4.15**. There was a statistically significant difference between most of the spinal segments. The difference between C4-C2 and C7-C4; and the difference between C4-C2 and T3-C7 were not significant.

Table 4.15 Comparison of the slope of spinal segments with a latex pillow

1 – comparison	Test	*p*-value
EOP and C2C4	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C4C7	Related Samples Wilcoxon Signed-Rank Tests	0.001
EOP and C7T3	Related Samples Wilcoxon Signed-Rank Tests	0.000
C2C4 and C4C7	Paired t-Test	0.062
C2C4 and C7T3	Paired t-Test	0.863
C4C7 and C7T3	Paired t-Test	0.044

EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.2.3 Polyester Pillow

The comparison of the spinal segment slopes with the participants heads supported by the polyester pillow is shown in **Table 4.16**. There was a statistically significant difference between all of the spinal segment slopes.

Table 4.16 Comparison of the slope of spinal segments with a polyester pillow

2 – comparison	Test	*p*-value
EOP and C2C4	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C4C7	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C7T3	Related Samples Wilcoxon Signed-Rank Tests	0.000
C2C4 and C4C7	Paired t-Test	0.007
C2C4 and C7T3	Paired t-Test	0.019
C4C7 and C7T3	Paired t-Test	0.000

EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.1.2.4 Simmons Beautyrest® Pillow

The comparison of the spinal segment slopes while using the Simmons Beautyrest® pillow is described in **Table 4.17**. With the Simmons Beautyrest® pillow, there was a statistically significant difference between all the slopes, except for the C4-C2 and T3-C7 slopes.

Table 4.17 Comparison of the slope of spinal segments with a Simmons Beautyrest® pillow

3 – comparison	Test used	*p*-value
EOP and C2C4	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C4C7	Related Samples Wilcoxon Signed-Rank Tests	0.000
EOP and C7T3	Related Samples Wilcoxon Signed-Rank Tests	0.000
C2C4 and C4C7	Paired t-Test	0.000
C2C4 and C7T3	Paired t-Test	0.081
C4C7 and C7T3	Paired t-Test	0.024

EOP= External Occipital Protuberance; C2=cervical vertebra 2; C4=cervical vertebra 4; C7=cervical vertebra 7; T3=thoracic vertebra 3; yellow highlighted text indicates statistically significant values

4.3.2 Sagittal Angular Displacement

Sagittal angular displacement refers to the extent of forward head posture. It is described by determining the cranio-vertebral angle and is measured in degrees (°). The paired sample descriptive statistics for the cranio-vertebral angle is shown in **Table 4.18**. The mean values for the sagittal angular displacement angle in the four conditions are displayed graphically in **Figure 4.7**. The smallest angle was produced when the participants head was not supported by a pillow. The largest angle was produced with the Simmons Beautyrest® pillow; however it did not differ significantly from the other pillows. The results for the paired samples t-test for the cranio-vertebral angle are displayed in **Table 4.19**. None of the *p*-values are less than 0.05 (the level of significance). That means that the differences in the means between the specified pairs were not significant.

Table 4.18 Paired samples descriptive statistics for the cranio-vertebral angle

		Mean	*n*	Std. deviation	Std. error mean
Pair 1	SAD-**0**	62.49	40	7.74	1.22
	SAD-**1**	63.16	40	7.43	1.18
Pair 2	SAD-**0**	62.49	40	7.74	1.22
	SAD-**2**	63.10	40	7.87	1.24
Pair 3	SAD-**0**	62.49	40	7.74	1.22
	SAD-**3**	63.30	40	8.17	1.29
Pair 4	SAD-**1**	63.17	40	7.43	1.18
	SAD-**2**	63.10	40	7.87	1.24
Pair 5	SAD-**1**	63.17	40	7.43	1.28
	SAD-**3**	63.30	40	8.17	1.29
Pair 6	SAD-**2**	63.10	40	7.87	1.24
	SAD-**3**	63.30	40	8.17	1.29

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest®; SAD=Sagittal Angular Displacement

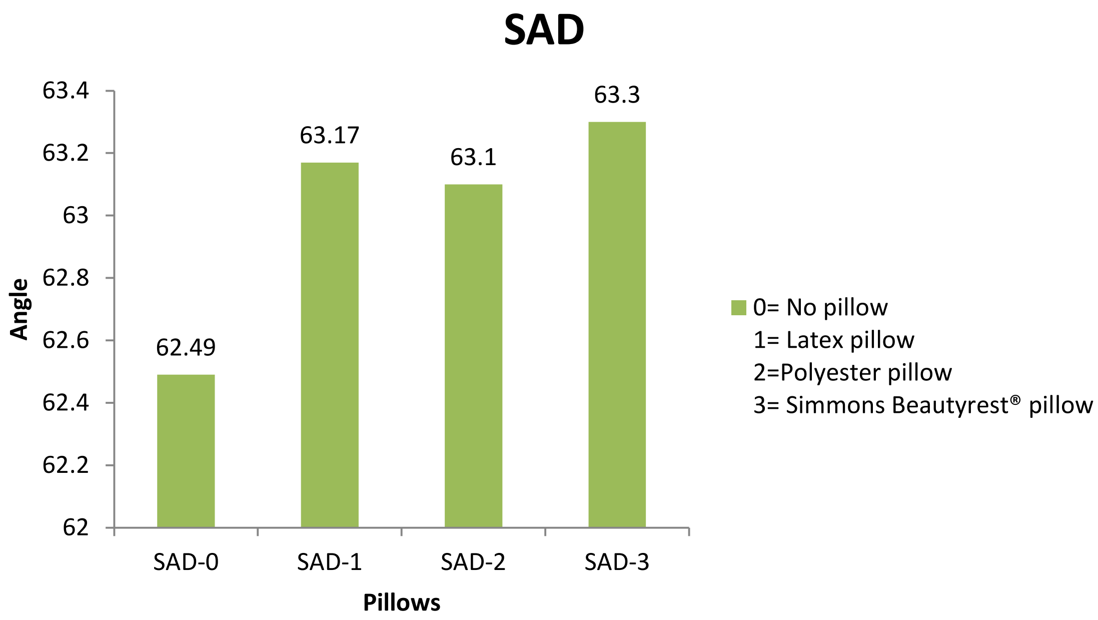

Figure 4.7 Mean angle values for sagittal angular displacement in the 4 conditions

Table 4.19 Paired samples t-test for cranio-vertebral angle

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	SAD-**0** - SAD-**1**	-0.68	5.90	0.93	-2.56	1.21	-0.72	39	0.473
Pair 2	SAD-**0** - SAD-**2**	-0.61	6.76	1.07	-2.77	1.56	-0.57	39	0.573
Pair 3	SAD-**0** - SAD-**3**	-0.81	7.17	1.13	-3.10	1.48	-0.72	39	0.479
Pair 4	SAD-**1** - SAD-**2**	0.07	4.49	0.71	-1.37	1.50	0.10	39	0.925
Pair 5	SAD-**1** - SAD-**3**	-0.14	5.58	0.89	-1.92	1.65	-0.15	39	0.879
Pair 6	SAD-**2** - SAD-**3**	-.20	6.15	0.97	-2.12	1.77	-0.21	39	0.836

0 = No pillow; 1 = latex pillow; 2 = polyester pillow; 3 Simmons Beautyrest®; SAD= Sagittal Angular Displacement

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 AGE, SEX, RACE AND OCCUPATION OF THE PARTICIPANTS

The participants in this study were young adults aged between 20 and 29 years which is in keeping with the inclusion criteria of this study. Other similar studies had comparable age ranges (Hagino et al., 1998; Jagarnath 2012) as mentioned in **Table 2.8**. This narrow age range provided a homogenous sample in terms of age, and reduced the impact of degeneration of the cervical spine (Yukawa et al., 2011) which could affect the slope values.

The distribution between the sexes was 45% male and 55% female. This is comparable to other spinal posture studies (Gordon et al., 2011; Van Deun et al., 2012) both of whom had sex ratios that were approximately 50:50 **(Table 2.8)**. The slightly higher preponderance of females may be explained by the sex statistics of the eThekwini municipality which reports that 48.9% of the population of Durban is male and 51.1% is female (www.statssa.gov.za). With regard to race distribution, the Indian race group was the highest, followed by Black, Coloured, White and Other. This is in agreement with the racial distribution of the eThekwini municipality which has a majority of Blacks and Indians (www.statssa.gov.za).

Due to the wide variety and diversity of occupations of the participants, the statistical analysis of the occupation groups could not be undertaken. However, the largest group within the occupation demographic was students. This could be attributed to the fact that the study was carried out at the Durban University of Technology and most of the advertising occurred in this area.

5.2 SUBJECTIVE OUTCOME MEASURES

5.2.1 Pillow preference

Pillow preference refers to the pillow that each participant found most comfortable. It should be borne in mind that the pillow preference mentioned in this study refers to the participants' immediate impression of the pillow and is not an accurate descriptor of pillow preference following prolonged used. Erfanian et al. (1998) have reported that it requires more than a week for a person to get used to using a pillow. Then only can a true result of pillow preference be obtained. The majority (42.5%) of participants found the Simmons Beautyrest® pillow most comfortable, followed by the latex pillow (37.5%) and lastly, the polyester pillow (20.0%). This is consistent with the results of Gordon et al. (2009) who found that participants rated latex pillows as more comfortable than their own pillow, and the study polyester pillows were rated as comfortable as their own. The latex and polyester pillows in this study were comparable to the ones used by Gordon et al. (2009) in terms of constituents and dimensions **(Table 2.9)**. Jagarnath (2012) reported that participants found the Simmons Beautyrest® pillow more comfortable than their own pillow (which is generally a polyester pillow). There are currently no studies comparing the latex pillow to the Simmons Beautyrest® pillow. This is the first study that compared the Simmons Beautyrest® pillow to other commercially-available pillows. Due to the wide diversity of available pillow types, few pillows have been tested more than once. Most of the pillow studies have examined new pillows or pillows that have not been tested before instead of examining different aspects of previously-tested pillows to determine their all-round efficacy. Therefore, the researcher chose three pillows which were previously studied.

The impact of the Hawthorne Effect on the participants' choice was minimal as the participants and the researcher were blinded to the pillow that was being tested. Although the participants were aware of the three pillows that were being tested, they were not aware of which pillow was being tested at any specific time. Therefore, any bias with regard to branding was minimized considerably. Furthermore, the researcher was also blinded and this prevented any non-verbal cues being given. A similar blinding method was used by Gordon et al. (2011, but Jagarnath 2012 could not blind the subjects in this manner as the participants took the pillows home were aware of which pillow they were using.

It was found that pillow preference was affected by sex. Overall, majority of females preferred the Simmons Beautyrest® pillow (45.5%), then the latex pillow (36.4%) and lastly, the polyester pillow (18.2%). In the male population, the preference for the latex and the Simmons Beautyrest® pillows were approximately the same (38.9% and 39.9% respectively), with only 18.2% preferring the polyester pillow. Gordon et al. (2009) also found that pillow preference was influenced by sex, but no explanation was provided by the researchers for this finding. However, certain anthropometric measurements of the participants (which were not assessed in this study) such as neck girth, posterior neck length and lateral neck length may have been a factor in determining pillow preference (Erfanian et al., 1998). It is possible that females, who generally have a shorter shoulder width, would have preferred the Simmons Beautyrest® pillow, which although high, adapts to the accommodate weight placed on it. Conversely, the polyester pillow is the lowest and does not provide enough support.

5.3 OBJECTIVE OUTCOME MEASURES

5.3.1 Cervico-thoracic spinal segments

The cervico-thoracic spinal segment slopes were determined in the recumbent position as demonstrated in Figure 3.1. This position was controlled in order to ensure that all the participants' positions were standardised. However, although the side-lying position is the most common sleeping position (Gordon et al., 2007) most people do not sleep in the exact manner described in this study (i.e. pure supine or recumbent positions) (Gordon et al., 2011). Therefore, the results might have varied if the participants were assessed while lying in their usual sleeping positions. Statistical analysis showed that there were significant differences in all the segment slopes, between all the pillow conditions, except for the slopes created by the latex and Simmons Beautyrest® pillows. These findings are partly consistent with the findings of Gordon et al. (2011) who observed that there was a significant difference between the slopes created by the polyester and latex pillow.

The most extreme slope for all the segments was formed in the condition without using a pillow. Sleeping without a pillow will result in non-neutral postures which increases the biomechanical stress placed on the spine and its supporting structures (Gordon et al., 2011) by loading the intervertebral discs and facet joints unevenly (Leilnahari et al., 2011). When lying on a firm mattress, only the wider areas of the body such as the shoulders and pelvis are supported, leading to lateral flexion away from the bed (Normand et al., 2005). On very soft surfaces, the heavier areas of the body such as the pelvis will sag, leading to lateral flexion toward the bed (Normand et al., 2005). This leads to compression of pain-sensitive structures such as muscles and joints causing symptoms on awakening such as neck pain, headaches and arm pain (Gordon et al., 2011). Correct neck support during sleep immobilises the facet joints, allowing the cervical paraspinal muscles to relax and maintain the cervical lordosis (De Laittre, 1974; Ambrogio et al., 1998; Erfanian et al., 1998). This reduces pressure on the pain-sensitive structures, leading to pain-relief for prolonged periods (Ambrogio et al., 1998). The vertebral column and surrounding structures are restored from the activities of the day (Hysmans et al., 2006). Growth, restoration and hydration of the intervertebral discs are based on the amount of pressure and its manner of application on them (Leilnahari et al., 2011). With the change in the direction of the gravity vector during sleep, the intervertebral discs are unloaded and can rehydrate to restore their elasticity (Leilnahari et al., 2011). The pressure in the lower cervical facet joints is decreased, allowing the articular cartilage to be restored (Hysmans et al., 2006). This is the first pillow research that has examined the effect of no pillow on the cervico-thoracic spine and cranio-vertebral posture.

The segment that displayed the largest extreme slope values was the C2-EOP segment. This was contrary to the findings of Gordon et al. (2011) who found the largest extreme slope values at the C4-C2 segment and the C7-C4 segments. This may be explained by the fact that the C2-EOP slope is at the open end of the biomechanical chain and would, therefore, be more susceptible to slope changes.

The slope that was closest to neutral for the C2-EOP slope was created by both the latex and the Simmons Beautyrest® pillows. The slope that was closest to neutral for the C4-C2 slope and C7-C4 was formed by the latex pillow. The slope that was closest to neutral for the T3-C7 slope was formed by the polyester pillow. Each segment slope, therefore, had the largest ‘neutral' slope produced by different pillows. Consequently, it cannot be conclusively said that any one pillow is better than the other in terms of maintaining the cervico-thoracic spine in the neutral position. This validates the premise put forth by Erfanian et al. (1998) that “one pillow does not fit all”. Instead, each person may be suited to a different pillow type.

When examining the segment slopes within pillows, it was noted that there were significant differences in the way each pillow supported each segment slope. However, in the condition without the pillow and while using the latex pillow, it was noted that the C4-C2 slope and the C7-C4 slope were supported similarly within conditions. When using the Simmons Beautyrest® pillow the C4-C2 and the T3-C7 were supported in a similar manner. The polyester pillow did not support any of the segments in a similar manner. This suggests that each segment slope has different requirements to achieve optimal support and this cannot be fulfilled when using a pillow with one type of filling only. Previous studies by Gordon et al., 2011 and Lin and Huang, 2007) that examined the effect of pillows on the cervico-thoracic spine did not examine the intra-pillow effect on slope values which limited the available information on the performance of actual pillow itself.

5.3.2 Sagittal Angular Displacement

Sagittal angular displacement was determined with the participants lying supine as depicted in **Figure 3.2.** This is the second most common sleeping position (Gordon et al., 2007). The smallest value for the forward head posture was created in the condition without a pillow and the largest value was produced with the Simmons Beautyrest® pillow. However, none of the differences were statistically significant and hence it cannot be concluded that any of the conditions cause more sagittal angular displacement than others. Research by Lin and Huang (2007) also found differences in craniocervical postures when comparing no pillow, a standard pillow and a cervical support pillow, but their findings were statistically significant. However, the exact position for the participants in their study is not known. The role of pillows in the supine position is not precisely known, but from the results of this study it be discerned that their effect on the cranio-vertebral posture is minimal.

5.4 LIMITATIONS OF THE STUDY

- The sample size (*n* = 40) of the study was relatively small. This was primarily due to financial, time and human resource constraints. However this sample size was generated by an experienced biostatistician (Van de Linde, 2012). It was calculated that with a sample size of 32 there would be a 80.36% power at alpha-level 5% to detect a moderate (0.25) effect size. A sample size of 40 subjects was recommended.
- The surface which the participants laid on (i.e. an examination plinth) did not mimic that of a real bed. The patients were resting instead of sleeping, but there is no data regarding on whether there is a difference in the cervical and thoracic muscle activity between resting and sleeping (Gordon et al., 2011).
- The Hawthorne Effect was first reported in industrial research (McCarney et al., 2007). It refers to the non-specific effects caused by the participants in a study knowing they are the subjects of a study (Hansson and Wigblad, 2005). However, it may be adapted to clinical research as well where it describes the response to treatment rather than productivity (McCarney et al., 2007). The Hawthorne effect can be large, and is often confused with the placebo effect (Berthelot et al., 2011), which is a true decrease in pain that is produced psychologically rather than physiologically (Kirsch, 2008). The Hawthorne effect is merely a distortion in the manner in which complaints are expressed and is larger in studies where the main outcome measure is subjective and the researcher has a likeable personality (Berthelot et al, 2011). Although the Hawthorne effect does not influence the difference between the intervention and control, it may exaggerate the effect that either has on the participants (McCarney et al., 2007). Inadequate double-blinding increases the measurement errors due to the Hawthorne effect (Berthelot et al., 2011).
- Participants in the study were resting rather than sleeping. However, there is very little information that differentiates between cervico-thoracic muscle function when resting and sleeping on a pillow. Stabilization of spinal segments occurs in 10 minutes when lying on a firm examination couch (Gordon et al., 2011). The authors

also reported that there were no significant differences in the change of the slope over 10 minutes.

5.5 RECOMMENDATIONS REGARDING PILLOW CHOICE FOR CHIROPRACTORS AND OTHER HEALTHCARE PRACTITIONERS

As the results of this study indicate, there is no one particular pillow that is better than the others. Therefore, the proposition of Erfanian et al. (1998) that “one pillow does not fit all” should be taken into account when healthcare practitioners recommend pillows to patients. However, the proper pillow for each individual should have the following characteristics based on the results of this study:

- It should be comfortable to the user. This was also mentioned by Persson, 2006 who described pillow comfort as one of the characteristics of an “ideal” pillow. The practitioner should advise the patient that pillow comfort can only be accurately assessed after using a pillow for more than one week (Erfanian et al., 1998) rather than an immediate impression. This should be borne in mind when using pillow comfort as a criterion for pillow choice.
- It should be 14-15cm in height. This is based on the findings of a previous study (Gordon et al., 2011) and the results of this study (the latex and Simmons Beautyrest® pillows were 14-15cm in height and were the preferred pillows of choice for the majority of the participants).
- It should provide support to the craniocervical and cervico-thoracic spine in the closest position to neutral in order to maintain spinal alignment and reduce stress on the various anatomical structures which may later lead to neck pain, headaches and scapular and arm pain. The practitioner may need to complete a basic biomechanical assessment similar to this study in order to determine optimal support provided by the pillow to the craniocervical and cervico-thoracic regions.
- Practitioners should be aware that it is the craniocervical and cervico-thoracic slopes determined with the patient in the recumbent position that provide significant information regarding support provided by the pillow rather than the sagittal angular displacement assessed in the supine position.

These recommendations should serve as a guideline until further research is carried out to determine both the subjective and objective findings of various pillows in a longitudinal study.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This study examined the effect of no pillow and three different pillows on the craniocervical and cervico-thoracic postures. The findings showed that not using a pillow created extreme segmental slopes compared to using a pillow. It was also observed that there is a change in the cervico-thoracic posture when changing from a polyester pillow to a latex pillow or Simmons Beautyrest® pillow and vice versa. There was no statistical difference between the four conditions when comparing craniocervical posture.

The Alternate Hypothesis (Ha), therefore, is partly accepted for the craniocervical and cervico-thoracic slopes in the recumbent position, but rejected for the sagittal angular displacement assessed in the supine position.

6.2 RECOMMENDATIONS

The recommendations arising from this study are the following:

- A longitudinal study should be conducted with a larger sample size and with a wider variety of pillows. This will allow for the results of the study to be more wide-ranging.
- A similar study should be repeated with patients lying on an actual bed to reproduce a more natural sleeping environment. The study should also observe the change in support of the pillows over a longer time and with the participants actually sleeping.

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DURBAN UNIVERSITY of TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

27 February 2013

IREC Reference Number: **REC 11/13**

Mrs Y Karim
P O Box 55371
North beach
4063

Dear Mrs Karim

The effect of various pillow types on cervico-thoracic and forward head posture in young adults

I am pleased to inform you that Full Approval has been granted to your proposal REC 11/13 subject to the following:

- Translation of information letter and consent form into isiZulu in the event potential participants not being familiar with English – see Ethics checklist No, 15 in this regard.

The Proposal has been allocated the following Ethical Clearance number IREC 014/13. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

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 IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

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

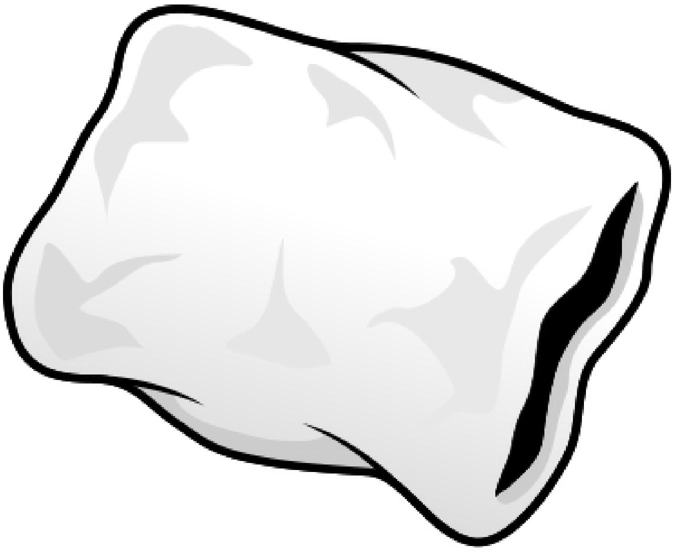
Yours Sincerely

[redacted]

Dr D F Naude
Chairperson: IREC

Appendix B

Are you interested in finding out how pillows support your neck?



IF YOU ARE:

- **Between the ages of 20-30 years**
- **Do not have neck pain**

YOU MAY BE ELIGIBLE TO PARTICIPATE IN MY RESEARCH.

IF YOU ARE INTERESTED CONTACT:
Yumna (073 141 4443)
OR
THE CHIROPRACTIC DAY CLINIC, DURBAN UNIVERSITY OF TECHNOLOGY (031 373 2205)

Appendix C1

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Title of the Research Study: The effect of different pillow types on cervico-thoracic and forward head posture in young adults

Principal Investigator/s/researcher: Yumna Karim (B. Tech. Chiro)

Co-Investigator/s/supervisor/s: Dr J Shaik (M. Tech. Chiro.; M. Med. Sci. (SM)

Brief Introduction and Purpose of the Study:

Cervical pillows and neck supports are also used frequently to decrease pain and improve neck symptoms. The purpose of a well-designed pillow is to support and maintain the head and neck in almost the same position that the head and neck assumes when the person is sitting or standing. Very few studies have investigated the effect of cervical pillows on the neck. The aim of the study is to determine the effect of different pillows on the neck posture.

Outline of the Procedures

The research will be conducted at the Chiropractic Day Clinic at the Durban University of Technology. First the study will be explained to you and you must read this document. By signing this, you have agreed to voluntarily take part in my study. You will then be screened to determine whether you will be included into the study. This is done via the inclusion/exclusion criteria, a case history, physical examination and cervical (neck) examination. Once you are included in the study, the study-related data will be collected. The consultation is expected to last between two and a half to three hours.

Consent for Digital Photographs:

The study-related data includes your age, sex, occupation, height, weight, case history and physical examination findings. It also includes taking photographs of your head, neck and spine. These photographs will only be used for my research. I will use the photographs to calculate the angle your neck or head makes when lying on the different pillows. Your name will not appear on the photographs. Your name or photograph will not appear in my dissertation, or in any journal article. To further protect your identity, your eyes will be covered during the assessment to prevent your face from being identified. By signing this consent form, you are also giving consent to photographs of your head, neck and spine being taken.

To be part of this study you must:

- Be between the ages of 20 and 30 years.
- Have a normal Body Mass Index (BMI) (18-25).

You will not be eligible to take part in this study if you:

- Have a history of neck or midback injury/trauma such as whiplash or spinal surgery

- Have a history of inflammatory arthritis of the spine such as ankylosing spondylitis or rheumatoid arthritis
- Develop dizziness during the clinical assessment or have a history of dizziness
- Have any clinically detectable abnormalities of the spine e.g. scoliosis
- Use more than one pillow to sleep
- Currently receiving neck treatment.

Risks or Discomforts to the Participant:

No adverse effects are anticipated from this study. However, you will be required to lie on different pillows, which have different levels of comfort.

Benefits:

- You will have a full medical history, physical examination and cervical (neck) spine orthopaedic assessment performed.

Reason/s why the Participant May Be Withdrawn from the Study:

- If you sustain any injuries to the back during the initial consultation
- You become ill during your participation in this study
- You are free to withdraw from the study at any time. Withdrawal from the study does not prevent you from receiving further treatment at the Chiropractic Day Clinic at the normal clinic rates.

Remuneration:

There is no remuneration for participating in the study

Costs of the Study:

You are not expected to pay for the consultation as the study is free. However, once you have used your one free treatment voucher, you will be expected to pay normal clinic rates should you wish to receive further treatment at the clinic.

Confidentiality: All patient information pertaining to the study will be coded to maintain confidentiality and will be stored in the Chiropractic Day Clinic. Results of the study will be made available at the Durban University of Technology library, without revealing any of the patients' details. Your name will not appear on the actual photographs or in my dissertation or any research article.

Persons to Contact in the Event of Any Problems or Queries:

Dr J. Shaik, supervisor: (031) 373 2588

Dr A. Docrat, Head of Programme: (031) 373 2589

Ms Lavisha Deonarian, Faculty of Health Sciences Officer, (031) 373 2900

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Yumna Karim, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: 014/13,
- 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, Yumna Karim 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 (If applicable) **Date** **Signature**

Appendix C2

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Title of the Research Study: The effect of different pillow types on cervico-thoracic and forward head posture in young adults

Principal Investigator/s/researcher: Yumna Karim (B. Tech. Chiro)

Co-Investigator/s/supervisor/s: Dr J Shaik (M. Tech. Chiro.; M. Med. Sci. (SM)

Isingeniso kanye nenhloso yalesi sifundo

Umcamelo weCervical nokuxhaswa komqala kusctshenziselwa ukunciphisa izinhlungu zomqala kanye nezimpawu zokuphathwa umqala. Inhloso yomcamelo owenziwe kahle ukuxhasa kanye nokugcina ikhanda nomqala kube sendaweni okufanele kube kuyo uma umuntu ehleli noma emile. Zincane izifundo esezenziwe ukuhlola imiphumela yalolu hlobo lo mcamelo. Inhloso yaldu newaningo ukuthola imiphumela ehlukene ngokusetshenziswa kwemicamelo ehlukene.

Ukuchaza uhlelo oluzolandelwa

Ucwaningo luzoqhutshelwa eChiropractic Day Clinic ese Durban University of Technology. Isifundo sokuqala uzochazelwa futhi kumele ufunde namadokumenti. Ukusayina, kuyobe kusho ukuthi uyazivumela ukuba yingxenye yalolu cwaningo. Uma ungafikanga nomcamelo wakho ngosuku lokuzobonanano dokotela uyokwenzelwa olunye usuku ongafika ngalo uma ususayinile. Uma uwupathile umcamelo uyobe usuhlolwa ukuthi ungakwazi yini ukuba yingxenye yalolu cwaningo. Kuzoba khona izindlela zokuhlunga abantu abazoba yingxenye yocwaningo njengomlando wakho wezempilo, ukuhlolwa kanye nokuhlolwa komqala. Uma usufakiwe utuba yingzenye yalolu cwaningo imininingwane ngawe iyoqokelelwe Lokhu kuhlanganisa izithombe zekhanda lakho, umqala nomgogodle Lezi zithombe ziyosetshenziswa kulola cwaningo. Igama lakho alizukuvezwa kwidissertation noma kwijenali. Konke lokhu kulindeleke luthathe isikhathi esingangamahova amabili nesigamu kuya emahoreni amathathu.

Ukuze ube yingxenye yalolu cwaningo:

- Kumele ube neminyaka enga mashumi amabi kuya emashumi amathathu.
- Ube nesisindo somzimba esivumelekile (BMI) (18-25)

Awubumelekile ukuba ingxenye yaldu cwaningo uma:

- Wake walimala eunqaleni noma emhlane njengokuhlinzwa umgogodla.
- Unesifo samathambo emgogodlweni esibizwa njo-ankylosing spondylitis, noma rheumatoid arthritis.
- Uba nenzululwane ngesikhathi uhlolwa.
- Usebenzisa ucamelo ongaphezulu kowodwa uma ulala.
- Ushitshe umcamelo enyangeni edlule.
- Uma ulashwa/uthola ukulashwa emqaleni.

Ubungozi noma ungazitholi uthokomele kwabayingxenye yalolu cwaningo

- Abukho ubungozi obulindelekile kulolu cwangingo. Noma kanjani uyocelaukuba ulale usebenzise imicamelo ehlukene ezoba nokuthokomala okwelukene.
- Inzuzo:
    - Uyoba nomlando ophelele wezempilo, ukuhlolwa okuphelele kanye nokuhlolwa komqala noma umgogodla.
    - Uzothola ivawusha yokulashelwa izinhlungu zomqala noma umhlane eChiropractic Day Clinic.

Izizathu zokuthi kungani bengaphuma/ shiya kuldu cwaningo

- Uma uthola ukulimali ngenkathi uzohlolwa okokuqala.
- Uma ugula ngesikhathi usuyingxenye yalolu cwaningo.
- Ungaphuma/ shiya kulolu cwaningo noma inini. Lokhu akukuvimbeli ukuthi uthole ukwelashwa eChiropractic Clinic ngemali ejwayelekile.

Ukuhlomula/ukukhokhelwa:

Awukhokelwa ngokuba yingxenye yalolu cwaningo…

Kubizu malini kalolu cwaningo:

Awulindelekile ukuthi ukhokhe. Lolu cwaningo lumahala. Ungakhokha kuphela uma usuyisebenzile ivawusha yakho yamahala, uma usuqhubeka nokwelashwa ngemali ejwayelekile.

Ulwazi oluyimfihlo

Yonke imininingwane yezigule iyonikezwa ikhod ukugcina ilwazi inyimfihlo futhi zizogcinwa eChiropractic Day Clinic. Imiphumela yocwaningo iyotholakala eLibrary yase DUT ngaphandle kokuveza imininigwane yesiguli. Igamalakho aliyuvezwa esithombeni, dissertation noma kwimibhalo ephathaleni nocwaningo.

Abantu ongaxhumana nabo uma kunenkinga noma imibuzo:

Dr J. Shaik, supervisor: (031) 373 2588 Dr A. Docrat, Head of Programme: (031) 373 2589

Ms Lavisha Deonarian, Faculty of Health Sciences Officer, (031) 373 2900

Isitatimendesesivumelwanosokuzibandakanyakulolucwaningo:

- Ngiyaqinisekisaukuthingitsheliwengumcwaningi, Yumna Karim,ngohlobo,ngokuziphatha, nangosizo, nangobungozibalolucwaningo – Research Ethics Clearance Number: 014/13,
- Ngiyitholile, futhingayifunda, ngayizwaincwadi (incwadiyombandakanyi) echazangalolucwaningo(incwadiyombandakanyi).
- Ngiyazifuthiukuthiimiphumelayalolucwaningo, imininingwaneyamiephathelenenobulili, iminyaka, usukulokuzalwa, amagamaafingqiwe(initials) and isifoesingiphethekuzodalulwakumbikowalolucwaningongalekoludalulaamagamaami.
- Ngokubukaokudingekayokulolucwaningo, ngiyavumaukuthiimininingwaneetholakelengesikhathilolucwaningoluqhubekaumcwaningial ufakekuhlelolwekhompuyutha.
- Nomangasiphiisikhathi, ngalekokucwaseka, ngingayekaukubaumbandakanyikulolucwaningo.
- Ngibenesikhathiesanelesokubuzaimibuzo (ngentandoyami) nokuzilungiselelaukubayingxenyeyalolucwaningo.
- Ngiyaqondaukuthiimiphumelaebalulekileetholakelengesikhathilolucwaningoluqhubekaegap hathelana name ngizikwaziswangayo.

…………………………………………………… …………………………. ………………………….

IgamalozibandakanyakulolucwaningoUsuku isiginisha/isithupha

Mina Yumna Karim ongiyaqinisekisaukuthilombandakanyiongaphezuluutholeincazeloegcwelemayelananohlobo, ngokuziphatha, nangosizo, nangobungozibalolucwaningo

………………………………………. …………………………. ………………………….

IgamalomucwaningiUsuku Isiginishayomcwaningi

………………………………………… …………………………. ………………………….

Igamalafakazi Usuku Isiginishakafakazi

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ______________________ Date: __________

File #: __________ Age: __________

Sex: __________ 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:

<u>Student's Case History:</u>

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

CHIROPRACTIC PROGRAMME

PHYSICAL EXAMINATION: SENIOR

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

Student: **Signature:**

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

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

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature:**

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION – CERVICAL SPINE

Patient: .... File No: ....

Date: .... Student: ....

Clinician: .... Sign: ....

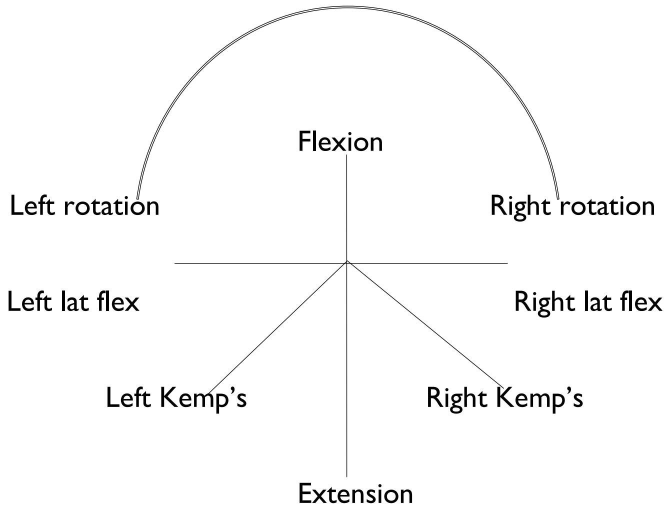
OBSERVATION:

Posture
Swellings
Scars, discolouration
Hair line
Body and soft tissue contours

Shoulder position
Left:
Right:
Shoulder dominance (hand):
Facial expression:

RANGE OF MOTION:

Extension (70°):
L/R Rotation (70°):
L/R Lat flex (45°):
Flexion (45°):



PALPATION:

Lymph nodes
Thyroid Gland
Trachea

MYOFASCIAL ASSESSMENT

Tenderness		Right	Left
Trigger Points:	SCM		
	Scalenii		
	Post Cervicals		
	Trapezius		
	Lev scapular		

ORTHOPAEDIC EXAMINATION:

	Right	Left		Right	Left
Adson's test			Halstead's test		
Brachial plexus test			Hyper-abduction test		
Cervical compression			Kemp's test		
Cervical distraction			Lateral compression		
Costoclavicular test			Lhermitte's sign		
Dizziness rotation test			Shoulder abduction test		
Doorbell sign			Shoulder compression test		
Eden's test					

NEUROLOGICAL EXAMINATION:

Dermatones	**Left**	**Right**	**Myotomes**	**Left**	**Right**	**Reflexes**	**Left**	**Right**
C2			C1			C5		
C3			C2			C6		
C4			C3			C7		
C5			C4					
C6			C5					
C7			C6					
C8			C7					
T1			C8					
			T1					
Cerebellar tests:		Left		Right				
Dysdiadochokinesis								

VASCULAR:	**Left**	**Right**		**Left**	**Right**
Blood pressure			Subclavian arts.		
Carotid arts.			Wallenberg's test		

MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:
Right: Motion Palpation:
Joint Play:

BASIC EXAM: SHOULDER:

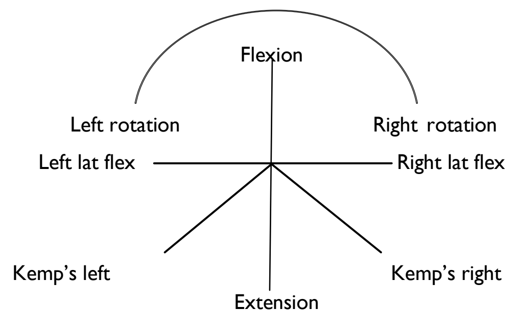
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic:
Neuro:
Vascular:

BASIC EXAM: THORACIC SPINE:

Case History:

ROM:



Motion Palpation:	
Orthopaedic:	
Neuro:	
Vascular:	
Observ/Palpation:	
Joint Play:	