A comparative study of a novel and school issued backpack on high school adolescent posture at the New Forest High School in the eThekwini district of KwaZulu-Natal

By

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I, Kimera Reddy, do hereby declare that this dissertation is representative of my own work in both conception and execution.

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DEDICATION

I dedicate this dissertation:

To my mum and dad, Deena and Shakun Reddy. Thank-you for the gift of my education, for all the support and unconditional love. Thank-you for always believing in me, encouraging me and never pushing me to go beyond my limits. Words cannot describe the appreciation and love that I have for the both of you. I hope that the completion of this dissertation, fills you with as much happiness and pride, as it does me.

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ABSTRACT

Research has shown that more than 90% of the scholars, use backpacks, worldwide. The backpack has the ability to transport books, sports equipment and clothing between school and home, climaxing in a capacity that may affect posture. Therefore, it is noted that a backpack, which is not carried correctly, fitted improperly and/or over packed may pose a threat to the scholar's posture

Aim: To determine the effect between a novel and school-issued backpack in terms of postural symmetry measurements (photographic measurements), when compared to no backpack, on high school adolescent standing posture.

Method: This research was a quantitative descriptive cross sectional experimental design. Each participating scholar underwent a BMI, height and weight screening, prior to inclusion into the data collection process. One hundred asymptomatic scholars, aged between 12 to 14 years, were recruited using convenience sampling. Thereafter, digital photographic images of each scholar was taken in 3 groups, i.e. no Backpack, with a school-issued backpack (Backpack A) and a novel backpack (Backpack B). These digital photographic images were then uploaded, by the researcher, onto the Posturepro 8 Computer Postural Software System. The objective measurement tool (Posturepro 8 Computer Postural Software System) calculated, in degrees, the postural measurements of the scholars' neck, shoulder and pelvis, by manually constructing lines (horizontal and vertical) between the anatomical landmarks (bilaterally). IBM SPSS version 21 was used to analyse the data. A two-tailed **p** value of <0.05 was considered as statistically significant. Parametric summary statistics such as mean and standard deviations were used to describe the outcomes in each group. Postural measurements were compared between the pairs (i.e. no Backpack versus Backpack A, no Backpack versus Backpack B and Backpack A versus Backpack B) using paired sample t-tests. A one sample t-test was used to compare the symmetry measurements to a null hypothesis value of 0.

Results: The mean age of the one hundred scholars was 13.5 (± 0.6 SD) years. The age of the scholars ranged between 12 and 14 years. This research was performed to determine which backpack (A or B) performed better in maintaining the scholar's posture (with no backpack). A direct comparison was performed with no Backpack to that of Backpack A and Backpack B. The comparison for each of the differences closest to zero ('0') in the no

Backpack, Backpack A and Backpack B groups was performed using a one sample t-test. The values closer to zero (‘0’) indicated a normal postural symmetry. None of the postural symmetry measurements were significantly different from zero in all 3 groups as the mean differences were very close to zero. Therefore, when comparing Backpack A to Backpack B, this research showed that there was no significant differences between the two backpacks when looking at postural symmetry (**p**=0.05).

Conclusion: The trends observed in this study partly supported the claims by the company (‘Improved Postural Alignment for You’) of the novel backpack. The novel backpack (Backpack B) showed significant differences in some instances when assessing other outcome measurements, but showed no significant difference when comparing postural symmetry between the two backpacks. Further studies need to be done incorporating all aspects of postural analysis, and not just postural symmetry measurements.

LIST OF DEFINITIONS

Backpack: a bag having one or two shoulder straps, allowing it to be carried on the back (Pascoe *et al*., 1997; Steele *et al*., 2001 and Grimmer *et al*., 1999).

School-issued backpack: for the purpose of this research, a school-issued backpack was the standard compulsory everyday backpack which scholars of New Forest High School carried to and from school. The backpack consisted of two shoulder straps.

Novel backpack: For the purposes of this research, the novel backpack was sponsored from the company 'Improved Postural Alignment for You'. The backpack consisted of two shoulder straps as well as additional comfort features (Posture Pro, 2011).

Normal posture: as similar to the word 'Posture' is the mechanical state that maintains equilibrium of the human body and allows for all movements and actions (Ferreira *et al*., 2011).

Postural symmetry: refers to a correspondence of anatomical parts on opposite sides of a dividing line (Encyclopaedia Britannica, 2014). It is demonstrated by a normal posture, where the shoulders are of equal height, hips are of equal height and the head is positioned straight with no abnormalities (Newman Chiropractic Offices, 2008).

Postural asymmetry: is understood as a disruption of the postural symmetry of anatomical parts, on both sides of the median plane (Rykala *et al*., 2013).

Chiropractor: a chiropractor is a health care professional, with an emphasis on treatment through manual adjustment and/or manipulation of the spine (Spine-health, 2014).

Physiotherapist: is a health care professional, concerned with helping to restore wellbeing, following injury, pain or disability (American Physical Therapy Association, 2014).

Adolescent: WHO identifies adolescence, as the period that occurs after childhood and before adulthood, from ages 10 to19 (World Health Organization, 2014).

LIST OF SYMBOLS AND ABBREVIATIONS

ABS: *A*crylonitrile-*B*utadiene-*S*tyrene

PVC: PolyVinyl Chloride

BMI: Body Mass index

°: Degree

SD: Standard deviation

Backpack A: School-issued backpack

Backpack B: Novel backpack

n: Sample size or count

IPA4U: 'Improved Postural Alignment for You'

SPSS: Statistical Package for the Social Sciences

cm: centimetres

m: metres

AP: Antero-posterior

m/s: metres per second

km/h: kilometres per hour

Kg: kilogram

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

Normal posture is presumed to be the state of musculoskeletal balance that comprises a marginal amount of stress and strain on the human body (Kendall, 2005 and Kim *et al*., 2008), and is vital for neuro-musculoskeletal health (McEvoy and Grimmer, 2005). Normal posture, in scholars, can be affected by loaded backpacks which scholars incorrectly carry, most being too large for their body frame (Puckree *et al*., 2004). When a backpack load is positioned posterior to the body, it causes a change in posture due to a change in the centre of gravity (Sharan *et al*., 2012).

The backpack has the ability to transport books, sports equipment and clothing between school and home, climaxing in a capacity that may affect posture (Feingold and Jacobs, 2002). Therefore, it is noted that a backpack, which is not carried correctly, fitted improperly and/or over packed may pose a threat to the scholar's posture (Steele *et al*., 2001).

The consequences of incorrect backpack usage have been noted by Lai and Jones (2001), in which they found that a scholar with a loaded backpack, will bend forward in an attempt to support the weight on their back rather than on their shoulders, due to the heavy weight that the backpack exerts on their spinal column and shoulders. Dochrell *et al.,* (2006) highlighted the negative consequences that a loaded backpack has on the developing spine, with particular concern noted in adolescents aged between 12 to 14 years, as their spine is at a critical stage of development. Bloom and Woodhull-McNeal (1987) found that a loaded backpack caused bending of the knees due to the displacement and uncompensated torque at the hips. Additionally, Pascoe *et al*., (1997) found an increased pelvic tilt when scholars carried an unframed backpack both bilaterally and unilaterally.

Grimmer *et al.,* (2002) assessed an array of backpack designs and brands. He found that most had common features such as: one size only, adjustable only at shoulder straps, no internal backpack frame or back support, no internal compartments to separate or distribute load and no waist or chest straps. A novel backpack was used for the duration of this research, the company ('Improved Postural Alignment for You') stated that this backpack has features such as "adjustable breast straps, tapered shoulder and waist straps, the base of the backpack is re-enforced so that the backpack can cope with rough usage due to impact. Even without any contents, the backpack is able to stand upright due to the side pleats and *A*crylonitrile-*B*utadiene-*S*tyrene (ABS) base insertion. The backpack contains three Poly Vinyl Chloride (PVC) dividers which allowed for equal weight distribution" (Posture Pro, 2011). The company claims that this novel backpack is better at maintaining posture. These claims, however, have not been investigated independently. This is the first independent study that will partly address the company claims.

Sharan *et al*., (2012) stated that there is neither any consensus nor guideline available for an ideal backpack weight, however, based on previous research, researchers have suggested a common backpack weight. Steele *et al*., (2001) for example, used a backpack limit of 15% of one's body weight, however, he noted that this limit was too heavy for a high school scholar to maintain their normal posture. Therefore, he concluded that a load less than 15% of one's body weight should be recommended. Other researchers have recommended that a backpack load should be limited to 10% body weight (Troussier *et al*., 1994 and Iyer, 2000; Al-Hazzaa, 2006; Connoly *et al*., 2008; Bauer and Freivalds, 2009 and Singh and Koh, 2009). Voll and Klimt (1977) did recommend a 10% body weight guideline which has continued to be the recommended guideline when using a backpack (Puckree *et al.,* 2004). Therefore, this research has made use of the 10% body weight guideline, when assessing the impact of the two backpacks (novel and school-issued) on a scholar's posture.

Many parents, teachers and scholars will inquire from a healthcare practitioner e.g. chiropractor or physiotherapist, on backpack of choice. It is, therefore, essential that a healthcare practitioner is armed with the proper knowledge and is able to advise the parent/teacher/scholar based on evidence obtained from previous research trials. Therefore, this research aimed to determine the effect between a novel and school-issued backpack in terms of postural symmetry measurements (photographic measurements), when compared to no backpack, on high school adolescent standing posture.

1.2 AIMS AND OBJECTIVES

1.2.1 The aim of this research was:

To determine the effect between a novel and school-issued backpack in terms of postural symmetry measurements (photographic measurements), when compared to no backpack, on high school adolescent standing posture.

1.2.2 The objectives of this research were:

Objective One:

- To assess a scholar's postural symmetry measurements with no backpack in terms of digital photographic postural measurement.

Objective Two:

- To assess a scholar's postural symmetry measurements with the use of the school-issued backpack in terms of digital photographic postural measurements (Backpack A).

Objective Three:

- To assess a scholar's postural symmetry measurements with the use of a novel backpack in terms of digital photographic postural measurements (Backpack B).

Objective Four:

- To compare both backpacks (A and B) digital photographic postural measurements to the original digital photographic postural measurement of the scholar (Backpack A and Backpack B versus no Backpack), and to statistically identify any postural symmetry pattern that may exist between the groups.

1.3 THE HYPOTHESIS

A significant difference in terms of postural symmetry will be seen when comparing the 3 groups, i.e. no Backpack, Backpack A (school-issued backpack) and Backpack B (novel backpack).

A null hypothesis was set which stated that there will be no significant change in postural symmetry measurements observed between the 3 groups, i.e. no Backpack, Backpack A (school-issued backpack) and Backpack B (novel backpack).

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Research has shown that more than 90% of scholars, of all age groups, use backpacks worldwide (Pascoe *et al*., 1997; Grimmer *et al*., 2002; Mackie *et al*., 2003; Marsh *et al.,* 2006; Macias *et al.,* 2008 and Mackie and Legg, 2008). Researchers have revealed that in South Africa, the load of a scholars backpack has increased over the years due to constant changes in the South African National Curriculum (Abrahams *et al*., 2011 and Puckree *et al*., 2004). Preceding research has established that South African scholars are similar to the scholars who carry backpacks overseas, In that most scholars appear to carry around backpacks which are too big and heavy for their body frame (Grimmer *et al*., 1999 and Vikat *et al*., 2000). Spinal stability can be maintained by carrying a backpack close to the spine (Voll and Klimt, 1977), however, Haselgrove *et al.,* (2008) demonstrated that backpack carrying resulted in an alteration of upright posture, in order to support the new stressor (i.e. the backpack).

Over the years, researchers have made efforts to set a safe backpack load limit for scholars, however these were inconclusive due to the unreliable results from the researched literature (Lindstrom-Hazel, 2009). Studies have estimated that the weight limit of a scholars backpack should be at 10% body weight (Troussier *et al*., 1994 and Iyer, 2000; Al-Hazzaa, 2006; Connoly *et al*., 2008; Bauer and Freivalds, 2009 and Singh and Koh, 2009). This limit is consistent with the general guideline of 10% body weight proposed by Voll and Klimt (1977) and continues to be the recommended guideline when carrying a school backpack (Puckree *et al.,* 2004). This research made use of this weight guideline limit of 10% body weight, however backpack weight did not constitute as a research variable for this research.

2.2 POSTURE

Normal posture is presumed to be the state of musculoskeletal balance that comprises a marginal amount of stress and strain on the body (Kendall, 2005 and Kim *et al*., 2008) and is vital for neuro-musculoskeletal health (McEvoy and Grimmer, 2005). However, normal posture is challenging to delineate, as each human being has a unique anthropometric and biomechanical outline (Trew and Everett, 2005).

"Normal" posture is best defined in the sagittal view, 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.,* 2008). When describing the neutral upright posture in terms of spinal curves, "normal" posture is defined as a minor cervical lordosis, thoracic kyphosis and lumbar lordosis (Claus *et al*., 2009).

Postural symmetry is demonstrated by a normal posture, where the shoulders are of equal height, hips are of equal height and the head is positioned straight with no abnormalities (Newman Chiropractic Offices, 2008).

2.2.1 Posture and the effects of backpack carriage

Discreet standing is termed a "static" stance, whereby a person remains in a stationary position (Goh *et al.,* 1998; Hong and Cheung, 2003 and Talbot *et al*., 2005). The external forces, acting on one's body, include constituents such as inertia, gravity and ground reaction forces whilst the internal forces, are formulated from muscle contraction and/or passive tension in tendons, ligaments, joints and further connective tissue structures (Goh *et al.,* 1998; Hong and Cheung, 2003 and Talbot *et al*., 2005). The internal and external forces which are present are controlled by the body to preclude movement and maintain posture (Niemi *et al.,* 1996; Goh *et al.,* 1998; Mikkelsson *et al*., 1998; Steele *et al*., 2001; Widhe, 2001; Hong and Cheung, 2003; Mackenzie *et al*., 2003; Sheir-Neiss *et al*., 2003 and Talbot *et al*., 2005). To remain in a stationary position with or without a backpack being carried, the internal and external forces must be in symmetry, which means that all of the forces acting on one's body must be equal to zero (Goh *et al.,* 1998; Hong and Cheung, 2003 and Talbot *et al*., 2005). Levangie and Norkin (2011) indicated that the least amount of energy expended by the body, is when a person is standing with the hip joint in a neutral position, the pelvis in a neutral position, the knee joint in full extension and the ankle in a neutral position.

The main populace carrying backpacks are adolescents and therefore it is important to understand how carrying a backpack affects posture in this age group (Talbot *et al*., 2005). The backpack load during this stage of development, could influence the overall postural formation, as the spine has not yet fully developed (Talbot *et al*., 2005). The physiological curves of the spinal column are moulded during early childhood (Keen, 1993). Initially, the spinal column is in an uninterrupted s or c-shaped curve that is convex posteriorly, starting from the occiput to the sacrum, and alters as the usual motor development continues (Keen, 1993). As the new born begins to raise his/her head in the third post-natal month, the occiput begins to rotate posteriorly and the cervical vertebrae forms an arc that is convex anteriorly (Keen, 1993). As an upright posture is assumed at approximately 6 to 8 months, the lumbar curve develops in a similar direction to the cervical curve. Active and passive forces from bones, ligaments and muscles pull on the developing curves to either increase or decrease each curve. In addition, gravity provides a constant force, functioning to increase both curves thereby resulting in a cervical lordosis, thoracic kyphosis and lumbar lordosis (Keen, 1993 and Talbot *et al*., 2005).

The pre-pubertal and puberty phases are periods of life when posture undergoes many adjustments and adaptations due to alterations in the body (Grimmer *et al*., 1999 and Perret *et al.,* 2001). Junghanns (1990) noted that adolescents' spinal structures are different from those of adults. The growth of their spinal column takes longer than the growth of any other musculoskeletal tissues, thereby resulting in an inconsistent rate of soft tissue development (Junghanns, 1990). In addition, Parfitt (1994) explained that adolescents experience periods of growth and physiological development, especially during the ages of 11 to 14 years, and it has been noted that their spinal columns are at a critical stage of development (Grimmer *et al*., 1999; Hong and Cheung, 2003; Dochrell *et al*., 2006 and Daneshmandi *et al*., 2008). The growth of the appendicular skeleton (the skeleton of the lower limbs) ceases between 16 to 18 years of age for male and female teenagers (Lanes *et al*., 1995), however secondary ossifications of the vertebrae are not complete until the mid-twenties (Lanes *et al*., 1995). Therefore, it is important to detect postural deviations between the ages of 7 and 14 years, as poor posture can be simply corrected at this stage of development (Lanes *et al*., 1995). If not corrected, the changes in posture due to an increased load, could have detrimental consequences on the growth, development and maintenance of human body alignment, which could negatively affect them in their adolescent lives and predispose them to postural changes in their adult lives (Troussier, 1994; Pascoe *et al.,* 1997; Leboeuf-Yde and Kyvik, 1998; Grimmer *et al*., 1999; Viry *et al*., 1999; Steele *et al*., 2001; Negrini and Carabalona, 2002; Cavallo *et al.,* 2003; Mackenzie *et al*., 2003; Sheir-Neiss *et al*., 2003; Talbott *et al*., 2005; Mayank *et al*., 2007; de Carvalho and Rodacki, 2008; Bauer and

Freivalds, 2009; Abrahams *et al*., 2011 and Golriz and Walker, 2012). However, in contrast to these researchers, Ko and Kim (2013), noted that there have been no demonstrated effects of carrying a backpack on an adolescent's normal growth.

2.2.2 Backpack safety with respect to posture

The study conducted by Forjuoh *et al.,* (2003) on the parental awareness of school backpack weights and contents revealed that a majority of parents have never inspected their child's backpack. According to Forjuoh *et al*., (2003), parents did not give any consideration towards the backpack design, or even the manner in which the child lifted, carried or wore their backpack. In addition to these findings, Forjuoh *et al.,* (2003) illustrated the importance of a backpack prevention programme to enhance backpack safety in schools. Some of these programmes are listed within recognized websites and associations that give proper guidelines regarding backpack safety (The International Chiropractic Paediatric Association, 2008; Kids Health, 2014 and The American Occupational Therapy Association, 2014). The American Occupational Therapy Association (2014) have created a national school backpack awareness day and the Congress of Chiropractic State Associations (COCSA) have designated a backpack safety month, to encourage scholars to use a backpack safely by educating them on both, the proper techniques of backpack usage, as well as the risks associated with carrying too much weight. In conclusion, Forjuoh *et al.,* (2003) recommended that schools should provide the scholars with educational pamphlets on how to care for their back. In addition to this study, there are many other researchers that have provided safety guidelines for backpack usage and backpack choice, in their research studies (Mackie *et al*., 2003; Al-Hazzaa, 2006; khalil AL-Qato, 2012; Sharan *et al*., 2012; Pahwa, 2013 and Arghavani *et al*., 2014). These researchers noted that these guidelines would be beneficial to a varied population of scholars whom carry backpacks. The guidelines suggested that scholars should choose a backpack, which consisted of two wide shoulder straps and a waist belt, the scholar should wear both straps, and the scholar should pack the heaviest items close to the back. These guidelines would help prevent excess pressure being placed on the shoulders and would keep the weight in the backpack evenly distributed to maintain a neutral posture (Mackie *et al*., 2003; Al-Hazzaa, 2006; khalil AL-Qato, 2012; Sharan *et al*., 2012; Pahwa, 2013 and Arghavani *et al*., 2014).

Hundekari *et al*., (2013) indicated that many adults are diagnosed with a varied number of spinal disorders, and therefore, the researchers have explored the lifestyle behaviours of

adolescents to investigate if there is any link to the possible causes of these disorders. However, there is limited understanding towards adolescent postural reactions to backpack loads and positions, and the amount of time that they carry their backpack (Voll and Klimt, 1977; Grimmer *et al*., 1999; Brackley and Stevenson, 2004 and Mayank *et al*., 2007). Postural modifications have been carefully investigated by a variety of researchers with regards to the issue concerning backpack carriage (Pascoe *et al*., 1997; Feingold and Jacobs, 2002; Grimmer *et al.,* 2002; Hong and Cheung, 2003; Chow *et al*, 2006; Devroey *et al*., 2007; Negrini and Negrini, 2007; Mackie and Legg, 2008; Brackley *et al*., 2009; Singh and Koh, 2009; Sharan *et al*., 2012; Kistner *et al.,* 2013 and Mo *et al*., 2013). Grimmer *et al*., (1999); Pascoe *et al.,* (1997); Negrini *et al*., (1998) and Negrini *et al*., (1999), studied the effects of backpack carriage and their results suggested that the weight being carried and postural differences due to backpack carriage are significant, and could cause postural problems in scholars. However, no long term studies have been conducted on the lasting effects on posture into adulthood, due to backpack usage.

Various researchers highlight that a backpack should be carried with its weight centred between the 2nd and 5th lumbar vertebra (L2 to L5), as this leads to the least amount of postural deviation and postural sway (Grimmer *et al.,* 2002; Brackley *et al.,* 2009 and Chow *et al*., 2010). Researchers have noted that carrying a backpack at different spinal positions affected the spinal muscles and consequently affected posture in both adolescents and adults (Grimmer *et al*., 2002; Fiolkowski *et al*., 2006; Devroey *et al*., 2007 and Chow *et al*., 2010). At present, there is no agreement on correct backpack positioning, this is predominantly due to the inconsistency of the definition of backpack positioning in previous literature (Grimmer *et al*., 2002; Fiolkowski *et al*., 2006; Devroey *et al*., 2007 and Abdullah *et al.,* 2012).

Studies have found that people who carry backpacks on their backs incorrectly, may have problems with their gait, which in turn may create spinal postural changes (Cottalorda *et al*., 2004). However, there has been no evidence to suggest that the use of a backpack may cause structural spinal deformities (Cottalorda *et al*., 2004). In addition, Negrini and Negrini (2007) studied the effect of unilateral (one shoulder strap used: asymmetrical) and bilateral (both shoulder straps used: symmetrical) backpack carrying on the posture of forty three adolescent scholars. They found that scholars who carried their backpacks unilaterally, demonstrated a greater postural change and reported becoming more fatigued than other scholars, who carried their backpacks bilaterally. However, this study did not recommend how best to carry a backpack. Hickey (1999) and Zimbler (2000) noted that when using both straps, the backpack weight is evenly distributed as posture is supported by the abdominal

and back muscles. When comparing unilateral versus bilateral backpack carriage, Palumbo *et al*., (2001) conducted a study on adults and pointed out that the effects of wearing a backpack over one or both shoulders resulted in a postural deviation. Furthermore, Pascoe *et al.,* (1997) reported an increase in lateral trunk flexion and shoulder depression contra-laterally, as well as trunk rotation and shoulder elevation ipsi-laterally, when using a one shoulder strap backpack. They also concluded that bilateral shoulder carrying caused an increase in the forward trunk lean and forward head posture. Studies performed by Knapik *et al*., (1996) and Voll and Klimt (1977), also assessed backpacks in which both researchers found that when wearing a backpack bilaterally, a minor postural change was seen and therefore this could have implied that the backpack weights were appropriate enough for the scholar to be able to maintain posture. In addition, Korovessis *et al.,* (2005) performed a longitudinal quantitative postural analysis in scholars, aged between 12 to 18 years, and they showed that one strap backpack carrying caused alterations in upper trunk, shoulder and cervical lordosis, and therefore recommended that scholars use both shoulder straps when carrying their backpack. In comparison to these studies, Schmidt and Docherty (2010) conducted a study in which the researchers compared the posture of thirty four scholars, aged between 6 and 8 years. They looked at the effect of carrying backpacks versus pulling them on trolleys and revealed that pulling a trolley was more of a risk to the scholar's posture than carrying a backpack. They concluded that it was better to pay attention to a suitable weight of a backpack and the respective carrying guidelines rather than using a trolley. Therefore, researchers have pointed out that to enhance postural symmetry, scholars wearing a double strap backpack, must be educated on how to adjust the shoulder straps so that they are distributing the weight of their backpacks evenly (Cook and Neuman, 1987; Legg *et al*., 1992; Waters *et al.,* 1993; LaBar, 1997; Pascoe *et al.,* 1997; Goh *et al.,* 1998; Grimmer *et al*., 1999; Lamar and Yu, 2000; Goodgold *et al.,* 2002 and Goodgold *et al*., 2002). In contrast to this, the study by Golriz and Walker (2012) pointed out that, there are "no backpacks that can minimize the negative effects on the body's posture".

2.3 AN OVERVIEW ON BACKPACK STUDIES

A “backpack” in layman’s terms, is defined as a bag having one or two shoulder straps, allowing it to be carried on the back (Pascoe *et al.,* 1997; Grimmer *et al*., 1999 and Steele *et al*., 2001). Most of the preceding literature have stated that they have used a ‘backpack’ in their studies (Fiolkowski *et al*., 2006; Kim *et al*., 2008 and Arghavani *et al*., 2014), but however, failed to give a description of the type of ‘backpack’ used, as shown in **Table 2.1** below. A wide range of studies have been conducted by various researchers worldwide (Australia, Iran, New Zealand, South Africa and the United States of America), as discussed below. Each of the studies have used different backpack designs and types, methodologies, and sample populations. Therefore, making it difficult to compare and contrast these studies to one another. A brief summary of the various backpacks which have been utilised in previous research studies is presented by the author in **Table 2.1** and discussed below.

Arghavani *et al*., (2014) conducted a descriptive, analytical cross sectional study in the Shiraz district of Iran. The objective was to, categorize the risks associated with musculoskeletal conditions, by assessing the rate of musculoskeletal pain amongst eight hundred 12 to 15 year old scholars. The large sample size was due to the researcher having incorporated more than one school in the study. The researchers recruited the scholars of this age group as the scholars were known to be school bag carriers, they had the ability of understanding the questionnaires and were undergoing developmental changes in body structure. The findings of the study revealed that scholars used ‘backpacks’ (62.6%), ‘handbags’ (16%) and ‘shoulder bags’ (21.3%), as shown in **Table 2.1** below. These findings are in contrast to the study performed by Puckree *et al*., (2004), in which the researchers revealed that 69% of the scholars used backpacks and Chow *et al*., (2007) revealed that 83% of the scholars used backpacks. The researchers suggested that, scholars should not carry their ‘backpacks’, ‘handbag’ or ‘shoulder bag’, for more than 20 minutes a day, as this could increase the risk of musculoskeletal pain. They also recommended that when carrying a ‘backpack’ use both shoulder straps and alternate between either shoulders when carrying a ‘shoulder bag’ or ‘handbag’.

Ramadan and Al-Shayea (2013) conducted a study, in which male scholars, aged between 6 to 22 years, participated from six schools. A total of two hundred and thirty eight scholars were selected by stratified random sampling to be assessed in the four selected age groups ['(6 ≤age ≤9); (10 ≤age ≤13); (14≤ age≤ 17) and (age≥ 18)']. Twenty male scholars from each grade (1st to 12th) were randomly selected by the researcher. The researcher was unable to recruit female scholars, due to the lack of female volunteers. The study used two different types of backpacks ('commercial' and 'modified'), as described in **Table 2.1** below. The 'modified' backpack was designed in order to decrease the impact of weight by distributing it over the scholar's chest and back. The weights were evenly distributed within the 'modified' backpack. Sandbags, instead of normal school books, were used as weights in the backpack. This method of using sandbags was also utilised in the study by Marsh *et al*., (2006). Both the 'commercial' and 'modified' backpacks were packed with six different weights (0%, 5%, 10%, 15%, 20% and 25%, respectively), the scholars walked around the test area for 5 minutes whilst different assessments occurred (muscle activity, heart rate, and muscle tension). These assessments were measured by using electromyography (EMG), electrocardiogram (EKG) and a modified Borg-CR10 scale. In conclusion, the researchers noted that, the 'modified' backpack was chosen by the scholars to be more comfortable than the 'commercial' backpack. The study revealed that the 'modified' backpack decreased muscle tension, cardiac muscle stress and exertion, and therefore was noted as performing better than the 'commercial' backpack. The researchers also noted that, the 'modified' backpack prevented the scholar from carrying their weight unilaterally, therefore resulting in an even weight distribution.

Abrahams *et al*., (2011) conducted a controlled, descriptive, epidemiological retrospective study in KwaZulu-Natal, South Africa. This study was termed 'retrospective', as the researchers recorded the frequency of 'schoolbag carriage musculoskeletal pain' over the last 12 months, therefore making this a longitudinal study. The researchers recruited six primary schools within the eThekwini district of KwaZulu-Natal, however, only four of those schools allowed for research conduction to occur. This recruitment method was similar to the study by Puckree *et al*., (2004) in which the researchers recruited four primary schools within the eThekwini district of KwaZulu-Natal. The sample population of this study comprised of one hundred and eighty seven, grade 7 scholars. Both male (44.92%) and female (55.08%) scholars, aged between 12 to 13 years, participated in this study. The objective of the study, was to determine the prevalence of 'schoolbag carriage musculoskeletal pain', after the distribution of findings by Puckree *et al*., (2004). Two questionnaires were used in the study ('parental guidance self-reported questionnaire' and 'musculoskeletal pain questionnaire'), the first questionnaire was adapted from the study of

Puckree *et al*., (2004). A schoolbag was used during the duration of this study, however, no description of what a 'schoolbag' was, was provided by the researcher, this was similar to Puckree *et al*., (2004) who also used a 'schoolbag' with no description, as shown in **Table 2.1** below. The schoolbag weighed a mean mass of 5.89 (±2.18) kg. The scholars underwent a postural analysis in order to assess any postural deviations during standing with no school bag so to record any deviations when using a schoolbag. The researchers revealed that, scholars whom carried their schoolbags as backpacks, sustained musculoskeletal pain. In conclusion, the researchers noted that, scholars living in the eThekwini district of KwaZulu-Natal, experienced 'schoolbag carriage musculoskeletal pain'. This finding is comparable to Puckree *et al*., (2004) in which they concluded that, the type of backpack used was correlated to the pain experienced.

Chow *et al*., (2011) conducted a study whereby the researchers recruited a sample of fourteen adults (5 male and 8 female) aged between 25 and 35 years. A 'conventional double strap' backpack was used during the duration of the study, Orloff and Rapp (2004) used a similar backpack in their study, as shown in **Table 2.1** below. The weight of the backpack was set at 10% body weight, this was also suggested to be the weight limit for backpacks in previous research (Al-Hazzaa, 2006; Connoly *et al*., 2008; Bauer and Freivalds, 2009 and Singh and Koh, 2009). Postural assessments occurred by means of a 'self-developed electrogoniometric system'. The first assessment occurred without a backpack and then with a backpack (10% body weight). After the postural assessment, the adults walked on a treadmill for 30 minutes, at a speed of 1.1m/s. This walking speed was utilised in the study by de Carvalho and Rodacki (2008), however the scholars walked for only 15 minutes with a backpack, as opposed to 30 minutes. The backpack was removed, after 30 minutes of walking. The postural assessment was conducted by the researcher before and after the removal of the backpack. The spinal posture and repositioning ability was assessed at different intervals by the researcher. During backpack carriage, the researchers noted a reduction in lumbar lordosis and pelvic tilt. They also noticed an increase in cervical lordosis, thoracic kyphosis and forward lean. These findings are comparable to those revealed by Chow *et al*., (2007) and Chow *et al*., (2010), these researchers found similar postural changes in their studies. In conclusion, Chow *et al*., (2011) noted constant changes in spinal curvature and poor repositioning ability, which had a greater risk on the spine even after the backpack was removed.

Bauer and Freivalds (2009) conducted a study in Pennsylvania, USA, on twenty scholars aged between 11 and 14 years. The sample size was very small, compared to the study by Puckree *et al*., (2004), who also recruited 11 to 14 year old scholars. The researcher used two specially designed backpacks in the study, as described in **Table 2.1** below.

Electromyography (EMG) was used to assess muscle activity (trapezius, lattissimus dorsi and erector spinae), the 'Borg-CR10' and 'Borg ratings of perceived exertion scale' (BORG-RPE) assessed the rate of exertion and pain of the scholar. The backpacks were packed with school books so that the total backpack weight equalled the percentage body weight which was then tested (i.e. 10%, 15% and 20%, respectively). The scholar underwent two tests, the first test required the scholar to stand in a stationary position for 3 minutes whilst carrying backpack weights of 10%, 15% and 20%, respectively. The second test required the scholar to walk on a treadmill with the same backpack weights (i.e. 10%, 15% and 20%, respectively) for 3 minutes, at a speed of 2.41 km/h. It was not clear in exactly how the backpack was carried in each test. The research did incorporate an experimental and two control groups, the control scholars for both the experimental tests did not carry a backpack. In both tests, for every 1 minute, the scholar gave a BORG-RPE rating, which was recorded with their heart rate. Trunk flexion in the lateral view, was analysed by digital photography methods. At the end of each test, the amount of pain the scholar experienced, was rated using the Borg-CR10 scale of perceived pain. The researchers concluded that, according to the Borg-CR10 rating and trunk flexion angle, a backpack should have a 10% body weight limit. This 10% body weight limit was also recommended in preceding literature (Troussier *et al*., 1994 and Iyer, 2000; Al-Hazzaa, 2006; Connoly *et al*., 2008 and Singh and Koh, 2009). The researcher suggested that, it was important that parents and teachers become more aware of the scholars backpack weight.

de Carvalho and Rodacki (2008) conducted a study, in which the researchers recruited a sample of ten male scholars, with a mean age of 13.9 (±0.6) years. The study aimed to investigate the effects of backpack carriage over the spine. The scholars visited the doctor twice prior to data collection. On the first visit, the scholar walked on a treadmill, in order to acquaint themselves with the 10 minute walking period. A comfortable walking speed (1.1m/s) was determined by the scholar. On the second visit, the scholar walked on the treadmill for 15 minutes carrying a specially designed backpack, as described in **Table 2.1** below, with a weight that corresponded '0.10%' and '20%' body weight. It was noted by the researcher that, the specially designed backpack was similar to the scholar's schoolbag, and therefore no pain or discomfort was reported by the scholars. The central aspect of the backpack was estimated by the researcher to rest at the eighth thoracic vertebra (T8). The results of the study showed differences between the two loads ('0.10%' and '20%' body weight) respectively. According to the study by Korovessis *et al*., (2005), there is no evidence between carrying a backpack and a change in thoracic kyphosis and lumbar lordosis. Upon conclusion of the study, the researchers noted that, a backpack weighted on '20%' body weight resulted in changes in spinal kinematics in all planes of motion. In the

study by Hong and Cheung (2003), they determined that, the distance carried and walking speed could also be the factors that affected spinal movement.

Kim *et al*., (2008) conducted a study using a sample of fifteen scholars (10 boys and 5 girls) aged between 9 to 11 years. The study experimented with three backpacks, as described in **Table 2.1** below, to test the effects on head posture and neck electromyography (EMG). The weight of the backpack was set at 15% body weight, since the researchers noted that in previous research studies, backpack weight varied between 10% and 20% body weight, respectively (Pascoe *et al*., 1997; Grimmer and Williams, 2000; Whittfield *et al*., 2001; Sheirr-Neiss *et al*., 2003; Limon *et al*., 2004 and Puckree *et al*., 2004). The researchers placed the centre of the backpack between the 11th (T11) and 12th thoracic (T12) vertebra. This level of backpack placement is in contrast to the study by Grimmer *et al*., (2002), in which they suggested that, the backpack should be positioned at hip level. This study determined the effects of different backpack designs, neck muscle activity, and neck posture whilst carrying a backpack. Four trials occurred, in which the scholar walked on a treadmill with; 'no backpack, a backpack, double pack and a modified double pack', weighing 5% and 10% body weight, respectively. The scholars walked at a speed of 0.8 m/s on the treadmill for 5 minutes, the researcher noted that this was a comfortable walking speed for the scholar. During this period, the scholars gait parameters were assessed (EMG and kinematic data). The results showed that, EMG activity of the upper back and neck muscles, forward head angle and forward head distance were greater when using a backpack as compared to the other 3 trials (i.e. no backpack, double pack and modified double pack). The researchers concluded that, when carrying a double pack compared to no backpack or a modified double pack, an extended head posture, decreased forward head distance, increased sternocleidomastoid (SCM) EMG activity and decreased mid-cervical paraspinals EMG activity was revealed. These findings were in comparison to the study by Motmans *et al*., (2006) in which they revealed that, trunk posture moved backwards whilst carrying a backpack. Fiolkowski *et al*., (2006) noted that carrying a front pack resulted in, head extension relative to the control condition (i.e. no backpack). Therefore, the results of this study for the double pack are similar to the results revealed in the front pack studies. The researcher suggested that, the modified backpack had the ability to minimise postural deviation, by redistributing the weight that was carried.

Fiolkowski *et al*., (2006) conducted a study with thirteen adults (5 male and 8 female). A 'front pack' and backpack, were utilised in the study, as shown in **Table 2.1** below. Data was assessed under two loads, the 'light load' and the 'heavy load'. The 'light load' was set at 10% body weight and the 'heavy load' was set at 15% body weight, by the researcher. The researcher assessed the adults gait kinematics by means of a 'Mac reflex' video

system. The data were collected whilst they walked on a treadmill, at a speed of 0.75 strides per second, during 5 conditions: 'light backpack', 'heavy backpack', 'control', 'light front pack and 'heavy front pack.' The researchers noted a change in hip flexion angle whilst the backpack was worn, this demonstrated an increased flexion in each stride. The study showed that when wearing a front pack, an upright posture was revealed, in comparison to wearing a backpack. The researchers suggested that, wearing a front pack was better in maintaining posture than a backpack.

Marsh *et al*., (2006) conducted a double blinded trial study, in which they recruited twenty scholars (11 boys and 9 girls) aged between 13 to 16 years. The study examined whether a backpack, with the use of an abdominal support device ('back balancer'), had the ability to improve posture and reduce exertion whilst walking on a treadmill. The 'Kelty Redwing' backpack, as shown in **Table 2.1** below, was chosen to be used for the duration of the study. The backpack could be worn either with or without the abdominal support. The researchers chose the backpack after observing the scholars everyday backpack. This method of backpack selection was similar to the study by Smith *et al*., (2006) as they also made use of the 'Kelty' backpack in their study, as shown in **Table 2.1** below. In this study, posture was assessed by digital photography in the sagittal plane, and the ratings of perceived exertion were measured using a BORG rating scale (BORG-RPE). The data collection occurred over a two day period, on the first day the scholar's height, weight, blood pressure, BORG-RPE scale and Visual Analogue Scale (VAS) were assessed. The scholars walked on the treadmill for 5 minutes, at a speed of 4.82 km/h without a backpack, and the BORG-RPE measurement was assessed at 4 minutes. At 5 minutes, digital photography, blood pressure and VAS were assessed. The 'Kelty Redwing' backpack was worn by the scholars on day two, four assessments were conducted with and without the 'back balancer' with a weight of 10% and 20% body weight, loaded in the backpack (sandbags used instead of school books), respectively. The postural measures were conducted by a blinded observer. In conclusion, the results of the study revealed that, postural changes (forward posture) were decreased when using the backpack with the abdominal support device, whilst carrying both 10% and 20% body weight versus using no abdominal device.

Smith *et al*., (2006) conducted an investigation, to determine what effect various methods of backpack usage, would have on the pelvic motions of thirty female scholars aged between 18 and 30 years. This large age range allowed the research to be applicable to most university aged females. The study only recruited female scholars, as the researcher noted that in previous literature, the studies that incorporated both genders failed to make their results gender specific (Martin and Nelson, 1986; Bloom and Woodhull-McNeal, 1987

and Cook and Neuman, 1987). The 'Kelty' backpack was used in this study, as shown in **Table 2.1** below, and was also used in the study by Marsh *et al*., (2006). The backpack was packed with a 3.4 kg cement block, as according to the researchers, was used to mimic a text book. The study consisted of a two part approach, during the first approach one hundred scholars completed a questionnaire on backpack usage and perceived pain. During the second approach thirty scholars from the one hundred, underwent the walking phase. It was hypothesized by the researchers that, walking with a heavy backpack, would alter the pelvic movements as compared to walking with no backpack. The scholar's pelvic rotation, angular pelvic tilt, pelvic obliquity and range of motion were assessed, during the three walking conditions (i.e. no backpack, carrying a backpack unilaterally, and carrying a backpack bilaterally). The backpacks contained materials that comprised 15% body weight, this weight was small in comparison to previous studies that utilised between 17% and 60% body weight (Bloom and Woodhull-McNeal, 1987; Kirk and Schneider, 1992 and Charteris, 1998). The scholars walked on a treadmill at their own speed for all the conditions. This method of selection of treadmill speed, is in contrast to previous studies (Cook and Neumann, 1987; Kirk and Schneider, 1992; Legg *et al.*, 1997 and Charteris, 1998) which allowed the scholars to walk on a treadmill until a speed was selected by the researcher, however the study by Mackie *et al*., (2003) allowed for self-selection of treadmill speed by the scholar. The researchers noted that, during bilateral backpack carriage, an increase in angular pelvic tilt was noted. The researchers noted that pelvic rotation, obliquity and range of motion, decreased when wearing a backpack both bilaterally and unilaterally, as compared to wearing no backpack. These findings were in contrast to previous studies, which noted an increase in angular pelvic tilt when scholars used their backpacks unilaterally or bilaterally (Bloom and Woodhull-McNeal, 1987 and Pascoe *et al*., 1997). Upon conclusion of the study, Smith *et al*., (2006) noted that a load of 15% body weight could alter pelvic biomechanics in females, and therefore suggested that long term studies are required in order to analyse the effects resulting from these altered pelvic biomechanics.

Orloff and Rapp (2004) conducted a repeated measures design, in which twenty five females were recruited as control subjects. The researcher used female subjects based on previous literature on the known differences between males and females in strength and physical build (Bhambhani *et al*., 1997 and Pandorf *et al*., 2001). A specially designed backpack, termed the 'Data recorder backpack' was used for the duration of the study, as described in **Table 2.1** below. The backpack measured spinal curvature, using displacement measures via variable resistances connected to 15 spring loaded displacement rods. The study determined whether spinal curvature and posture was affected by minor fatigue during backpack carriage. The scholars walked at a speed of 1.79

m/s around a 200 metre circuit, whilst carrying the 9 kg Data recorder backpack. The researchers found that, neither head nor spinal flexion changed during the fatigued condition, however spinal curvature did change from the 3rd minute to the 18th minute. This finding is in support of the theory of Potvin and Norman (1993) in which the researchers found that, fatigue can be detected as early as 20 minutes when loaded with a relatively light backpack and would lead to an increase in spinal curvature. The researchers suggested that, more studies are required to be conducted on the measurements of spinal curvature and intervertebral disc pressure, so that more accurate measurements of postural changes could be assessed.

Forjuoh *et al*., (2003) conducted a long term cross sectional study (30 November 2000 to 15 January 2001) in Texas, USA. Three primary schools were recruited, this is in comparison to Grimmer *et al*., (1999 and 2002) that conducted a backpack study in five schools, with a much larger sample population. Two backpacks were used in this research, as shown in **Table 2.1** below. Two objectives were carried out by the researcher, the first was to determine the weight of the backpacks and then calculate the percentage body weight represented by these backpacks. The second was to determine the amount of scholars that used 'wheeled backpacks'. Of the three schools that participated, all the scholars in the first school volunteered (grade 0-6), only scholars in the fourth and fifth grade volunteered at the second school and most of the scholars in the third school volunteered (grade 0-5). Therefore, the study recruited a total of seven hundred and forty five scholars, this number was in comparison to the study by Grimmer *et al*., (2002) which had a population of seven thousand five hundred scholars. The study comprised of a research team (5 to 10 people) that were assigned to each school over a period of one to three days. The parental consent form provided no information on backpack weighting, as it was in the researchers' interest to blind the parents and the scholars of the data collection procedure. This was done to ensure that the scholars did not leave their heavy books at home. The researchers formulated two hypotheses, the first being that the bulk of the backpacks were heavier than 10% body weight and the second was that 'wheeled backpacks' are used by no more than 10% of the scholars. Therefore, during data collection, if the backpack was found to be 10% or more, the scholar underwent further analysis to assess the methods of backpack carriage and the pain associated. The results revealed that, for all scholars the 'wheeled backpacks' had a mean weight of 4.9 kg, which was in comparison to the backpack, which had a mean weight of only 2.5 kg and represented 8.2% body weight. The researchers noted that twenty five (3.5%) scholars used 'wheeled backpacks', because they were concerned that the weight of the backpacks would increase each year, therefore making it difficult for them to carry. However, in the study it was shown that the mean weight

of the backpack was lower (2.5 kg) than the 'wheeled backpacks' (4.9 kg), therefore the researchers concluded that the 'wheeled backpacks' were hazardous to the scholar's body. The researchers also noted concern over backpack usage, as it was revealed that, the scholars were using the 'wheeled backpacks' as normal backpacks, carrying them on both shoulders. This incorrect method of carriage would place extra strain on the scholar's shoulders. These findings are similar to the more recent study by Schmidt and Docherty (2010) in which they revealed that, pulling a trolley was more of a risk to the scholars posture than carrying a backpack, therefore concluding that, attention should be paid to the weight of the backpack and carrying guidelines rather than pulling a trolley.

Mackie *et al*., (2003) conducted a study in Auckland, New Zealand, in which 12 scholars (6 male and 6 females) with a mean age of 12.6 years were recruited. The study compared four different types of backpacks (Backpack A, B, C and D), as described in **Table 2.1** below. Of the four backpacks, three were made precisely to be used in schools, based on ergonomic principles. The fourth backpack was selected by the manufacturer, the manufacturer selected the fourth backpack after questioning a group of twenty eight scholars on school backpack preference. The chosen backpack (Backpack D) was used in the study alongside the other backpacks (Backpack A, B and C). The scholars assessed each of the backpacks by means of a questionnaire study, inquiring about the practicality of the four backpacks. Once the scholars chose a backpack, they wore it for at least 2 minutes and was able to adjust the backpack weight for themselves (mean=3.7 kg). They then walked on a treadmill for 20 minutes at a 'self-determined' speed (mean=2.9 km/h) whilst wearing the backpack. The self-selection of weight and speed provided the scholars with the ability to focus on backpack design, rather than backpack load whilst walking. The results indicated that, Backpack D was the preferred choice by the scholar, as they found it better than the other three backpacks (Backpack A, B and C) with regards to functionality and fit. The researchers suggested that backpack manufacturers should spend more time on backpack research and ergonomics in order to ensure scholar satisfaction.

Grimmer *et al*., (2002) conducted a longitudinal randomised controlled experimental study in South Australia. Previous studies were conducted by Grimmer *et al*., (1999) and Steele *et al*., (2001) in Australia, on adolescent educational load carriage behaviours, pain and posture. Five high schools participated in this study, the researchers recruited a total of seven thousand five hundred scholars. The researcher required five male and five female scholars from each year, in each school, to participate in the study. This large sample was based on the researcher's previous reviews into backpack loads and head on neck posture, therefore the sample was a valid study protocol derived from preceding studies (Grimmer *et al*., 1999; Grimmer and Williams, 2000 and Steele *et al*., 2001). The aim of the study was

to assess the effects of backpack weight and position by using a 'typical' school backpack, as described in **Table 2.1** below. The scholars were not blinded during the study, however, they were blinded to the hypothesized outcomes. Nine investigational conditions were conducted: combinations of backpack loads (3%, 5% or 10% body weight), and backpack positions centred at the 7th to the 12th thoracic vertebra (T7 to T12) or 3rd lumbar vertebra (L3). Digital photographs were taken of the scholars in the sagittal view under the nine investigational conditions. The evidence did not support the notion of carrying backpacks high on the spine nor the 10% body weight limit. In conclusion, the researcher recommended that school backpacks should be positioned with the middle of the backpack at hip level, this suggestion was in accordance to Grimmer *et al*., (1999) in which they suggested that the backpack should be worn over the lower back for the maintenance of body position. Grimmer *et al*., (2002) however, did suggest that scholars should actively reduce their backpack weights, in spite of the fact that this study did not support the 10% body weight limit.

Legg *et al*., (1997) conducted a study in Auckland, New Zealand, in which they recruited ten male adults with a mean age of 22.5 (±6.3) years. The study used two 'high performance leisure backpacks' which were titled 'Pack A' and 'Pack B' by the researchers, as described in **Table 2.1** below. Both backpacks were weighted at the same value of 20 kg. The study, however did not use school books to pack the backpacks, the backpacks were packed with 20 kg of potatoes, therefore making this methodology difficult to compare with previous studies. Each scholar walked for 30 minutes on a treadmill, at a speed of 3 km/h, whilst carrying each backpack. The scholars 'perceived regional discomfort' was assessed after 30 minutes for each of the twenty four body regions by means of a regional body diagram and category ratio scale (CRS) rating system. The scholar filled out a questionnaire before and after treadmill walking with each backpack. The researchers were unable to differentiate between 'Pack A' and 'Pack B' due to either the fact that, the backpacks were similar in design, or that the study used the CRS rating system to distinguish between the backpacks. The results of the questionnaires indicated that, the scholars found 'Pack A' better than 'Pack B', in terms of maintaining posture and balance and decreasing muscular strain. In conclusion, the researchers noted that, seven scholars preferred 'Pack A' and only three scholars preferred 'Pack B'. The researchers suggested that using a questionnaire study, to distinguish between backpacks of similar weight and design, is more effective than using a perpetual rating scale.

Table 2.1 Types of backpacks utilised in previous research (formulated by the author)

Author	Sample	Type	Description
Arghavani *et al*., (2014)	Sex 800 scholars Age Range: 12-15	Backpack Hand bag Shoulder bag	No description for all.
Ramadan and Al-Shayea (2013)	Age Range: 6-22 238 scholars	Commercial backpack Modified backpack	No description for commercial backpack Modified backpack: similar design for a life jacket. The backpack is divided into two parts, it contains two small pockets. A natural cork on the back and bilaterally provides support. The modified backpack is designed in four different sizes (S, M, L and XL).
Abrahams *et al.,* (2011)	Age Range: 12-13 187 scholars	School bag	Double strap backpack. Single strap backpack.
Puckree *et al.,* (2004)	Age Range: 11-14 176 scholars	School bag	Double strap backpack. Single strap backpack.
Chow *et al.,* (2011)	Age Range: 25-35 Sex Male: 5 Female: 8	Conventional double strap backpack	Dimensions: '47x29x30cm. Capacity of 35 litre. The conventional double strap backpack incorporated a tunnel design which permitted the channel of sensors attached to the adults' 12th thoracic vertebra'.
Bauer and Freivelds (2009)	Age Range: 11-14 Sex Male: 10 Female: 10	Double pack Modified double pack	Double pack: consisted of a front pack and a backpack. Modified double pack: consisted of two types of packs. The front pack was designed to be half of the backpack size.
de Cavalho and Rodacki (2008)	Age Mean: 13.9 years Sex Male: 10	Specially designed backpack	Pair of lead bars connected at the top. Central aspects of the entire contour were visible. Two small pockets allowed for adjustments of weight.
Kim *et al.,* (2008)	Age Range: 9-11 Sex Male: 10 Female: 5	Backpack Double pack Modified double pack	No description Double pack: consists of a front pack and a backpack. Modified double pack: consists of two types of packs. The front pack was designed to be half the backpack size.
Fiolkowski *et al*., (2006)	Age Mean: 24.6 years(male) 25 years (female) Sex Male: 5 Female: 8	Front pack Backpack	No description for both.

Marsh *et al.,* (2006)	Age Range: 13-16 Sex Male: 11 Female: 9	"Kelty Redwing' backpack	No description.
Smith *et al.,* (2006)	Age Range: 18-30 Sex Female: 30	'Kelty' backpack	No description.
Orloff and Rapp (2004)	Age Mean: 21 years Sex Female: 25	Data-recorder backpack	Consisted of 15 protruding spring loaded metal rods which are attached to a resistor that acted as a voltage divider.
Forjuoh *et al.,* (2003)	Age; Range: 12-15 745 scholars	Backpack Wheeled backpack	No description for both.
Mackie *et al.,* (2003)	Age Mean:12.6 years Sex Male: 6 Female: 6	Four specially designed backpacks	Backpack A: Australian deigned two main compartments, backpack padding system and compression straps Backpack B: British deigned. Expandable side pockets, internal waterproof bag. Backpack C: Australian designed. Unique rigid design Backpack D: New Zealand design. Not designed for school use. Harness system and waist strap.
Grimmer *et al.,* (2002)	Age Range: 12-15 7500 scholars	Typical backpack	The typical backpack was designed to be made of soft material, it contained no internal framing or internal compartments and no spinal support, and it also had no added chest or waist straps. It had only two padded adjustable shoulder straps, and was designed in one size only.
Legg *et al.,* (1997)	Age Mean: 22.5 years; Sex Male: 10	Two high performance leisure packs Pack A Pack B	Pack A: Manufactured in New Zealand. Consists of a pivoting hip belt, side straps and an 'ultraloc' strap system. Pack B: Manufactured in the United Kingdom. Consisted of diagonal hip belt and a wide shoulder attachments. Packs A and B consisted of wide, padded shoulder, hip, lumbar and waist straps and an internal contour frame.

2.4 DIGITAL IMAGING

In the preceding literature, there have been various methods which were used to assess posture. These are described in **Table 2.2** below. For the purpose of this research, the digital imaging technique (photography) was the preferred method utilised in this research and is discussed further in the methodology section of this research outlined in **Chapter 3**.

Table 2.2 Reported methods described in the literature to evaluate posture (formulated by the author)

Methods	Reference	Description	Mechanism	Benefits	Disadvantages	Units of measurements	Reliability/Validity
Photography	Steele *et al.,* (2001); Grimmer *et al.,* (2002); Talbot (2005); McEvoy and Grimmer (2005) ; Dunk *et al*., (2005); Marsh *et al*., (2006); Lafond *et al.,* (2007); Perry *et al*., (2008); Ferreira *et al*., (2011); Abrahams *et al*., (2011); Kistner *et al*., (2012) and Kistner *et al.,* (2013)	Digital photography is used to determine spinal alignment and posture	The relevant anatomical points were marked off. A digital image was captured. The linear coordinates of each point were determined and used to assess symmetry/angle/slope.	It is easy to execute, economical, non-invasive	The patient position must be consistent to ensure reproducibility. The users require training and this method has deemed to become time consuming	The use of angles measured in degrees and distances measured in mm. If measuring spinal segments, the gradient of the slope with a + or - sign indicating the direction of the slope	Digitisation techniques were consistent on repeated occasions of measurement (Steele, 2001). Interclass correlation coefficients were used to assess reliability.
Plain-film radiographs	Talbot (2005); Claus *et al.,* (2009) and Pausic *et al.,*(2010)	The use of radiographs to envisage the skeletal system.	Emission of x-rays	Accurate	Radiation exposure, costly and time consuming	The use of angles measured in degrees and distances measured in mm.	It is known to be the gold standard for determining spinal defects. Interclass correlation coefficients were used to assess reliability.
Skin surface tracking	Kim *et al*., (2008) and Claus *et al*., (2009)	The Markers/ sensors are stuck to the skin, which overlies the spinous processes.	Tracking device recorded 3D position of sensors in relation to the source.	High reproducibility.	Requires training by the user and is deemed time consuming	Spinal curvature is represented by angles (measured in degrees).	It has been validated against radiography.

2.5 CONCLUSION

The studies testing backpacks have varying methodologies, some have examined the effect of the backpacks on muscle activity, perceived exertion and gait kinematics (Fiolkowski *et al*., 2006; Smith *et al*., 2006; Kim *et al.,* 2008 and Bauer and Freivalds, 2009 and Ramadan and Al-Shayea, 2013), whilst others have examined the effect of backpacks on posture and pain (Jacobson *et al.,* 2003; Korovessis *et al*., 2005 and Abrahams *et al.,* 2011). This makes comparisons between studies difficult. Previous literature also displays various methods of analysing posture **(Table 2.2)**. Researchers have revealed that, in South Africa, the load of a scholar's backpack has increased over the years, due to the increase in heavy school books (Puckree *et al*., 2004 and Abrahams *et al*., 2011). A study by Golriz and Walker (2012) pointed out that, there is "no one backpack that can minimize the negative effects that a backpack may have on a body's posture", although previous researchers have conducted studies whereby scholars found one backpack more favourable over another (Legg *et al*., 1997 and Mackie *et al*., 2003).

The preceding literature suggests a 10% body weight limit (Voll and Klimt, 1977; Troussier *et al*., 1994; Iyer, 2000; Connoly *et al*., 2008; Bauer and Freivalds, 2009 and Singh and Koh, 2009), which this research made use of. The company ('Improved Postural Alignment for You') claimed that the novel backpack has the ability to maintain posture. However, there are no independent studies demonstrating the effect of this novel backpack on a scholar's posture. Therefore, this research investigated if there was a significant postural symmetry difference compared to the scholars' original posture, when two different backpacks (a novel and a school issued backpack) of equal weight was placed on each of the one hundred participating scholars, respectively. The research assessed the difference in postural symmetry of the neck, shoulder and pelvis.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY DESIGN

This was a quantitative descriptive cross sectional experimental design, as it involved taking and comparing postural measurements between groups of scholars, where different variables were involved. It was an off campus research study, which was conducted on the co-educational premises of New Forest High School. Approval for the research was obtained from the Faculty of Health Sciences Research Committee and the Institutional Research Ethics Committee (IREC). Permission to conduct this research at the New Forest High School was obtained from the Department Of Education **(Appendix A1 and A2),** the school principal, deputy principal and chairperson of the school's governing body **(Appendix B1 and B2)**. The consent for participation of the scholar's in this research was obtained from the parents/guardians of the scholar's **(Appendix C1)** and the scholars also had to give consent for themselves **(Appendix C2)**.

(Ethics Certificate Clearance Number: IREC 011/14 [Appendix G])

3.2 SCHOLAR RECRUITMENT

Once the Department of Education gave permission for this research, the principal of New Forest High School was contacted with the view of making an appointment.

On the day of the meeting, the researcher proposed the idea of the research study to the principal and requested permission to undertake it at the school. A permission letter **(Appendix B1)** was presented to the principal for her perusal and signature. A subsequent meeting was then scheduled in which the principal, deputy principal and chairperson of the

school's governing body attended. At this meeting the researcher provided a brief overview of this research and the letter of information and informed consent **(Appendix B2)** circulated to all attendees to read and sign for their final consent. A picture illustrating the scholar and how they would be photographed was highlighted on the reverse of the letter of information and informed consent **(Appendix B2)**. The approval was given by the attendees and a date for this research to begin was agreed upon at the meeting.

The researcher then addressed an assembly of Grade 8 and 9 scholars. The form teachers of the respective classes were present at this assembly meeting. The letters of information and informed consent **(Appendix C1 and C2)** were presented to the teachers to distribute amongst the scholars. A copy of this letter of information and informed consent was also available in isiZulu **(Appendix C1)**, for isiZulu speaking scholars and their parents to have a better grasp of what the research was all about. This was purely an English speaking school, however isiZulu translated letters of information and informed consent were supplied to the scholars. A picture illustrating the way in which the scholar would be asked to stand, so that he/she could be photographed, was highlighted on the reverse of the letter of information and informed consent **(Appendix C1 and C2)**. A date of collection for the completed letter of information and informed consent was also confirmed at the assembly (a week after the presentation). It was stressed to the scholars that the letters of information and informed consent were of utmost importance and as such needed to be returned to their teachers as soon as possible.

3.3 SAMPLING

A convenience sampling strategy was utilized for this study. A sample of 100 paired observations was used in this study. This was decided on the basis of logistical criteria at the time of the study start, since objective estimates of means and standard deviations were not available to base any prior calculations on. However, post hoc calculations were done to see the power, to detect clinically important effect sizes between the groups. It was considered that a moderate effect size of 0.25 and above was considered as clinically important. Using the results of the study (means and standard deviations) n=59 per group was calculated, to detect atleast 0.25 effect size. This current study was more than sufficiently powered to detect moderate to large differences as statistically significant (Esterhuizen, 2014), at a set sample size of 100 scholars.

3.4 SAMPLE CHARACTERISTICS

3.4.1 Inclusion criteria

1. High school scholars between the ages of 12 to 14 years. This was consistent with a study by Grimmer *et al*., (1999) in which he found significant postural change related to backpack usage in this age group.
2. Scholars who were asymptomatic, in terms of any acute or current injury to their neck, pelvis and upper limb.
3. Scholars with a normal, healthy BMI (15-23 kg/m²).
4. Scholars with a normal, healthy weight of between 38-56 kg (mean=47 kg).
5. Scholars with a height limit of 1.4-1.6 m (mean=1.56 m).

3.4.2 Exclusion criteria

1. Scholars who did not return the signed letters of information and informed consent by the date of collection **(Appendix C1/2)**.
2. Scholars who did not meet any one of the required BMI, weight and/or height values.
3. Scholars who had a history of neck or mid back injury/trauma (e.g. whiplash or spinal injury).
4. Scholars who had any clinically detectable abnormalities of the spine (e.g. scoliosis/anterior head carriage).
5. Scholars who had any history of trauma to the extremities (e.g. previously fractured arms or a shoulder injury).

3.5 RESEARCH PROCEDURE

The research procedure occurred over two days (25th and 26th of March 2014) at the New Forest High School. The procedure started at approximately half past seven in the morning (07:30 am) and continued until half past two in the afternoon (14:30 pm).

The researcher and three research assistants arrived at the New Forest High School on the 25th of March 2014. The time frame for each class, depended on the number of scholars who met the inclusion criteria during research conduction. If all 32 scholars from a single class met the inclusion criteria, then approximately three and a half hours was required during the photographic procedure. A target of three or more classes was determined by the researcher for the research days.

The researcher and the three research assistants attended the New Forest High School prior to the main research day, 25th of March, to prepare the venue for research conduction. Three separate research stations were assembled, in which one research assistant was assigned to each station, as illustrated in **Figure 3.1** below.

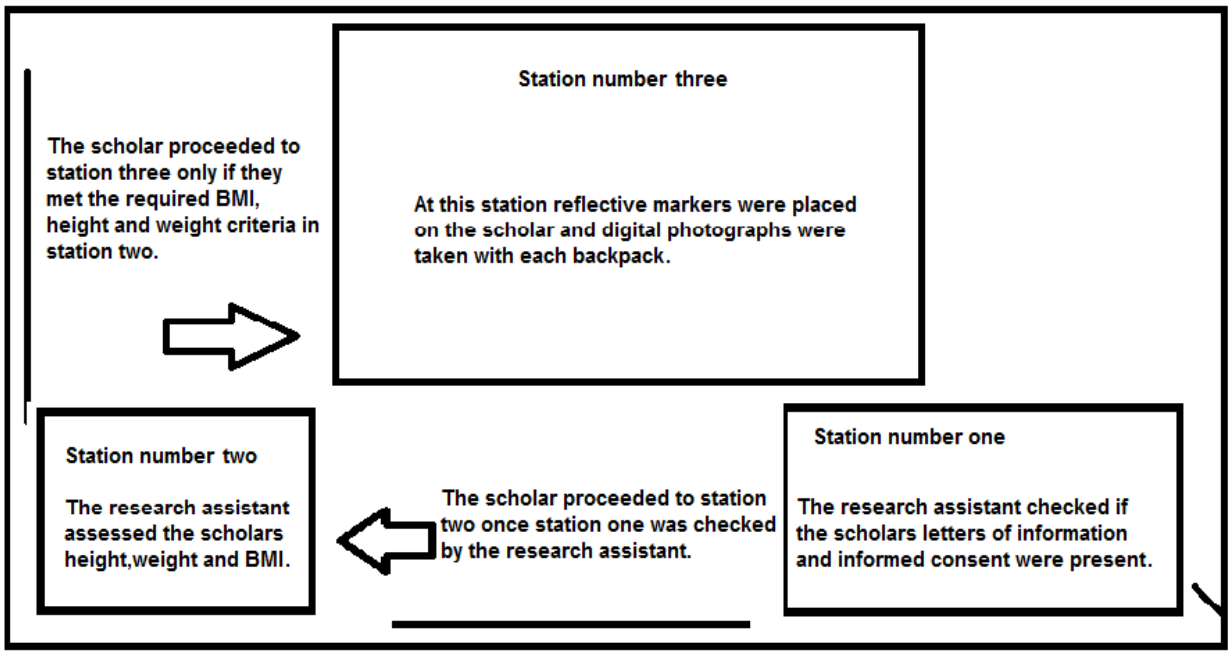

Figure 3.1 Set up of research conduction venue

Day one: (Grade 8 scholars aged between 12 to 13 years). The research assistant at station one called in a single class at a time to the research conduction venue. Once the class completed station two, the next class was called in. Once the required number of scholars was photographed the research conduction day was concluded, and no further scholars were assessed.

Station one: A table was set on which the completed letters of information and informed consent **(Appendix C1 and C2)** for each class were arranged in separate piles according to the class register. The participant sheets **(Figure 3.2)** were also set in a separate pile.

A research assistant was assigned to Station one. The scholar stated his/her name to the research assistant. The research assistant then checked if the scholar's letters of information and informed consent in the assigned pile was completed correctly and if all was in order, and then completed and ticked the relevant boxes on the participant sheet. The participant sheet is illustrated in **Figure 3.2** below.

PARTICIPANT SHEET	
1. Participant no.	1
2. Informed consent obtained	☐
3. Height (1.4-1.6m)	
4. Weight (38-56kg)	
5. BMI(15-23kg/m^2)	
6. Weight and BMI obtained	☐
7. Sex(male/female)	
8. Age	
9. Race group	

Figure 3.2 Participant sheet (formulated by the author)

Station two: The scholar proceeded to station two, only once the letter of information and informed consent at station one had been checked by the research assistant. At station two, the scholar presented the participant sheet to the assigned research assistant, who checked that all necessary details had been completed by the research assistant at station one. The research assistant at station two, then assessed the scholars' height by means of a stadiometer (1.4-1.6 m) and weight was measured by means of a digital scale (38-56 kg). The scholars BMI was then calculated (15-23 kg/m^2) by the research assistant.

All measurements were recorded on the participant sheet by the research assistant **(Figure 3.2)**.

The research assistant at station two decided if the scholar was to be included in this research or not. If the scholar met the BMI, weight and height criteria, then he/she proceeded to station three. If the scholar did not meet the recommend BMI, weight and height criteria, he/she were thanked for their interest and were asked to return to class by the research assistant at station two.

Station three: The main photographic area was assembled by the researcher and research assistant, assigned at station three. The research assistant that was assigned, was the main representative from 'Improved Postural Alignment for You' (IPA4U). Initially, the scholars

were supposed to be dressed in shorts and a sleeve-less top, but as many scholars did not bring shorts and a sleeve-less top to change into for the research conduction, digital photographs had to be conducted in their school uniform. This was then uniformly done throughout. This change was granted by the permission of the Institutional Research Ethics Committee (IREC) **(Appendix H)**.

Individual scholars were photographed one at a time in the Antero-posterior and lateral views for all three groups (i.e. no Backpack, Backpack A and Backpack B). This process ensured that the reflective markers, which were placed on specific anatomical landmarks on each scholar, remained constant for the duration of the digital photographic procedure. All scholars remained in their school uniforms, however, a slight modification was made to the boy's school uniform in that they were asked to roll up their pant legs. This was done so as to expose their knees, so that reflective markers could be stuck on their knee joints. The scholars wore their shoes and socks during the entire research procedure, even so, the researcher was able to palpate the lateral malleolus through their socks. The reflective markers were noted to stick well onto the scholars' socks, shirts and skirts. The female scholars were requested to tie their hair back in a ponytail, so to ensure visibility of the reflective markers, particularly in the lateral view. All reflective markers were visible at all times to the researcher.

The scholars were asked to stand within the marked area on the floor. An adult (teacher/parent) was present at station three, as the researcher and the research assistant were photographing an adolescent (minor). The reflective markers were placed on the scholars' anatomical landmarks (as stated below) by the researcher and verified by the representative of 'IPA4U' at station three. A digital photographic image was then taken using a SONY digital camera (camera type: DSC-H55). The resultant digital photographs were then transferred, by the researcher, to the Posturepro 8 Computer Postural Software System for postural assessment (©*VenturaDesigns* 2012). Postural measurements were calculated by the Posturepro 8 Computer Postural Software System, the Biostatistician then assessed the postural measurements to calculate differences in postural symmetry (Esterhuizen, 2013).

In the anterior view, the researcher placed fifteen reflective markers over the following landmarks: glabella, tragus of ears (bilaterally), sternal notch, acromion (bilaterally), umbilicus, anterior superior iliac crest (ASIS) (bilaterally), the midpoint of patella (bilaterally), the midpoint of the lateral joint line of the knee (bilaterally), midpoint of feet (a mid-aspect of metatarsals of left and right foot) (Posture Pro, 2011). As depicted in **Figure 3.3** below.

Figure 3.3
Scholar in Antero-posterior view

In the lateral view, the researcher placed five reflective markers over the following landmarks: tragus, acromioclavicular notch, greater trochanter, the upper tip of the fibula, anterior inferior aspect of the lateral malleolus (Posture Pro, 2011). As depicted in **Figure 3.4** below.

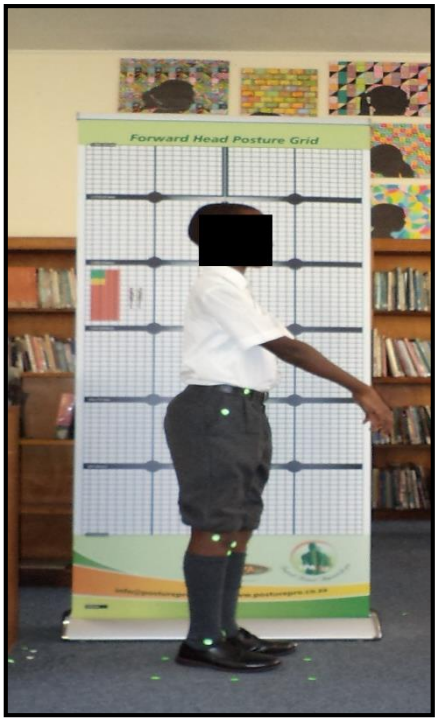

Figure 3.4
Scholar in lateral view

The Posturepro 8 Computer Postural Software System allowed the researcher to import the digital photographs of the scholars and click on the various anatomical landmarks (reflective markers). The Posturepro 8 Computer Postural Software System thereafter calibrated the digital photograph and calculated (in degrees) the relevant postural measurements, from normal (no Backpack) to wearing Backpack A and then Backpack B, in the Antero-posterior and lateral views, for the purpose of postural analysis. A one sample t-test was used to compare the postural symmetry measurements to a null hypothesis value of 0. The Posturepro 8 Computer Postural Software System also had the ability to calculate the physical forces of Posterior Cervical Muscular Tension (PCMT), which was measured in the Newton (N) value, and the additional cervical forces which was calculated in Kilograms (Kg). The placements of the reflective markers were in accordance to the Posture Pro guidelines for digital photographic analysis (Posture Pro, 2011). The reflective markers were placed on the specific landmarks in order for the Posturepro 8 Computer Postural Software System to analyse any changes in the postural measurements. The reflective markers also acted as a relative vertical plumb line, therefore the placement of the reflective markers were important for postural assessment (Posture Pro, 2011). The main aim of the digital photographic analysis was to compare the two backpacks to the scholar's normal posture, in an attempt to compare which of the two backpacks showed a significant difference in the scholars' posture.

The main representative from 'Improved Postural Alignment for You' (IPA4U) accompanied the researcher on the research conduction days, to make sure all postural equipment was assembled and calibrated correctly. The main photographic area was set accordingly by using the Posture Pro tools, measurements and guidelines. The equipment was not moved during the two days the researcher undertook the research study. A picture illustrating the main photographic area is depicted in **Figure 3.5** below.

- The Posture Pro grid was set upright and level to the floor (vertical and horizontal). Markings were provided so that the scholar knew where to stand. The markings were set at 40 cm from the grid. The tripod was set 3 m in front of the markings. The height of the tripod was 87 cm from the ground. A Sony digital camera (camera type: DSC-H55) was used; the camera resolution was processed at 640x480 pixels. The camera was calibrated at 27 cm point to point. There was a vertical line on the grid, measuring 27 cm (Block on the grid).
- In the AP view, the scholar stood with his/her feet slightly apart, so to ensure equal weight distribution.

- In the lateral view, the ankle closest to the side of the camera (with the reflective marker placed anterior to the lateral malleolus) was in line with the median on the 40 cm mark.

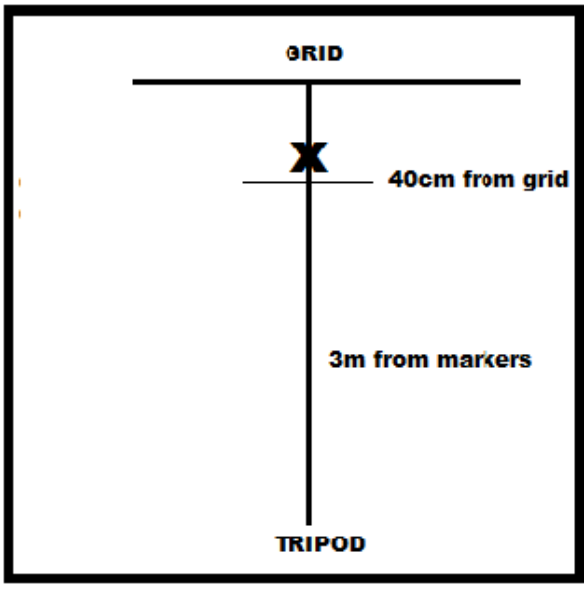

Figure 3.5
Set up of main photographic area (Posture Pro, 2011)

Once the reflective markers were placed correctly on the scholar's respective anatomical landmarks, the researcher immediately took the first photograph.

A table was set up, on which two pre-packed backpacks were placed (novel and school-issued). The researcher loaded the backpacks to a maximum 10% body weight of the scholars (Voll and Klimt, 1977). The backpacks were loaded with the scholars' books and text books. The average mean weight for 12 to 14 year olds were calculated at 47 kg (38-56 kg). The researcher calculated that the weight of each of the two backpacks should be 47 kg x 10% body weight, which is the recommended body weight limit, this equalled 4.7 kg for each backpack. The backpacks were set at the same weight so to make the assessment of the backpacks comparable with respect to weight.

The researcher adhered to the guideline by Sharan *et al*., (2012) when packing both the backpacks (Backpack A and Backpack B), which was to pack the heaviest items close to the back, this guideline was noted to keep the weight in the backpack evenly distributed, it prevented excess pressure being placed on the shoulders and it helped to maintain a neutral posture (Sharan *et al*., 2012). The researcher also followed other guidelines (i.e. choose a backpack, which consisted of two wide shoulder straps and a waist belt, the scholar should wear both shoulder straps), which researchers noted would be beneficial for backpack usage

(Mackie *et al*., 2003; Al-Hazzaa, 2006; khalil AL-Qato, 2012; Sharan *et al*., 2012; Pahwa, 2013 and Arghavani *et al*., 2014).

A scholar was first photographed with no Backpack, in the Antero-posterior and lateral views. The same scholar was then fitted with the pre-loaded Backpack A, as shown in **Figure 3.6** below, using both shoulder straps and ensuring that the backpack was fitted correctly on the scholar. The same scholar carrying Backpack A was photographed in the Antero-posterior and lateral views. The same scholar was then fitted with Backpack B, as shown in **Figure 3.7** below. As can be seen in **Figure 3.7** below, Backpack B did have additional comfort features such as a breast strap and waist strap which was used during the duration of this research.

Figure 3.6
Backpack A

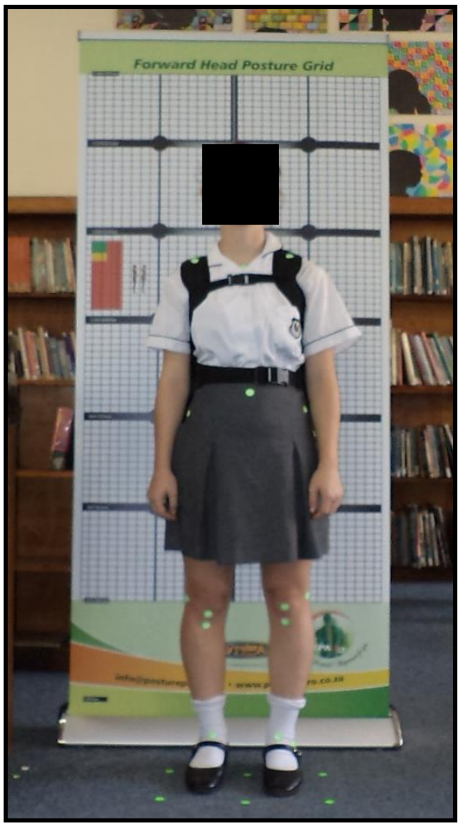

Figure 3.7
Backpack B

The same scholar carrying Backpack B was photographed in the Antero-posterior and lateral views. One hundred scholars were each photographed for comparative purposes (i.e. no Backpack, Backpack A and Backpack B). Once the scholar completed their photographic assessment at station three, the scholar was thanked by the researcher for their participation in this research, and was presented with an educational pamphlet issued by the Chiropractic Association of South Africa titled “Watch your back” **(Appendix E)**.

Day two occurred the same way as day one. The postural equipment was not moved so to ensure measurement consistency. To avoid any further lost learning time of the scholars,

photographic transfer to the Posturepro 8 Computer Postural Software System was conducted off school premises.

To ensure that the conducted test results were unbiased, an external Biostatistician was used to assess the statistics derived from the Posturepro 8 Computer Postural Software System (Esterhuizen, 2014).

3.6 OUTCOME MEASURES

3.6.1 Objective measurement tool

Scholars were assessed in the form of an objective data capturing system called the Posturepro 8 Computer Postural Software System (©*VenturaDesigns*, 2012).

The image tool, Posturepro 8 Computer Postural Software System (Version 8, ©*VenturaDesigns*, 2012, Overland Park, Kansas) is the latest version of Posture Pro and served as the main measurement tool used to objectively evaluate the scholar's posture. Posturepro 8 was specifically developed for digital photographic analysis. It can quickly and accurately analyse and compare posture in the Antero-posterior and lateral views by measuring the various distances/degrees between anatomical landmarks (Posture Pro, 2011).

Posturepro 8 Computer Postural Software System is compatible with all versions of windows. The software can easily be downloaded from http://www.posturepro.co.za/2011. The actual use of the software is protected by a security lock and therefore will only work in demo mode until unlocked. In the demo mode, the user can easily access tutorials and resources to understand the usage of the software. A Posturepro 8 instruction manual (Posturepro 8, Posture analysis and retention tool, Build 8, ©*VenturaDesigns*, 2012) is easily accessed on the demo mode of the software. This manual provides the user with simple step-by-step instructions on the photo digitization process and software usage (Posture Pro, 2011).

3.6.2 Computer software validity and reliability

The Posturepro Computer Postural Software System (©*VenturaDesigns*) is a valid technological device which was developed in 1996, and it has been in continuous use for over 16 years. It has been the only software to be endorsed by the National Posture Institute (United States of America) and is used by various health care professionals (including, chiropractors) worldwide (Posture Pro, 2011). Based on this, the researcher assumed that the Posturepro 8 Computer Postural Software System was a valid and reliable tool.

Several other companies have developed computerized postural analysis software systems (Pausic *et al*., 2010). Normand *et al*., (2007), noted that several computer assisted postural measurement systems have been studied for measurement reliability (Swinkels and Dolan, 2000; Dunk *et al*., 2004 and Dunk *et al*., 2005). In the study by Lafond *et al*., (2007), the researchers used a postural analysis system (Biotonix) to evaluate posture. This method was said to be reliable in performing a quantitative postural evaluation, which was then used for patient therapy (Lafond *et al*., 2007). The approach is the same for all software systems, which includes digitizing an image of the patient's relaxed standing posture and calculating various measurements in the anterior and lateral views (Dunk *et al.,* 2005). To ensure the reliability of the photographic studies, special attention was paid to factors such as placement of the reflective anatomical markers and a correct photo digitization process (McEvoy and Grimmer, 2005). This research used the Posturepro 8 Computer Postural Software System (Version 8, ©*VenturaDesigns*). In an email communication on the 11th October 2013, Dr Ventura, the founder of 'Posture Pro' stated, "We have conducted no studies on the reliability/validity of 'Posture Pro' but others have tested the concept using other software. Since we all use the same concept of capturing screen pixels and making measurements based on screen coordinates, there is no need for every company to conduct those tests."

3.7 ETHICAL CONSIDERATIONS

1. Approval to conduct this research was obtained from the Faculty of Health Sciences Research Committee (FRC) and the Institutional Research Ethics Committee (IREC) at the Durban University of Technology (DUT) **(Ethics Certificate Clearance Number: IREC 011/14 [Appendix G])**.

2. All parents were required to sign a letter of information and informed consent to allow their children to be photographed **(Appendix C1)**.

3. All scholars had to sign a letter of information and informed consent prior to participating in the study **(Appendix C2)**.

4. The scholars' identities were protected as their names did not appear on the actual photographs. To further protect the identity of the scholars, their faces were "censored" by the researcher.

5. The novel backpack used in this research was sponsored by the company, 'Improved Postural Alignment for You' (IPA4U), as stated in the letter of agreement **(Appendix D)**.

6. Permission for the use of the 'Posture Pro' name in this research was granted by the founder of 'Posture Pro' **(Appendix F)**.

7. No free backpacks were given to the scholars.

3.8 STATISTICAL ANALYSIS

IBM SPSS version 21 was used to analyse the data. A two-tailed **p** value <0.05 was considered statistically significant. Parametric summary statistics such as mean and standard deviation were used to describe the outcomes in each group. Postural measurements were compared between the pairs (i.e. no Backpack versus Backpack A, no Backpack versus Backpack B and Backpack A versus Backpack B) using paired sample t-tests. A one sample t-test was used to compare the postural symmetry measurements to a null hypothesis value of 0. Statistical analyses were done using the quantitative data generated by the Posturepro 8 Computer Postural Software System to compare results with the aid from an independent Biostatistician (Esterhuizen, 2013). The Posturepro 8 Computer Postural Software System demonstrated differences from normal posture (indicated by a value of zero degrees). The results are visual, easy to understand and objective (Posture Pro, 2011). Neck, shoulder and pelvic postural measurements was assessed by means of the Posturepro 8 Computer Postural Software System.

The main representative of 'IPA4U' assisted the researcher at the respective high school. The representative ensured that the equipment was assembled correctly and that reflective markers were reliably placed on the scholars anatomical landmarks. The representative assessed the area where the marker was placed, to make sure that it was placed over the correct anatomical landmark. The representative was not involved in comparing/analysing the end results, which ensured the results were not biased.

3.9 THE REVIEW OF METHODS USED IN THIS RESEARCH

Various methods are used to assess posture **(Table 2.2)**. The study by, Raine and Twomey (1994), used photography to calculate the relationships between anatomical landmarks. Radiographic imaging has also been used to assess posture, however, repeated radiographic imaging of the same patient could result in high radiographic exposure, which eventually could lead to hazardous health risks (Smith, 1998). In a study performed by Steele *et al.,* (2001), it was noted that photographic digitisation techniques were very reliable and reproducible. In comparison, Talbot (2005) noted that various investigators have verified the reliability of digital photography (McEvoy and Grimmer, 2005 and Grimmer *et al.*, 2002). The researcher noted that various factors affected the reliability of photographic postural assessments in children, which included anthropometric factors as well as palpation of anatomical landmarks for reflective marker placement, and the reproducibility of the digitisation process (McEvoy and Grimmer, 2005). Pausic *et al*., (2010) noted that many studies assessed the reliability of photographic methods in children, adolescents and young adults (Dunk *et al*., 2005; Penha *et al*., 2008 and Perry *et al*., 2008). These researchers noted that, photographic methods are low cost, non-invasive and simple to use and are therefore suitable for school intervention programs and they believed that it was imperative to use a non-invasive and simple method when assessing standing posture in a school environment. In comparison to this, Kistner *et al.*, (2013) believed that digital photography had the ability to examine and measure various postural angles, in a non-invasive manner.

Therefore, the method utilised in this research was digital photography, where photographs were taken of anatomical landmarks (by means of reflective markers placed on the scholars). The digital images were used to determine the linear coordinates of each landmark and this was used to compare the postural measurements of each scholar. The advantages and disadvantages of this method, based on the experience of the researchers, are tabulated in **(Table 3.1)**. In the researcher's opinion, this method of analysing posture was simpler because it did not require complicated equipment or specific participant positioning as required in other methods such as radiography and skin surface tracking. It is also a relatively inexpensive method. A digital camera and tripod stand were the only basic postural equipment required for this research conduction. These are less expensive than radiographic equipment and skin tracking devices. Furthermore, there was no danger of radiation exposure and as such, digitisation techniques may be safely executed in children and pregnant women.

However, this process is relatively time consuming as the co-ordinates of each landmark needed to be determined before the actual measurements were determined. The researcher needed to have a good understanding of surface anatomy and proper experience in palpating the landmarks, so to achieve accurate results. **Table 3.1** below illustrates the advantages and disadvantages of the digital photographic method used in this research.

Table 3.1 The review of the photographic method used in research (formulated by the researcher)

Advantages	**Disadvantages**
Simple to use	Can be time consuming
Inexpensive	Requires training to use
Safe	
Reproducible	Requires practical experience

CHAPTER FOUR

RESULTS

4.1 THE SCHOLARS DEMOGRAPHIC AND SELECTED ANTHROPOMETRIC CHARACTERISTICS

The mean age of the one hundred scholars were 13.5 (± 0.6 SD) years. The ages ranged between 12 and 14 years. The mean (± SD) of the BMI was 20.9 (± 1.8 SD) $kg.m^{-2}$. The mean, range of the age, BMI, height and standard deviation of the scholars are shown in **Table 4.1** below.

Table 4.1 The anthropometric characteristics of the scholars

n=100	Mean	Standard Deviation	Minimum	Maximum
Age (years)	13.5	0.6	12.00	14.00
BMI ($kg.m^{-2}$.)	20.9	1.8	15.80	23.00
Height (m)	1.6	0.03	1.45	1.60
Weight (kg)	51.5	4.8	38.00	56.00

This research incorporated various ethnic groups and genders. The two pie charts which follow, illustrate the demographic variety. The gender split between the number of males (59%) and females (41%), represented in percentage form, is illustrated in **Figure 4.1** below.

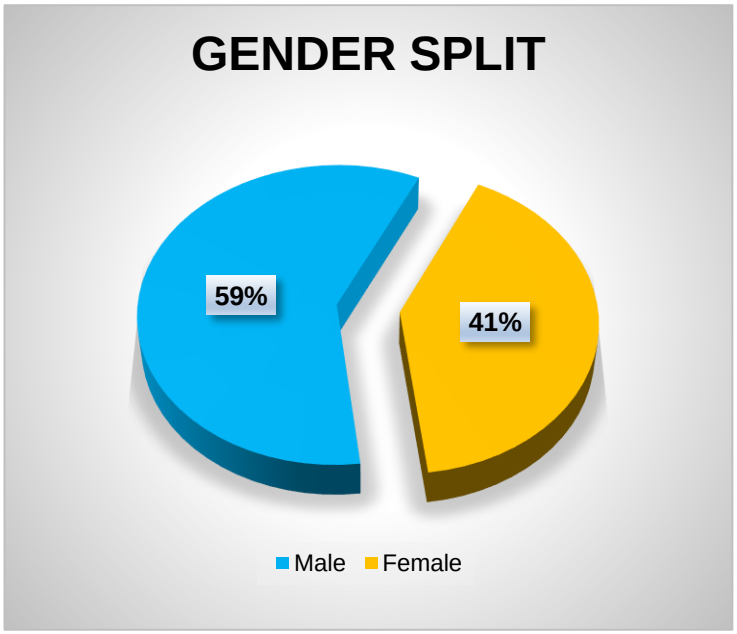

Figure 4.1 Gender Split

When assessing the ethnic demographics, one can observe that there were more black scholars (72%) that participated in this research, followed by Indian scholars (11%). Illustrated in **Figure 4.2** below.

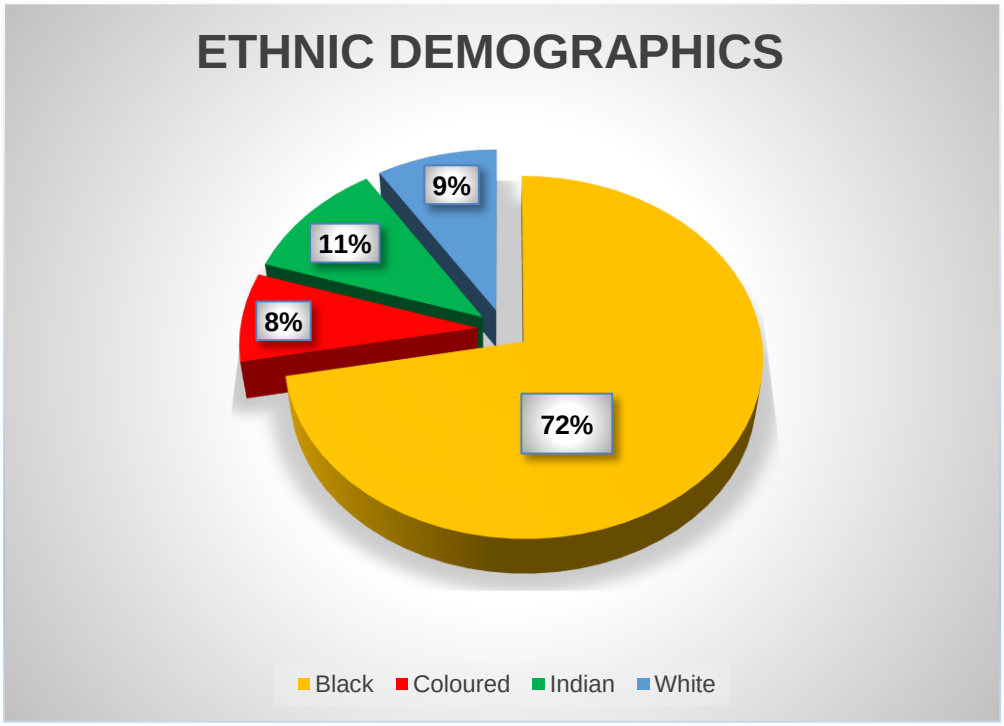

Figure 4.2 Ethnic Demographics

4.2 THE OBJECTIVE OUTCOME MEASURES

This research was performed to determine which backpack (A or B) performed better at maintaining the scholar's posture compared to when no backpack was used. A direct comparison was made between no Backpack and Backpack A and Backpack B. Backpack A, in this research, refers to the school-issued backpack, which scholars carry every day, and Backpack B refers to the novel backpack which was specifically used for this research. Parametric summary statistics, such as mean and standard deviation were used to describe the outcomes in each group.

These values were calculated by using the data obtained from the Posturepro 8 Computer Postural Software System *(©VenturaDesigns,* 2012). IBM SPSS version 21 was used to analyze the data. A two-tailed **p** value of <0.05 was considered as statistically significant. The Biostatistician (Esterhuizen, 2014) used parametric summary statistics such as mean and standard deviation to describe the outcomes in each group. The differences (right and left sides) for the AP head, shoulder and pelvic measurements were calculated to work out the difference in postural symmetry for each scholar. This was done for no Backpack, Backpack A and Backpack B. It is interesting to note that although this research took into account other outcome measurements (i.e. Additional cervical forces, lateral measurements, Posterior Cervical Muscular Tension (PCMT) and Total deviation), the main objective of this research was to assess postural symmetry. Therefore, postural symmetry was measured by calculating the differences in the head, shoulder and pelvis in all 3 groups.

The comparison for each of the differences closest to zero (‘0’) in the no Backpack, Backpack A and Backpack B were performed using a one sample t-test. The values closer to zero (‘0’) indicates a normal postural symmetry. As shown in **Table 4.2** and illustrated in **Figure 4.3** below.

Table 4.2 Postural symmetry comparison between all 3 groups

Measurements	No Backpack	Backpack A	Backpack B
	Mean	Mean	Mean
Symmetry AP Head (°)	0	-0,02	0
Symmetry AP shoulders (°)	0,08	-0,07	0,06
Symmetry AP hips (°)	0,06	0,09	0,06

Note: Symmetry AP head no backpack, could not be tested since the mean and standard deviation were =0. None of the symmetry measurements were significantly different from 0 for the no Backpack, Backpack A or Backpack B. The mean differences were very close to 0 (Esterhuizen, 2013).

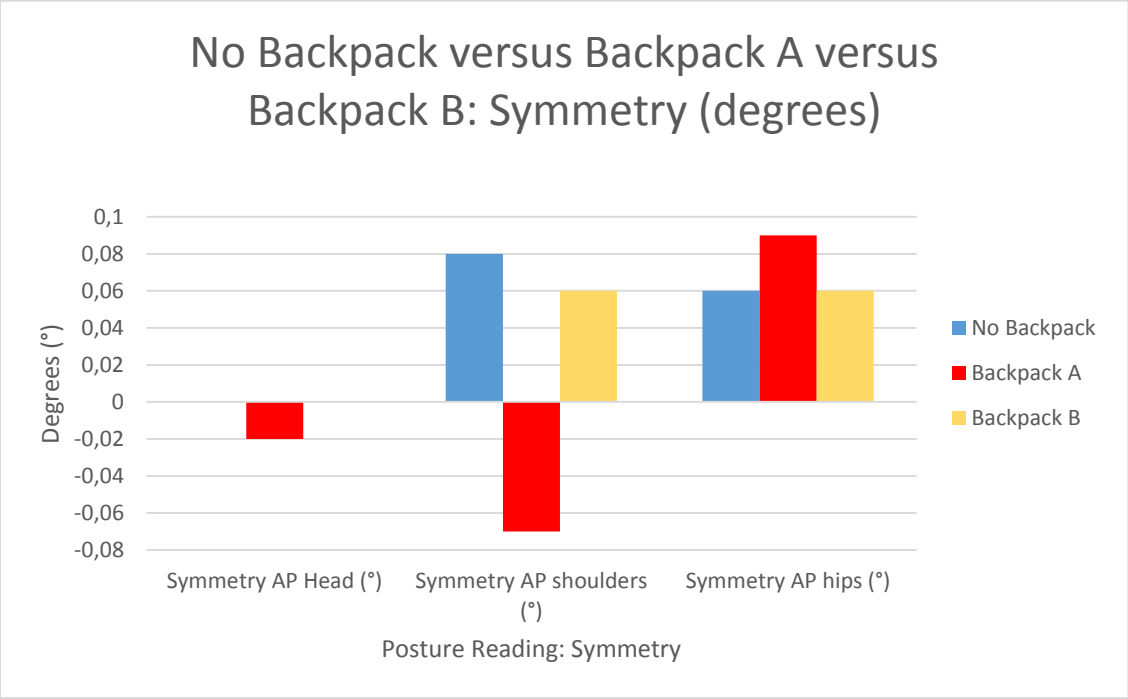

Figure 4.3 Postural symmetry comparison between the 3 groups

The **Table 4.3** and **Figure 4.4** below, depicts the comparison between the 3 groups of data (i.e. no Backpack, Backpack A and Backpack B). In **Figure 4.4** below it can be interpreted that where there is no backpack, the Backpack A values differ significantly, which means that Backpack A's value was higher than the no Backpack value. A high value is unfavourable as it indicates a degree further away from the optimal zero value. Backpack A was significantly different to the no Backpack measurements for all measurement outcomes other than the symmetry measurements as shown in **Table 4.2** (highlighted in gold) and illustrated **Figure 4.3** above. The measurement outcomes for Backpack A were higher than those for the no Backpack measurements as seen in **Tables 4.3, 4.4 and 4.5** and as illustrated below in **Figures 4.4, 4.5 and 4.6** for Backpack A. This suggests that wearing Backpack A is not as conducive to posture as wearing no Backpack.

In **Tables 4.3, 4.4 and 4.5 and Figures 4.4, 4.5 and 4.6** below, it can be seen that Backpack B was mostly similar to the no Backpack for most measurement outcomes: AP hips left, lateral head left, total deviation left, PCMT left and right and additional cervical forces left. There were significant differences in some measurement outcomes between no Backpack and Backpack B: lateral hips right and left and total deviation right as shown in **Tables 4.3** below. In these instances, the Backpack B measurements were higher than the no Backpack measurements. In the other measurement outcomes the difference between the no Backpack and Backpack B were not significant. This suggests that wearing Backpack B is more conducive to maintaining posture.

Table 4.3 Postural comparison of all 3 groups

Measurements	No Backpack	Backpack A	Backpack B
	Mean	Mean	Mean
AP HEAD right (°)	-0,59	-0,48	-0,48
AP SHOULDERS right (°)	-0,54	0,71	0,49
AP HIPS right (°)	-0,99	-0,9	-1,04
LATERAL HEAD right (°)	7,86	9,42	8,35
LATERAL HIP right (°)	4,9	6,98	6,36
TOTAL DEVIATION right (°)	18,24	22,29	20,22
AP HEAD left (°)	-0,59	-0,5	-0,48
AP SHOULDERS left (°)	-0,46	0,64	0,55
AP HIPS left (°)	-0,93	-0,81	-0,98
LATERAL HEAD left (°)	8,61	9,67	8,58
LATERAL HIP left (°)	3,76	5,3	4,69
TOTAL DEVIATION left (°)	18,12	21,07	18,98

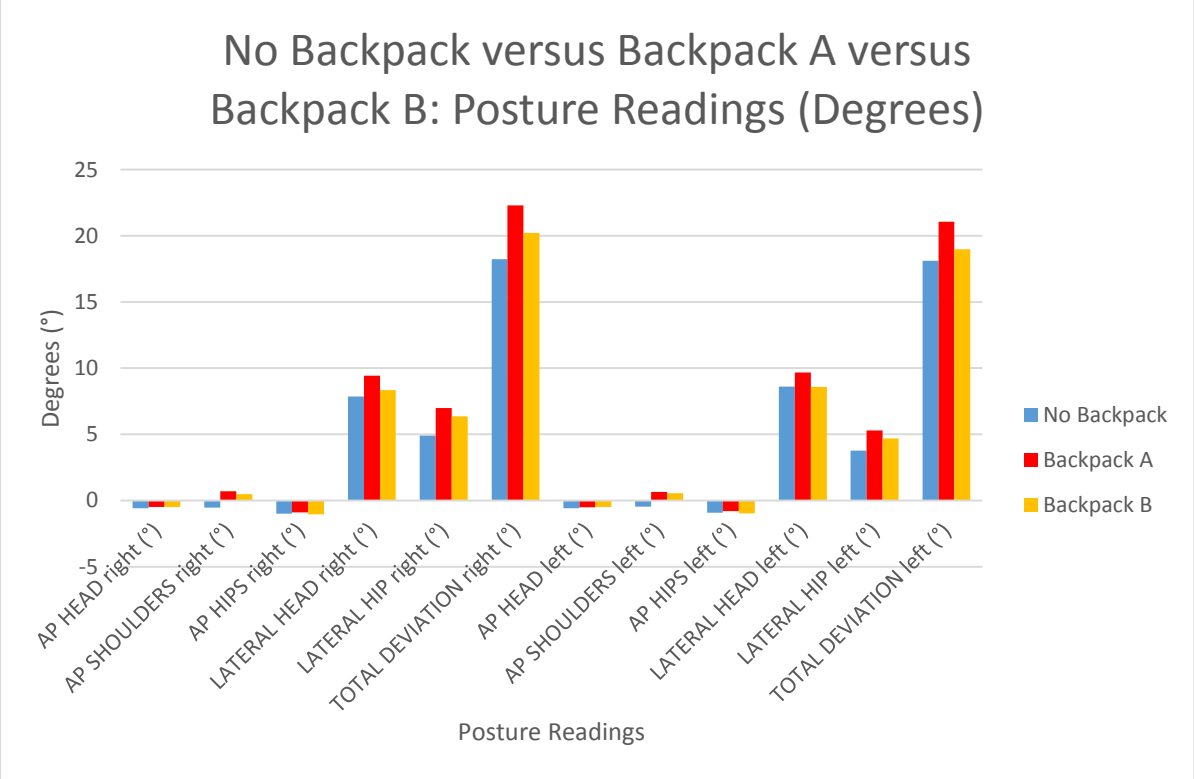

Figure 4.4 Postural reading measures of the 3 groups

Table 4.4 Comparison of PCMT for the 3 groups

Measurements	No Backpack	Backpack A	Backpack B
	Mean	Mean	Mean
PCMT right (kg)	0,3	0,38	0,33
PCMT left (kg)	0,33	0,38	0,33

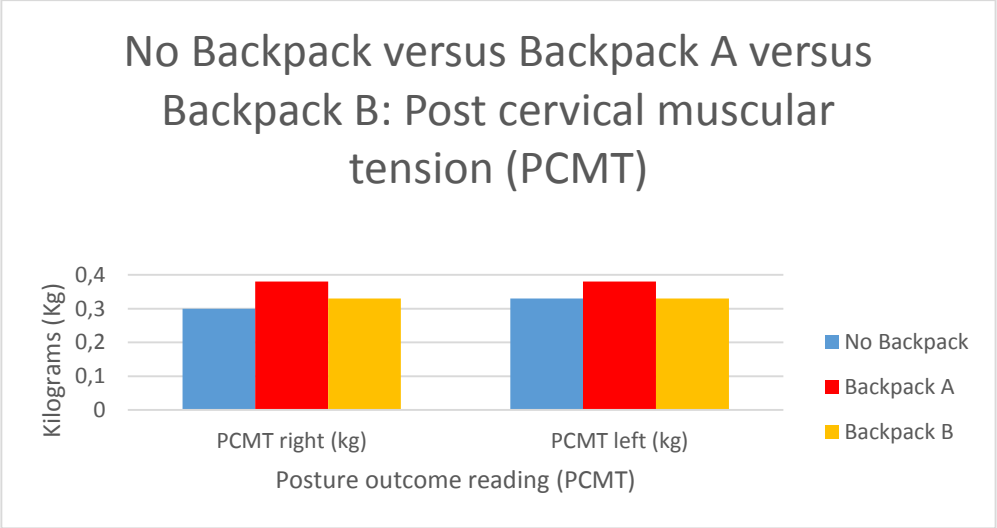

Figure 4.5 Posterior cervical muscular tension of the 3 groups

Table 4.5 Comparison of the additional cervical forces of the 3 groups

Measurements	No Backpack	Backpack A	Backpack B
	Mean	Mean	Mean
ADD FORCES right (N)	33,54	40,16	35,52
ADD FORCES left (N)	36,85	41,7	36,76

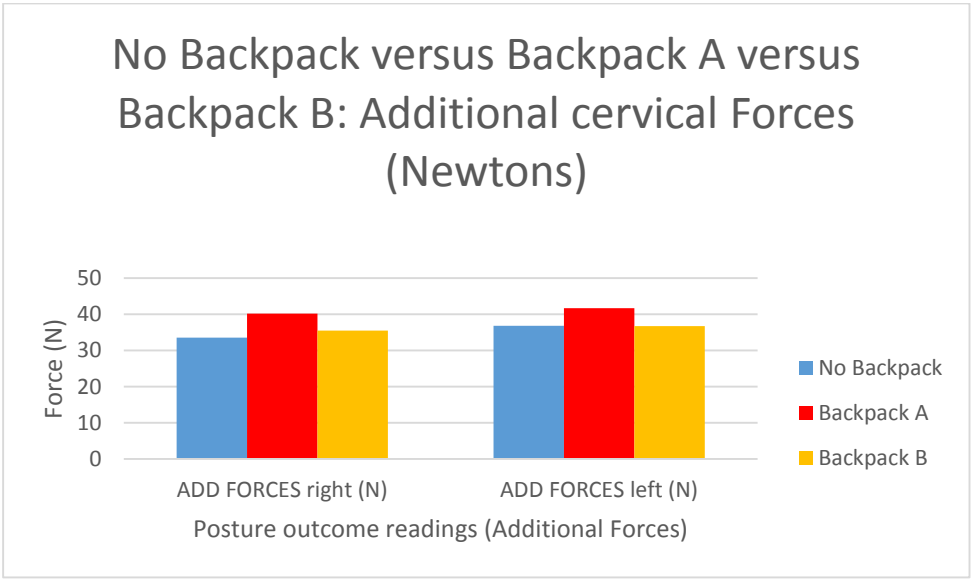

Figure 4.6 Additional cervical forces of the 3 groups

A paired sample t-test was performed to compare the difference between Backpack A versus Backpack B which is illustrated in **Figure 4.4, 4.5 and 4.6** above and **Table 4.6** below. This showed that there were some significant differences (**p**<0.05) between Backpack A and Backpack B. These were in the total deviation right (**p**=0.008), PCMT left (**p**=0.006), additional cervical forces left (**p**=0.019), lateral head left (**p**=0.021) and total deviation left (**p**=0.001). In these outcomes, the mean differences were positive, meaning that the measurements for Backpack A were higher than that of Backpack B. The symmetry measurements, however did not significantly differ (**p**=0.05) between Backpack A and B. Therefore, the researcher cannot convincingly conclude that Backpack B performed better than Backpack A when comparing these two groups.

Table 4.6 The comparison between Backpack A versus Backpack B

Paired Samples t-test									
		Paired Differences					t	Df (º)	**P**
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PCMT A right - PCMT B right	0.05	0.256	0.03	-0.01	0.01	1.91	99	0.059
Pair 2	ADD CERVICAL FORCES A right - ADD CERVICAL FORCES B right	4.63	25.37	2.54	-0.40	9.67	1.83	99	0.071
Pair 3	LATERAL HEAD A right - LATERAL HEAD B right	1.07	5.68	0.57	-0.06	2.19	1.89	99	0.062
Pair 4	LATERAL HIP A right - LATERAL HIP B right	0.62	3.66	0.37	-0.11	1.35	1.69	99	0.094
Pair 5	TOTAL DEVIATION A right - TOTAL DEVIATION B right	2.07	7.71	0.77	0.54	3.60	2.69	99	0.008
Pair 6	PCMT A left - PCMT B left	0.06	0.2	0.02	0.17	0.09	2.83	99	0.006
Pair 7	ADD FORCES A left - ADD FORCES B left	4.94	20.64	2.06	0.85	9.03	2.39	99	0.019
Pair 8	LATERAL HEAD A left - LATERAL HEAD B left	1.09	4.63	0.46	0.17	2.00	2.35	99	0.021
Pair 9	LATERAL HIP A left - LATERAL HIP B left	0.61	3.49	0.35	-0.08	1.30	1.74	99	0.084
Pair 10	TOTAL DEVIATION A left - TOTAL DEVIATION B left	2.09	6.35	0.64	0.83	3.35	3.28	99	0.001
Pair 11	Symmetry AP Head A - Symmetry AP Head B	-0.02	0.20	0.02	-0.06	0.02	-1.00	99	0.320
Pair 12	Symmetry AP Shoulders A - Symmetry AP Shoulders B	-0.13	1.07	0.11	-0.34	0.08	-1.22	99	0.227

A=backpack A; B=backpack B; AP=Antero-posterior; **p**=**p** value<0.05 is considered as significant; df =degrees of freedom; t= t-statistic; (-) =negative

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 SCHOLARS DEMOGRAPHIC DATA

5.1.1 AGE AND BMI

The participants in this research were high school adolescents aged between 12 and 14 years. Other similar studies had comparable age ranges (Grimmer *et al*., 2002; Puckree *et al*., 2004; Abrahams *et al*., 2011 and Arghavani *et al*., 2014) as mentioned in **Table 2.1**. The mean BMI in this research was 20.9kg/m² **(Table 4.1)** which is similar to the results of other studies (Bauer and Freivalds, 2009; Abrahams *et al*., 2011). The narrow age range was selected, as it was noted that their spine is at a critical stage of development (Dochrell *et al*., 2006).

5.1.2 GENDER

The distributions between the genders was 59% males and 41% females **(Figure 4.1**). Therefore, the majority of the scholars that participated in this research were males. This gender distribution result is comparable to other backpack studies (Grimmer *et al*., 2002; Mackie *et al*., 2003 and Bauer and Freivalds, 2009), in which these studies had gender ratios which were approximately 50:50 **(Table 2.1)**. The slightly higher preponderance of males may be explained by the gender statistics established in the eThekwini region for young people aged between 10 to 14 years. This statistic reports that 4% of the population are male and 3.9% are female (beta2.statssa.gov.za).

5.1.3 ETHNICITY

The black scholars made up the high ethnic profile in this research **(Figure 4.2)**, followed by Indians, Whites and Coloureds. A contributing factor to the high percentage of Black scholars may be due to the significant percentage which resides in the eThekwini region of KwaZulu-Natal, approximately 73.85%, followed by 16.7% of Indians (beta2.statssa.gov.za).

5.2 OBJECTIVE OUTCOME MEASURES

In South Africa, it has been found that the load that scholars carry around in their backpacks have increased over the recent years due to the constant changes in the South African National Curriculum (Abrahams *et al*., 2011; Puckree *et al*., 2004). This requires scholars to carry more books to and from school (Abrahams *et al*., 2011; Puckree *et al*., 2004).

The impact of the Hawthorne Effect on the scholars' was minimal. The scholars and the researcher were aware of the backpacks being tested, however the scholar was not aware of the design differences between the 2 backpacks. The scholar was aware that he/she was being photographed and this could have led to a possible increased Hawthorne effect, in terms of posture. However this would have hopefully not impacted on the outcomes of the study, as photographic postural measurements were taken, for the same scholar using a school issued backpack, a novel backpack and no backpack.

Most backpack studies have been conducted using different types of backpacks **(Table 2.1)** and have used varying methodologies and outcome measures to assess a scholar's posture. The assessments of postural symmetry using the Posturepro 8 Computer Postural Software System were not conducted in previous studies and a comparison of the results to other studies could therefore not be made.

In this research, direct comparisons were made from amongst one hundred high school adolescent scholars. Each scholar was digitally photographed in the Antero-posterior and lateral views. The scholar was first photographed with no backpack, followed by the school-issued backpack (Backpack A) and lastly by the novel backpack (Backpack B). The same individual scholar was photographed in the same two views (Antero-posterior and lateral) in the three groups, as were the following one hundred scholars. This allowed for comparative results between each individual. Both backpacks were weighted and worn the same way, which decreased any bias between the two different backpacks. This was the first independent study, which assessed this novel backpack and therefore comparisons could not be made between other studies.

Each comparison revealed differences between all groups and the values closest to zero was termed favourable when assessing postural symmetry. The values closest to zero indicated a normal postural symmetry. This is partially similar to a study conducted by Ferreira *et al*., (2011), in which they found that when assessing postural alignment, the value indicative of postural symmetry was zero. Thereby in the present study, the negative values were

considered unfavourable as they indicated a value further away from the optimal zero value. Postural symmetry was assessed using a one sample t-test, no significant difference was noted between the 3 groups (Backpack A, Backpack B and no Backpack). This resultant insignificance (**p**=0.05) could be due to the fact that both the backpacks were packed and worn the same way and weighed the same value. This is similar to the study findings of Hickey (1999) and Zimbler (2000) in which they noted that, when wearing both backpack straps bilaterally, the weight of the backpack is evenly distributed as the person's posture is supported by the abdominal and back muscles. Additionally, Pascoe *et al*., (1997) noted that when wearing a loaded backpack on both shoulders, a minor effect on posture was seen and no significant change was noted when compared to the no backpack trial. Studies performed by Knapik *et al*., (1996) and Voll and Klimt (1977), also assessed backpacks in which both researchers found that when wearing a backpack bilaterally, a minor postural change was seen and therefore this could have implied that the backpack weights were appropriate enough for the scholar to be able to maintain posture. These findings are similar to the findings of this research, and this could be because the same backpack weights were used, however not every scholars backpacks complies with the weight guideline. Therefore, further studies on the effects of backpack weights should be done with a novel and school-issued backpack whereby scholars carry their normal everyday load in their backpack.

The Posturepro 8 Computer Postural Software System also included measurements which the researcher took into consideration when assessing the backpacks. Statistical analysis between Backpack A and no Backpack showed a significant difference (**p**<0.05) for some of these measurements. This revealed that the outcomes, such as lateral deviation, total deviation, PCMT and additional cervical forces in Backpack A was better than the results analysed when the scholars were not wearing a backpack. Therefore, the results concluded that using Backpack A (school-issued backpack) had an unfavourable effect (**p**>0.05) when compared to using no Backpack. When analysing Backpack B to no Backpack, a similar reading was identified between using Backpack B and using no Backpack. Therefore, when assessing the outcome measures in comparing Backpack B to no Backpack, there was no significance noted (**p**=0.05). These findings of both Backpack A and B when compared to no Backpack is partially similar to Bauer and Freivalds' (2009) findings, in which they noted that there was a difference between wearing a backpack and not wearing a backpack.

A paired sample t-test was performed to compare the mean difference between Backpack A versus Backpack B. When analysing the mean outcomes, the mean differences were positive, meaning that the value outcomes for Backpack A was higher in some instances (total deviation right, PCMT left, additional forces left, lateral head left and total deviation left)

as compared to Backpack B, and thus were significantly different (**p**<0.05). This could be due to the additional comfort features within the Backpack B (adjustable breast straps, tapered shoulder and waist straps).

5.3 LIMITATIONS OF THE RESEARCH

1. The white reflective markers were noticeable on the scholar, however clothing frequently shifted when the backpacks were placed on the scholar's shoulders, thereby causing the reflective markers to be moved from the original position. The researcher had to re-assess the area and replace the reflective marker.

2. Both research conduction days were conducted over normal school days. The researcher therefore had to abide by the rules of the New Forest High School. The scholars had to attend assembly, classes, meetings and detention in between the data collection phase, making it challenging for the researcher to adhere to the time limits of New Forest High School.

3. The Hawthorne Effect 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). 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). In this study a possible Hawthorne effect could have occurred as the scholars were aware that they were being photographed. Hopefully, this would have not impacted on the outcomes of the study as photographic postural measurements were taken, for the same scholar using a school issued backpack, a novel backpack and no backpack.

4. The assessment outcome measurements were based on the Posturepro 8 Computer Postural Software System and therefore measurement results can only be researched by another researcher using the same values obtained from the Posturepro 8 Computer Postural Software System which was used in this research.

5. The research focused on comparing postural symmetry measurements as the main objective, however the Posturepro 8 Computer Postural Software System was also able to analyse other measurements, which the researcher should have included in the measurement objectives of this research.

6. This research focused on determining postural symmetry measurements in scholars by once off backpack usage, as opposed to 'postural behaviour' which requires a more complex analysis.

7. The research focused on applying one weight to all scholars ie. 4.7kg (calculated as the mean weight for the sample), however very few of the scholars presented with the actual weight of 47kg, and therefore not everyone carried a weight of 10% of their body weight.

8. The research was conducted in one high school only and therefore final results were limited to only that one high school in the eThekwini district of KwaZulu-Natal.

5.4 RECOMMENDATIONS REGARDING BACKPACK CHOICE FOR CHIROPRACTORS AND OTHER HEALTHCARE PRACTITIONERS

As the results of this study indicated, none of the postural symmetry measurements were significantly different from zero in all 3 groups. Therefore when comparing Backpack A to Backpack B, this research showed that there was no significant differences between the two backpacks when looking at postural symmetry (**p**=0.05). This is in support of the study by Golriz and Walker (2012) in which they pointed out that, there is "no backpack that can minimize the negative effects on the body". However, guidelines have been researched, which researchers (Mackie *et al*., 2003; khalil AL-Qato, 2012; Sharan *et al*., 2012 and Pahwa, 2013; Arghavani *et al*., 2014) recommended for proper backpack usage. The novel and school-issued backpack used in this research adhered to these guidelines, however, only the novel backpack was able to comply with the usage of a waist/hip belt as the school issued backpack did not have this additional feature.

- A backpack should have two wide padded straps on both sides (Pahwa, 2013). Arghavani *et al*., (2014) suggested in their study that the scholars must use both straps when carrying a backpack.
- The backpack should also have a hip/waist belt as this would help to stabilise the load and prevent any injury (Mackie, 2003).
- The backpack should be packed and fitted correctly on the scholar (Al-Hazzaa, 2006).
- The backpack should have separate compartments so to avoid the items from moving around (khalil AL-Qato, 2012).
- Pack the heaviest items close to the back, this helps to keep the weight in the backpack evenly distributed, it prevents excess pressure being placed on the shoulders and it helps to maintain a neutral posture (Sharan, 2012).

When taking these guidelines into account, the researcher noted no difference between Backpack A and Backpack B, in terms of postural symmetry. Other measurements included in the Posturepro 8 Computer Postural Software System, suggested that the novel backpack (in accordance with the guidelines) performed better than the school-issued backpack. However, it is recommended that further studies need to be conducted on this novel backpack when compared to a school-issued backpack, taking other measurement outcomes into account.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The research investigated the effect of a school-issued backpack (Backpack A) and novel (Backpack B) on high school adolescents' postural symmetry. It was observed that when comparing the postural symmetry measurements of Backpack A, Backpack B and no Backpack, no significant changes in postural symmetry were noted, hence there was no statistical difference seen between the 3 groups. However, when comparing other measurement outcomes some significant differences ($\mathbf{p}<0.05$) were noted and Backpack B was considered to be more effective than Backpack A.

Therefore, the study supported the null hypothesis statement, that there was no significant difference in terms of postural symmetry when comparing the 3 groups (i.e. no Backpack, Backpack A and Backpack B).

6.2 RECOMMENDATIONS

The recommendations arising from this research are the following:

1. A longitudinal study should be conducted with a larger sample size and include scholars packing their own backpacks so as to reflect the daily reality of scholars packing their own backpacks.
2. A similar study could be conducted whereby two different age groups are compared so as to assess if there will be a difference in lateral and posterior-anterior postural measurements.

3. Future studies should look further into the anatomy and biomechanics and compare relevant biomechanical measurements involved when carrying backpacks and how it effects postural symmetry. This will likely provide more objective data which can be compared in future studies.
4. More studies using the Posturepro 8 Computer Postural Software System should be conducted so that further comparisons can be made as no other studies have been conducted using this software system.
5. Long term studies should be performed to indicate if backpack usage negatively affects the spine in the long term.
6. Further studies should analyse postural symmetry by having the scholar carry the backpack over a longer period of time, so that postural behaviour could be assessed.
7. Future studies should consider the effects of all measurement outcomes more carefully, such as PCMT and additional cervical forces and not just look into the effects of backpack usage based on postural symmetry measurements.
8. Future studies should incorporate more than one school so as to ensure a larger sample and better population representation.
9. It may be more effective if a questionnaire study is included with a backpack clinical trial as many other studies used this method to add depth to their clinical trials.
10. There is a need for future studies to include feedback from the scholars, in terms of backpack usage and comfort.
11. It was recommended that the title of the research should be changed, ‘A comparative study of the direct effect of a novel and school-issued backpack on postural symmetry of high school adolescents at the New Forest High School in the eThekwini district of KwaZulu Natal’.
12. Future studies should state that scholars use a bathing suit, so that anatomical landmarks are readily palpable and so that the reflective markers do not shift. However, this does add an ethical concern, when working with minors.

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APPENDIX A1

Permission letter to the Department of Education

Ethics reference number: IREC 011/14

Ms K. Reddy
11 Steve Biko Road
Ritson campus, Gate 6
Berea
Durban
4001
Tel: (031) 3732205

10/03/2014

KZN Department of Education
Private Bag X9137
Pietermaritzburg
3200

Dear Department of Education Representative

PERMISSION FOR THE CONDUCTION OF RESEARCH AT NEW FOREST HIGH SCHOOL

My name is Kimera Reddy. I am a 6th year chiropractic master's degree student at the Durban University of Technology. I request permission from the Department of Education to conduct this research at New Forest High School. The title of this research: A comparative study of a novel and school-issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu-Natal.

The conduction of this research requires the use of the high school premises over 2 days. A sample size of one hundred 12 to 14 year old scholars will be recruited provided that the letters of information and informed consents are returned and they meet the required inclusion criteria on each day.

This research will pose no threat to the school or the scholars. No risk or discomfort is anticipated in this research. The scholar's identification will be protected. Scholars will undergo a free photographic postural screening. The aim of this study is to determine the effect of a novel and school-issued backpack on high school adolescent posture.

At the end of this research day each participating scholar will be thanked for their participation and be sponsored an educational pamphlet, "Watch your back", compiled by the Chiropractic Association of South Africa (CASA).

This research is of benefit to the scholar however it is a voluntary process therefore no pressure will be placed on the scholars to participate. Once permission is given by the Department of Education, the high school principal will be contacted for her permission. Permission from the principal will have to be obtained prior to accessing the scholars.

I will be grateful if you would grant permission for me to conduct this research at the high school. Your assistance would be highly appreciated and is vital to this research.

By signing this letter, you (The representative of the Department of Education) permit the conduction of this research at this high school.

_____	_____	_____
Full Name of representative of Department of Education	**Date**	**Signature**

I, Kimera Reddy herewith confirm that the representative of the Department of Education has been fully informed about the nature, conduct and risks of this research.

_____	_____	_____
Full Name of Researcher	**Date**	**Signature**
_____	_____	_____
Full Name of Supervisor	**Date**	**Signature**
_____	_____	_____
Full Name of Co-Supervisor	**Date**	**Signature**

Attached is a letter of information and informed consent, providing a brief overview of this research. Please read and sign accordingly.

Regards
Ms K. Reddy (MTech Chiropractic)
Researcher
(031) 373-2205/0834419271

APPENDIX A2

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Title of the Research Study: A comparative study of a novel and school issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu-Natal.

Principal Investigator/s/researcher: Kimera Reddy (BTech. Chiro)

Co-Investigator/s/supervisor/s: Dr H. Kretzmann (MTech. Chiro) and Dr P. Maharaj (MTech. Chiro.)

Brief Introduction and Purpose of the Study:

Permission for conduction of this research at New Forest High School is required from the Department of Education and the high school principal.

Scholars have been incorrectly using their backpack and therefore causing postural misalignment which will eventually lead to postural imbalance. The aim of this study is to determine the effect of a novel and school-issued backpack on high school adolescent posture. The company (Improved Postural Alignment for You) have claimed that their novel backpack is able to improve postural symmetry in a scholar. This research will attempt to investigate the validity of this claim.

Outline of the Procedures

Research will be conducted over 2 days at New Forest High School. You must first read this document. A sample size of one hundred 12 to14 year old scholars will be recruited. The scholar's will be required to wear shorts and a sleeve-less top on the day of this research conduction. The scholar will then be screened on the research day to determine whether he/she will be qualified for inclusion into this research. This requires the scholar to have a normal healthy BMI value, weight and height limit. If the scholar does not meet the required BMI value, weight and height limit then he/she will be excluded from this research on the day of conduction. Should the scholar be included in this research, reflective markers will be placed on specific anatomical landmarks on their body by the researcher (i.e. their ears, shoulders, knees). No further exposure of the body is required. After the reflective markers are placed the scholar will undergo a free photographic postural screening. The scholar's identity will be protected when photographs are being taken, their face will be censored and their name will not appear on this research. A form teacher will be present at the conduction of this research. The photographic procedure is expected to last approximately 5 minutes for each scholar. The scholar will proceed back to class once their photographs have been taken.

By signing this, you have agreed for conduction of this research to occur at New Forest High School over 2 days.

Consent for confidential Digital Photographs:

The photographs of the scholar will be taken using a digital camera. The scholar's wellbeing will not be harmed in any way. Photographs will be taken from the front and side views. The photographs will only be used for this research. I will use the photographs to assess possible postural deviations, by comparing the 2 backpacks (novel and school issued) to the scholar's normal posture (with no backpack). The scholar's name will not appear on the photographs. The scholar's name will not appear in my dissertation, or in any journal article. To further protect the scholar's identity, their face will be censored out when results are being transferred to the Posturepro 8 Computer Postural Software System.

By signing this consent form, you are also giving consent for the scholar's photograph to being taken at New Forest High School by the researcher.

To be part of this research the scholar must be:

1. High school scholars of 12-14 years of age. This is consistent with a study by Grimmer *et al*., (1999) in which he found significant postural change in the younger age group.
2. Scholars who are asymptomatic (pain free), in terms of any acute or current injury to the neck, pelvis and upper limb.
3. Scholars with a normal healthy BMI (15-23kg/m²). (Banas, 2010).*
4. Scholars with a normal healthy weight limit of 38-56kg (mean=47kg). (Harle, 2011).*
5. Scholars with a normal height limit of 1.4-1.6 m (mean=1.56m). (Callaway, 2010).*

***Please note**: The references above, pertaining to BMI, height and weight, have been replaced by new references in the dissertation: (Noyes, 2006; Schwanke, 2014 and Disabled World, 2014). This was due to the website being updated and the pages being removed.

The scholar will be excluded from this research if:

1. Scholars who do not return the signed letter of assent and information and informed consent by said date of collection **(Appendix C1/2)**.
2. Scholars who do not meet the required BMI, weight and height limit.
3. Scholars who have a history of neck or mid-back injury/trauma e.g. whiplash or spinal injury.
4. Scholars who have any clinically detectable abnormalities of the spine e.g. scoliosis / anterior head carriage.
5. Scholars who have any history of trauma to the extremities e.g. broken arms or a shoulder injury.

Risks or Discomforts to the scholar

No adverse effects are anticipated from this research.

Benefits:

- As remuneration for their participation, each scholar will be given a free educational "watch your back" pamphlet.

If you would like a copy of the end results to be emailed to you, please can you tick the box and fill in your email address in the space provided below:

Email address: _____ ☐

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

Kimera Reddy, researcher: 0834419271

Dr H. Kretzmann, supervisor: (031)2055520 Dr P. Maharaj, co-supervisor: (031)2627490

IN**STITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)**

LETTER OF CONSENT

Statement of Agreement to allow conduction of this Research:

- I hereby confirm that I have been informed by the researcher, Kimera Reddy, about the nature, conduct, benefits and risks of this research - Research Ethics Clearance Number: IREC 011/14
- I have also received, read and understood the above written information (Letter of Information) regarding this research.
- I am aware that the results of this research, including personal details regarding the scholar's: sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of this research, I agree that the data collected during this research can be processed in a computerised system by the researcher.
- I have had sufficient opportunity to ask questions.
- I understand that significant new findings developed during the course of this research, which may relate to the scholar's participation, will be made available to me at my request.
- I am aware that a copy of the end results of this research will be available to me at my request.

_____	_____	_____
Full Name of representative of the Department Of Education	**Date**	**Signature**

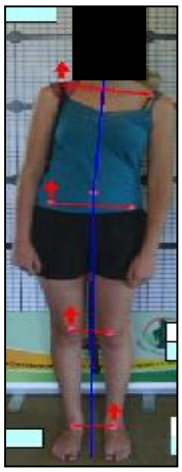
I, Kimera Reddy herewith confirm that the Department Of Education has been fully informed about the nature, conduct and risks of this research.

_____	_____	_____
Full Name of Researcher	**Date**	**Signature**
_____	_____	_____
Full Name of Supervisor	**Date**	**Signature**
_____	_____	_____
Full Name of Co-Supervisor	**Date**	**Signature**

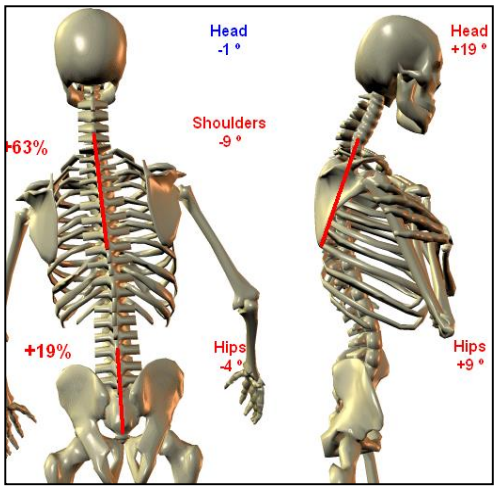
Photographic postural screening procedure

Reflective markers will be placed on the specific anatomical landmarks of the body (as shown in the flanking pictures, one marker will be placed between the scholars eye brows and one on the outside of their ear. Photographs will be taken from the front and side views. Landmarks on which the reflective markers will be placed will be the same for boys and girls. In this research the scholars will be wearing shorts and a sleeve-less top and no further exposure is required. First the photographs will be taken with no backpack, then with the school-issued backpack (A) and then with the novel backpack (B).

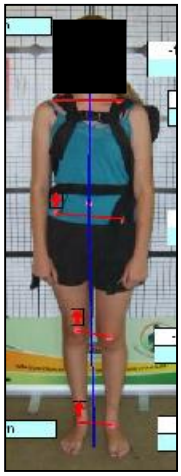
Example1: Photographic imaging with a school-issued backpack (A).



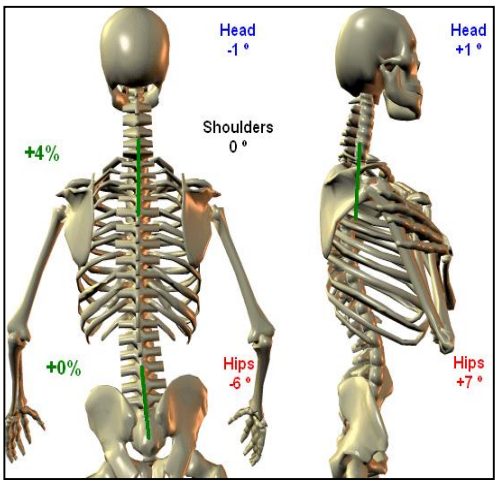
End results transferred to the Posturepro 8 Computer Postural Software System.



Photographic imaging with novel backpack (B)



End results transferred to the Posturepro 8 Computer Postural Software System.



APPENDIX B1

Letter of permission to the high school principal

Ethics reference number: IREC 011/14

Ms K.Reddy
11 Steve Biko Road
Ritson campus, Gate 6
Berea
Durban
4001
Tel: (031) 3732205

10/03/2014

Principal of New Forest High School
PO BOX, 53194
Yellowwood Park
Durban
4004

To: The School Principal

PERMISSION FOR THE CONDUCTION OF THIS RESEARCH AT NEW FOREST HIGH SCHOOL

My name is Kimera Reddy. I am a 6th year chiropractic master's degree student at the Durban University of Technology (DUT). I am also proud to have matriculated from New Forest High School in 2007.

I request your permission to conduct my research at New Forest High School. The title of this research is: A comparative study of a novel and school-issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu-Natal.

The conduction of this research requires the use of the high school premises over a 2 day period. A sample size of one hundred 12 to 14 year old scholars will be recruited provided that letters of information and informed consents are returned and they meet the required inclusion criteria on each day.

This research will pose no threat to the school or the scholars. No risk or discomfort is anticipated in this research. The scholar's identification will be protected. Scholars will undergo a free photographic postural screening. The aim of this study is to determine the effect of a novel and school-issued backpack on high school adolescent posture.

At the end of each research day, each participating scholar will be sponsored an educational "Watch your back" pamphlet compiled by the Chiropractic Association of South Africa (CASA).

This research is of benefit to the scholar however it is a voluntary process therefore no pressure will be placed on the scholars to participate.

It will give me great pleasure knowing that I have completed my research dissertation at this high school. The dissertation is the final part of me obtaining my MTech: Chiropractic degree.

Permission from you is required for me to access the high school learners, in order to conduct this research.

Your assistance would be highly appreciated and is vital to this research.

_____	_____	_____
Full Name of Principal	**Date**	**Signature**

I, Kimera Reddy herewith confirm that the high school principal has been fully informed about the nature, conduct and risks of this research.

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

_____	_____	_____
Full Name of Supervisor	**Date**	**Signature**

_____	_____	_____
Full Name of Co-Supervisor	**Date**	**Signature**

Attached is a letter of information and informed consent, providing a brief overview of this research. Please read and sign accordingly

Kind Regards
Ms K. Reddy (MTech Chiropractic)
Researcher
(031) 373-2205/0834419271

APPENDIX B2

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Title of this Research Study: A comparative study of a novel and school issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu- Natal.

Principal Investigator/s/researcher: Kimera Reddy (BTech. Chiro)

Co-Investigator/s/supervisor/s: Dr H. Kretzmann (MTech. Chiro) and Dr P. Maharaj (MTech. Chiro)

Brief Introduction and Purpose of this Research:

Permission for research conduction has been granted by the Department of Education and permission for research conduction at this high school is required by the school principal, the deputy principal and the chairperson of the governing body.

Scholars have been incorrectly using their backpack and therefore causing postural misalignment which will eventually lead to postural imbalance. The aim of this study is to determine the effect of a novel and school-issued backpack on high school adolescent posture.

The company (Improved Postural Alignment for You) have claimed that their novel backpack is able to improve postural symmetry in a scholar. This research will attempt to investigate the validity of this claim.

Outline of the Procedures

Research will be conducted over 2 days at this high school. You must first read this document. A sample size of one hundred 12 to 14 year old scholars will be recruited. The scholar's will be required to wear shorts and a sleeve-less top on the day of this research conduction. The scholar will then be screened on the research day to determine whether he/she will be qualified for inclusion into this research. This requires the scholar to have a normal healthy BMI value, weight and height limit. If the scholar does not meet the required BMI value, weight and height limit then he/she will be excluded from this research on the day of conduction. Should the scholar be included in this research, reflective markers will be placed on specific anatomical landmarks on their body by the researcher (i.e. their ears, shoulders, knees). No further exposure of the body is required. After the reflective markers are placed they will undergo a free photographic postural screening. The scholar's identity will be protected when photographs are being taken, their face will be censored and their name will not appear on this research. A form teacher will be present at the conduction of this research. The photographic procedure is expected to last approximately 5 minutes for each scholar. The scholar will proceed back to class once their photographs have been taken.

By signing this, you have agreed for this high school to be used by the researcher over 2 days and have allowed for the scholars of this high school to voluntarily participate in this research.

Consent for confidential Digital Photographs:

The photographs of the scholar will be taken using a digital camera. The scholar's wellbeing will not be harmed in any way. Photographs will be taken from the front and side views. The photographs will only be used for this research. I will use the photographs to assess possible postural deviations, by comparing the 2 backpacks (novel and school-issued) to the scholar's normal posture (with no backpack). The scholar's name will not appear on the photographs. The scholar's name will not appear in my dissertation, or in any journal article. To further protect the scholar's identity, their face will be censored out when results are being transferred to the Posturepro 8 Computer Postural Software System.

By signing this consent form, you are also giving consent for the scholar's photograph to being taken at this high school by the researcher.

To be part of this research the scholar must be:

1. High school scholars of 12-14 years of age. This is consistent with a study by Grimmer *et al*., (1999) in which he found significant postural change in the younger age group.
2. Scholars who are asymptomatic (pain free), in terms of any acute or current injury to the neck, pelvis and upper limb.
3. Scholars with a normal healthy BMI (15-23 kg/m^2). (Banas, 2010).*
4. Scholars with a normal healthy weight limit of 38-56 kg (mean=47 kg). (Harle, 2011).*
5. Scholars with a normal height limit of 1.4-1.6 m (mean=1.52 m). (Callaway, 2010).*

***Please note**: The references above, pertaining to BMI, height and weight, have been replaced by new references in the dissertation: (Noyes, 2006; Schwanke, 2014 and Disabled World, 2014). This was due to the website being updated and the pages being removed.

The scholar will be excluded from this research if:

1. Scholars who do not return the signed letter of assent and information and informed consent by said date of collection **(Appendix C1/2)**.
2. Scholars who do not meet the required BMI, weight and height limit.
3. Scholars who have a history of neck or mid-back injury/trauma e.g. whiplash or spinal injury.
4. Scholars who have any clinically detectable abnormalities of the spine e.g. scoliosis / anterior head carriage.
5. Scholars who have any history of trauma to the extremities e.g. broken arms or a shoulder injury.

Risks or Discomforts to the scholar

No adverse effects are anticipated from this research.

Benefits:

- As remuneration for their participation, each scholar will be given a free educational "watch your back" pamphlet.

If you would like a copy of the end results to be emailed to you, please can you tick the box and fill in your email address in the space provided below: ☐

Email address: _____

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

Kimera Reddy, researcher: 0834419271

Dr H. Kretzmann, supervisor: (031)2055520 Dr P Maharaj, co-supervisor: (031)2627490

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF CONSENT

Statement of Agreement for conduction of this Research at this high school:

- I hereby confirm that I have been informed by the researcher, Kimera Reddy, about the nature, conduct, benefits and risks of this research - Research Ethics Clearance Number: IREC 011/14
- I have also received, read and understood the above written information (Letter of Information) regarding this research.
- I am aware that the results of this research, including personal details regarding the scholar's: 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 research can be processed in a computerised system by the researcher.
- I have had sufficient opportunity to ask questions.
- I understand that significant new findings developed during the course of this research, which may relate to the scholar's participation, will be made available to me at my request.
- I am aware that a copy of the end results of this research will be available to me at my request.

_____ _____ _____

Full Name of Principal **Date** **Signature**

I, Kimera Reddy herewith confirm that the High school principal has been fully informed about the nature, conduct and risks of this research.

_____ _____ _____

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

_____ _____ _____

Full Name of Deputy Principal **Date** **Signature**

_____ _____ _____

Full Name of chairperson **Date** **Signature**

_____ _____ _____

Full Name of Supervisor **Date** **Signature**

_____ _____ _____

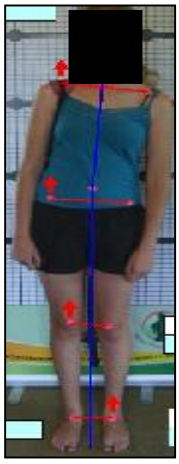
Full Name of Co-Supervisor **Date** **Signature**

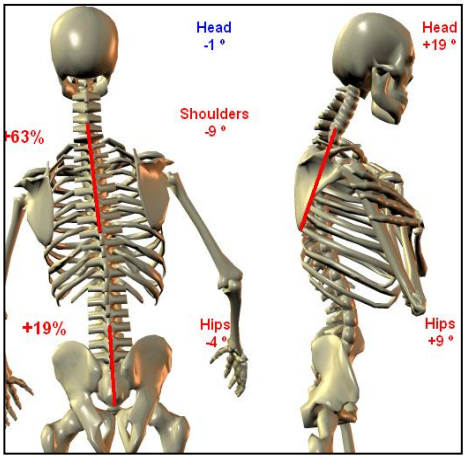
Photographic postural screening procedure

Reflective markers will be placed on the specific anatomical landmarks of the body (as shown in the flanking pictures, one marker placed between the scholar's eye brows and one on the outside of their ear). Photographs will be taken from the front and side views. Landmarks on which the reflective markers are applied will be the same for boys and girls. In this research the scholars will be wearing shorts and a sleeve-less top and no further exposure is required. First the photographs will be taken with no backpack, then with the school-issued backpack (A) and then with the novel backpack (B).

Example1: Photographic imaging with a school-issued backpack (A).

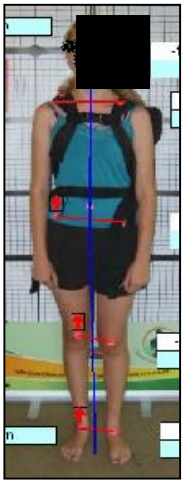
End results transferred to the Posturepro 8 Computer Postural Software System

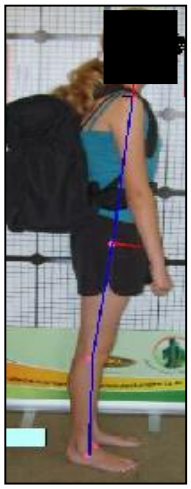


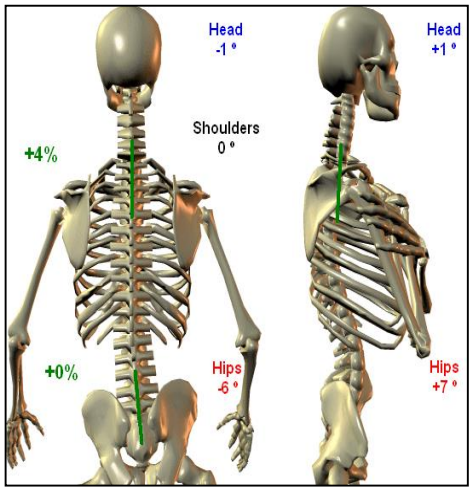


Photographic imaging with novel backpack (B)

End results transferred to the Posturepro 8 Computer Postural Software System







APPENDIX C1

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Title of the Research Study: A comparative study of a novel and school-issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu- Natal.

Principal Investigator/s/researcher: Kimera Reddy (BTech. Chiro)

Co-Investigator/s/supervisor/s: Dr. H. Kretzmann (MTech. Chiro) and Dr P. Maharaj (MTech. Chiro.)

Brief Introduction and Purpose of the Study:

Permission has been granted by the Department of Education and the school principal for the conduction of this research to be performed at this high school. Your assistance would be highly appreciated and is vital to this research. Therefore you must first read through this document

Scholars have been incorrectly using their backpack and therefore causing postural misalignment which will eventually lead to postural imbalance. The aim of this study is to determine the effect of a novel and school issued backpack on high school adolescent posture.

The company (Improved Postural Alignment for You) have claimed that their novel backpack has the ability to improve postural symmetry in a scholar. This research will attempt to investigate the validity of this claim.

Outline of the Procedures

Research will be conducted over 2 days at this high school. A sample size of one hundred 12 to 14 year old scholars will be recruited. Your child will be required to wear shorts and a sleeve-less top on the day of this research conduction. Your child will then be screened on the research day to determine whether he/she will be qualified for inclusion into this research. This requires your child to have a normal healthy BMI value, weight and height limit. If your child does not meet the required BMI value, weight and height limit then he/she will be excluded from this research on the day of conduction. Should your child be included in this research, reflective markers will be placed on specific anatomical landmarks on their body, by the researcher (i.e. their Ears, shoulders, knees). No further exposure of the body is required. After the reflective markers are placed they will undergo a free photographic postural screening. Your child's identity will be protected when photographs are being taken, their face will be censored and their name will not appear on this research. A form teacher will be present at the conduction of this research. The photographic procedure is expected to last approximately 5 minutes for each child. Your child will proceed back to class once their photographs have been taken.

By signing this, you have agreed for your child to voluntarily participate in this research.

Should you wish to be present on this research day, please tick the box and write down your cell-phone details in the space provided below. The date of the photographic postural screening will be sms'd to you.

Cell-phone number: _____ ☐

Consent for confidential Digital Photographs:

The photographs of your child will be taken using a digital camera. Your child's wellbeing will not be harmed in any way. Photographs will be taken from the front and side views. The photographs will only be used for this research. I will use the photographs to assess possible postural deviations, by comparing the 2 backpacks (novel and school-issued) to your child's normal posture (with no backpack). Your child's name will not appear on the photographs. Their name will not appear in my dissertation, or in any journal article. To further protect your child's identity, their face will be censored out when results are being transferred to the Posturepro 8 Computer Postural Software System. By signing this consent form, you are also giving consent for your child's photograph to being taken.

To be part of this research your child must be:

1. High school scholars of 12-14 years of age. This is consistent with a study by Grimmer *et al*., (1999) in which he found significant postural change in the younger age group.
2. Scholars who are asymptomatic (pain free), in terms of any acute or current injury to the neck, pelvis and upper limb.
3. Scholars with a normal healthy BMI (15-23kg/m²). (Banas, 2010).*
4. Scholars with a normal healthy weight limit of 38-56kg (mean=47kg). (Harle, 2011).*
5. Scholars with a normal height limit of 1.4-1.6m (mean=1.52). (Callaway, 2010).*

***Please note**: The references above, pertaining to BMI, height and weight, have been replaced by new references in the dissertation: (Noyes, 2006; Schwanke, 2014 and Disabled World, 2014). This was due to the website being updated and the pages being removed.

Your child will be excluded from this research if:

1. Scholars who do not return the signed letter of assent and information and informed consent by said date of collection **(Appendix C1/2)**.
2. Scholars who do not meet the required BMI, weight and height limit.
3. Scholars who have a history of severe neck or mid-back injury/trauma e.g. whiplash or spinal injury.
4. Scholars who have any clinically detectable abnormalities of the spine e.g. scoliosis
5. Scholars who have any history of severe trauma to the extremities e.g. broken arms or a shoulder injury.

Please tick this box if your child has any of the pre-existing conditions as listed above. This will automatically exclude your child from this research. ☐

Risks or Discomforts to your child:

No adverse effects are anticipated from this research.

Benefits should your child be included in this research:

- As remuneration for their participation, each child will be given a free educational "watch your back" pamphlet.

A copy of the end results of the photographic postural screening will be made available to the school principal of New Forest High school. If you would like a copy of the end results to be emailed to you, please can you tick the box and fill in your email address in the space provided below: ☐

Email address: _____

Persons to Contact in the Event of Any Queries:

Kimera Reddy, Researcher: 0834419271/ (031)3732205

Dr H. Kretzmann, supervisor: (031)2055520 Dr P Maharaj, co-supervisor: (031)2627490

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF CONSENT

Statement of Agreement to Participate in this Research:

- I hereby confirm that I have been informed by the researcher, Kimera Reddy, about the nature, conduct, benefits and risks of this research - Research Ethics Clearance Number: IREC 011/14
- I have also received, read and understood the above written information (Letter of Information) regarding this research
- I am aware that the results of this research, including personal details regarding my child's sex, age, date of birth, initials and diagnosis will be anonymously processed into this research report.
- In view of the requirements of research, I agree that the data collected during this research can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation of my child in this research.
- I have had sufficient opportunity to ask questions and (of my own free will) hereby permit the participation of my child in this research.
- I understand that significant new findings developed during the course of this research, which may relate to my child's participation, will be made available to me.
- I understand that a copy of the end results of this research will be made available to me at my request

_____ _____ _____

Full Name of parent/Legal guardian **Date** **Signature**

I, Kimera Reddy herewith confirm that the Parent/ Legal guardian has been fully informed about the nature, conduct and risks of this research.

_____ _____ _____

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

_____ _____ _____

Full Name of Witness **Date** **Signature**

_____ _____ _____

Full Name of Supervisor **Date** **Signature**

_____ _____ _____

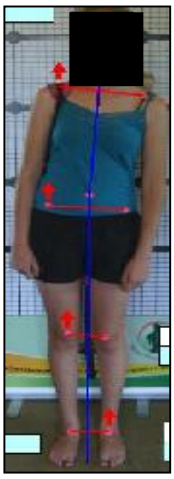
Full Name of Co-Supervisor **Date** **Signature**

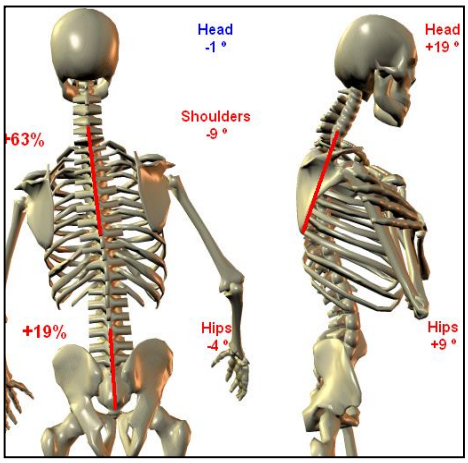
Photographic postural screening procedure

Reflective markers will be placed on the specific anatomical landmarks of the body (as shown in the flanking pictures, one marker will be placed between the scholars eye brows and one on the outside of their ear). Photographs will be taken from the front and side views. Landmarks on which the reflective markers are applied will be the same for boys and girls. In this research the scholars will be wearing shorts and a sleeve-less top and no further exposure is required. First the photographs will be taken with no backpack, then with the school-issued backpack (A) and then with the novel backpack (B).

Example1: Photographic imaging with a school-issued backpack (A).

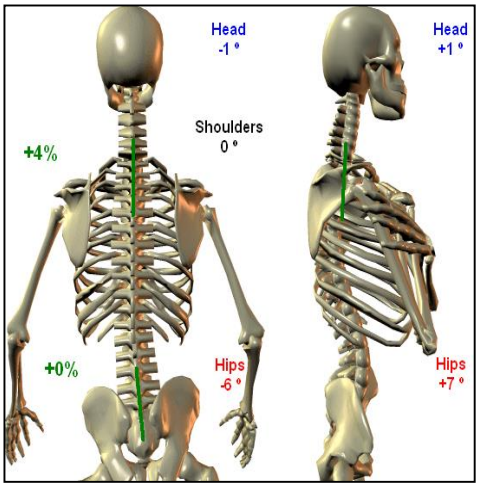
End results transferred to the Posturepro 8 Computer Postural Software System





Photographic imaging with novel backpack (B)

End results transferred to the Posturepro 8 Computer Postural Software System



APPENDIX C1

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Mbandakanyi Othandekayo

Isihloko socwaningo: Ucwaningo lokuqhathanisa isikhwama esisanda kukhiqizwa kanye naleso abantwana abanikwa sona emazingeni aphezulu esikoleni New Forest High School nokubuka indlela abamisa ngayo umzimba Ethekwini esifundazweni iKwazulu-Natal.

Umcubungulu omkhulu/umcwaningi: Kimera Reddy (BTech. Chiro)

Umcubungulu wesibili/umphathi: Dk H. Kretzmann (MTech. Chiro) and Dk P. Maharaj (MTech. Chiro.)

Incazelo emfishane nenhloso ngalolucwaningo:
Imvume ngiyinikeziwe Umnyango Wezemfundo (HODoe) nothishanhloko wesikole ukuthi ngenze lolucwaningo kulesissikole. Kumele ufunde lencwadi kuqala.

Abafundi banokusebenzisa izikhwama zokuphatha izincwadi ngendlela okungeyona okwenza umzimba ungami ngendlela efanele okungenza kuthikameze umgogodla wabo. Lolucwaninngo luhlose ukuqhathanisa isikhwama esisanda kukhiqizwa kanye naleso abantwana abanikwa sona emazingeni aphezulu esikoleni nokubuka indlela abamisa ngayo umzimba.

Inkampani(Improved Postural Alignment for You) bathi isikhwama sabo esisanda kukhiqizwa siyakwazi ukwenza ngcono indlela abafundi abamisa ngayo umzimba. Lolucwaningo luhlose ukucubungula lokhu lenkampani ekushoyo.

Inqubo yalolucwaningo:
Lolucwaningo luzoqhubeka izinsuku ezimbili emazingeni aphezulu esikoleni. Kuyothathathwa abayikhulu kubantwana beminyaka eyishumi nambili kuya kwishuminane. Umntwana wakho kuzomelle agqoke isikhindi nesikhibha esinemikhono emifishane ngezinsuku lolucwaningo lwenziwa. Umntwana wakho uzohlolwa kubhekwe ukuthi angakwazi yini ukuba yingxenye yalolucwaningo. Lokhu kudinga ukuthi umntwana wakho abe nobude nesisindo esilingene. Uma umntwana wakho engenaso isisindo nobude obulingene angeke akwazi ukuba ingxenye yalolucwaningo. Uma umntwana wakho ekhethiwe ukuthi abe ingxenye yalolucwaningo umcwaningi uzobe esenamathisela izitikha emadlebeni, emahlombe, nasemadolweni. Ngeke umntwana akhunyuliswe akugqokile.. uma izitikha sezinamathelisiwe kuzobe sekuthathwa isithombe. Amagama omntwana wakho angeke adalulwe, nobuso ngeke buvezwe kulolucwaningo. Uthisha uzobe ekhona ngesikhathi lolucwaningo lwenziwa. Lokhu kuthathwa kwezithombe kuzothatha imizuzu eyisihlanu(5) umntwana emunye. Umintwana uyobe esebuyela ekilasini uma eseqedile.

Ngokusayina lencwadi uvuma ngokuthanda ukuthi umtntwana abe ingxenye yalolucwaningo.

Uma ufisa ukuba khona ngosuku locwaningo faka uphawu lokumaka bese ubhala inamba yocingo kulolayini ongezansi. Usuku nesikhathi lokuthathwa kwezithombe kuzobe sekuthunyelwa kuwe ngocingo.

inamba yocingo:_____

Imvume eyimfihlo yokuthathwa kwezithombe:

Izithombezizothathwa kusetshenziswa ikhamera edijithali. Akukho okuzolimaza umntwana wakho. Izithombe zizothathwa ngasemacaleni omzimba. Lezizithombe zizosetshenziselwa lolucwaningo kuphela. Ngizosebenzisa lezizithombe ukubona ukuthi umntwana wakho uma ngendlela okuyiyo na, ngokuqhathanisa isikhwama esisanda kukhiqizwa kanye naleso abantwana abanikwa sona emazingeni aphezulu esikoleni nalapho engaphethe khona isikhwama. Igama lomntwana wakho alizukuvezwa ezithombeni. Angeke futhi livezwe igama lakhe emqulwini wencwadi yocwaningo lwami, noma emqulwini wocwaningo. Ukukhusela umntwana wakho, ubuso bakhe ngeke buvezwe. Ngokusayina lencwadi unika imvume ukuthi kuthathwe isithombe somntwana wakho.

Ukuze umntwana wakho abe ingxenye yalolucwaningo kumele:

1. Abafundi basemabangeni aphezulu esikoleni abaneminyaka ewu 12-14. Lokhu kuhambisana nokwenziwa uGrimmer nabanye ukuhlola indlela yokuma ezinganeni.
2. Abafundi abangaguli(abangenazinhlungu), abangalimele emqaleni, esinqeni nasezingalweni.
3. Abafundi abanesisindo nobude obulingene(15-23kg/m²). (Livingstrong, 2010).*
4. Abafundi abanesisindo esinempilo esiwu 38-56kg (i-avareji=47kg). (Livingstrong, 2011).*
5. Abafundi abanobude obujwayelekile 1.4-1.6m (i-avareji = 1.56m). (Livestrong, 2010).*

***Please note**: The references above, pertaining to BMI, height and weight, have been replaced by new references in the dissertation: (Noyes, 2006; Schwanke, 2014 and Disabled World, 2014). This was due to the website being updated and the pages being removed.

Umntwana wakho ngeke abe ingxenye yalolucwaningo uma e:

1. Engabuyisi izincwadi zolwazi nemvume zisayiniwe umzali kanye nomntwana, zibuyiswe futhi ngosuku locwaningo**(isaziso C1/2).**
2. Abafundi abangenasi isisindo nobude obulingene.
3. Abafundi abake balimala emqaleni noma emgogodleni.
4. Abafundiokubonakala benemiqolo engaphilile.
5. Abafundi abake balimala ezingalweni.

Ngicela ufake uphawu lokumaka uma umntwana enalokhu okubaliwe ngaphezulu, okuyokwenza ukuthi umntwana angakwazi ukuba ingxenye yalolucwaningo. ☐

Ukulimala /ubungozi obuqondene nocwaningo:
Abukho ubungozi obulindelekile kulolucwaningo.

Uzozuzani umntwana uma ekhethiwe ukuba ingxenye yalolucwaningo?
Ukubonga umntwana ngokuba ingxenye yalolucwaningo uzothola ibhuku elimluleka ngokuphatha kahle umqolo wakhe.

Imininingwane ethlakele yashicilelwa yezithombe ezithathiwe ungayithola kuthisanhloko wase New Forest High School. Uma ufisa futhi ukuthi sikuthumelele nge email, ngicela ufake iemail yakho bese ufaka nophawu olushoyo esikhaleni esinikiwe:

Email: _____ ☐

Ngobani ongabathinta uma kukhona ofuna ukukubuza:
Kimera Reddy, umcwaningi: 0834419271 / (031)3732205
Dk H. Kretzmann**,** umphathi,: (031)3732205
Dk. P. Maharaj, usekela mphathi: (031) 2627490

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Isitatimende sesivumelwano sokuzibandakanya kulolucwaningo:

- Ngiyaqinisekisa ukuthi ngitsheliwe ngumcwaningi, **Kimera Reddy** ,ngohlobo, ngokuziphatha, nangosizo, nangobungozi balolucwaningo – Research Ethics Clearance Number: IREC 011/14
- Ngiyitholile, futhi ngayifunda, ngayizwa incwadi (incwadi yombandakanyi) echaza ngalolucwaningo(incwadi yombandakanyi).
- Ngiyazi futhi ukuthi imiphumela yalolucwaningo, imininingwane yami ephathelene nobulili, iminyaka, usuku lokuzalwa, amagama afingqiwe(initials) and isifo esingiphethe kuzodalulwa kumbiko walolucwaningo ngale koludalula amagama ami.
- Ngokubuka okudingekayo kulolucwaningo, ngiyavuma ukuthi imininingwane etholakele ngesikhathi lolucwaningo luqhubeka umcwaningi alufake kuhlelo lwekhompuyutha.
- Noma ngasiphi isikhathi, ngale kokucwaseka, ngingayeka ukuba umbandakanyi kulolucwaningo.
- Ngibe nesikhathi esanele sokubuza imibuzo (ngentando yami) nokuzilungiselela ukuba yingxenye yalolucwaningo.
- Ngiyaqonda ukuthi imiphumela yokuthathwa kwesithombe sokuma komntwana wami ngingayithola uma ngiyicela.

…… …… ……

gama lomzali/umvikeli osemthethweni **Usuku** **isiginisha/isithupha**

Mina **Kimera Reddy** ngiyaqinisekisa ukuthi lomzali/umvikeli osemthethweni uthole incazelo egcwele mayelana nohlobo, ngokuziphatha, nangosizo, nangobungozi balolucwaningo

…… …….. …….

Igama lomucwaningi **Usuku** **Isiginisha yomcwaningi**

…… …… ……..

Igama likafakazi **Usuku** **Isiginisha kafakazi**

…… …… ……..

Igama lomphathi wocwaningo **Usuku** **Isiginisha**

…… …….. ……..

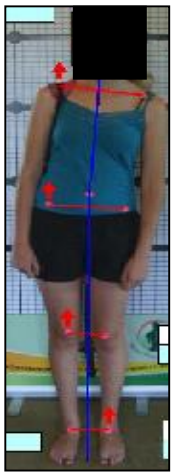
Igama likasekela mphathi wocwaningo **Usuku** **Isiginisha**

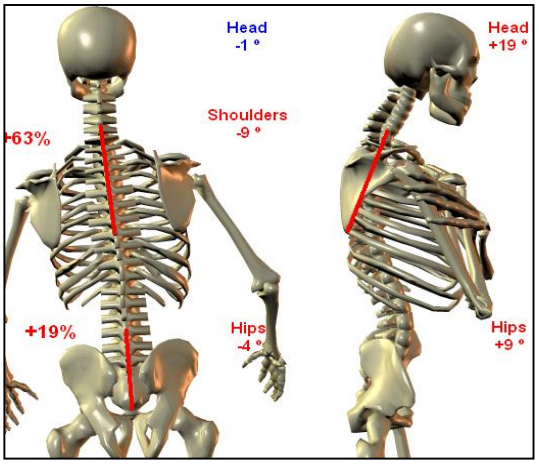
UKUTHATHWA KWEZITHOMBE UKUKHOMBISA UMOMO WOMGOGLA

Sizosebenzisa izembozo ezizokwenza ukuthi umuntu angabonakali ukuthi ungubani (njengoba isithombe sikhombisa). Isembozo lesi sizoba kumashiya omfundi kanti esinye sizobekwa semboze indlebe. Izothombe zizothathwa ngaphambili kanye naseceleni ukuthola izinhlangothi zombili. Indlela ekusetshenziswa ngayo isembozo iyofana kanye nakubafana namantombazane. Kulolucwaningo abafana namatombazane bayogqoka izikhindi Kanye. Bayothathwa izithombe okukuqala besebenzisa isikhwama sesikole esijwayelekile (A) bese bethathwa futhi besebenzisa lesi socwaningo inovel (B).

Ukuthathwa kwesithombe nesikhwama sesikhole esijwayelekile (A)

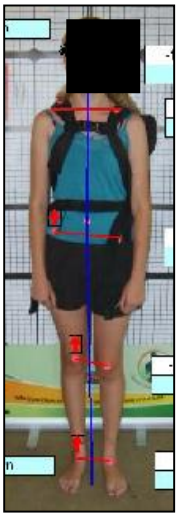
Imiphumela idluliselwa kwikhompiyutha ebonisa ukuhlala kwesikhwama esijwayelekile sesikole.

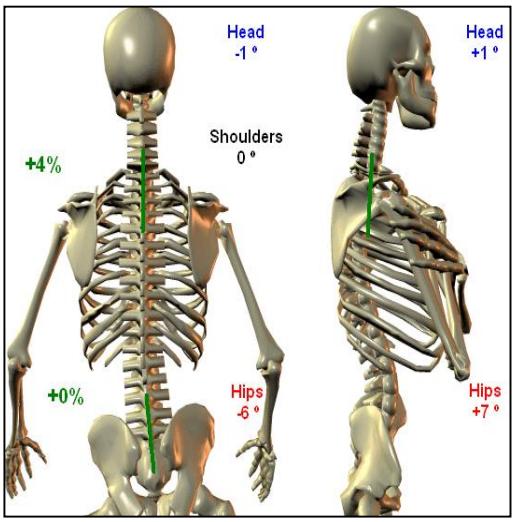




Ukuthathwa kwesithombe nalesisikhwama inovel(B)

Imiphumela idluliselwa kwikhompiyutha ebonisa ukuhlala kwesikhwama inovel.





APPENDIX C2

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION AND INFORMED CONSENT

Title of the Research Study: A comparative study of a novel and school-issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu- Natal.

Principal Investigator/s/researcher: Kimera Reddy (BTech. Chiro)

Co-Investigator/s/supervisor/s: Dr H. Kretzmann (MTech. Chiro) and Dr P. Maharaj (MTech. Chiro.)

Introduction:

Permission has been granted by the Department of Education and the school principal for the conduction of this research to be performed at this high school. I humbly ask you to participate in my study. Your help would be highly appreciated and important to this research.
First you must read through this document for better understanding.

Why I am doing this study: Scholars have been incorrectly using their backpack and therefore causing postural misalignment which will eventually lead to postural imbalance. The aim of this study is to determine the effect of a novel and school-issued backpack on high school adolescent posture.

The company (Improved Postural Alignment for You) have claimed that their novel backpack has the ability to improve postural symmetry in a scholar. This research will attempt to investigate the validity of this claim.

Outline of the Procedures

Research will be conducted over 2 days at this high school. A sample size of one hundred 12 to 14 year old scholars will be recruited. You will be required to wear shorts and a sleeve-less top on the day of this research conduction. You will then be screened on the research day to determine whether you will be qualified for inclusion into this research. This requires you to have a normal healthy BMI value (body-mass index), weight and height limit. If you do not meet the required BMI value, weight and height limit then you will be excluded from this research on the day of conduction. Should you be included in this research, reflective markers will be placed on specific anatomical landmarks on your body by the researcher (i.e. ears, shoulders, knees). No further exposure of your body is required. After the reflective markers are placed you will undergo a free photographic postural screening. Your identity will be protected when photographs are being taken, your face will be censored and your name will not appear on this research. A form teacher will be present at the conduction of this research. The photographic procedure is expected to last approximately 5 minutes for each participating scholar. You will proceed back to class once your photographs have been taken.

By signing this, you have agreed to voluntarily participate in this research.

Consent for confidential Digital Photographs:

The photographs of you will be taken using a digital camera. Your well-being will not be harmed in any way. Photographs will be taken from the front and side views. The photographs will only be used for this research. I will use the photographs to assess possible postural deviations, by comparing the 2 backpacks (novel and school issued) to your normal posture (with no backpack). Your name will not appear on the photographs. Your name will not appear in my dissertation, or in any journal article. To further protect your identity, your face will be censored out when results are being transferred to the Posturepro 8 Computer Postural Software System. By signing this consent form, you are also giving consent for your photograph to being taken.

You will be part of this research if:

1. You are between 12-14 years of age. This is consistent with a study by Grimmer *et al*., (1999) in which he found significant postural change in the younger age group.
2. You are asymptomatic (pain free), in terms of any acute or current injury to the neck, pelvis and upper limb.
3. You have a normal healthy BMI (15-23kg/m²). (Banas, 2010).*
4. You have a normal healthy weight limit of 38-56kg (mean=47kg) (Harle, 2011).*
5. You have a normal height limit of 1.4-1.6m (mean=1.52m). (Callaway, 2010).*

***Please note**: The references above, pertaining to BMI, height and weight, have been replaced by new references in the dissertation: (Noyes, 2006; Schwanke, 2014 and Disabled World, 2014). This was due to the website being updated and the pages being removed.

You will not be part of this research if:

1. You do not return the signed letter of assent and information and informed consent by said date of collection **(Appendix C1/2)**.
2. You do not meet the required BMI, weight and height limit.
3. You have a history of severe neck or mid-back injury/trauma e.g. whiplash or spinal injury.
4. You have any clinically detectable abnormalities of the spine e.g. scoliosis
5. You have any history of severe trauma to the extremities e.g. broken arms or a shoulder injury.

Please tick this box if you have any of the pre-existing conditions as listed above. This will automatically exclude you from this research. ☐

Risks or Discomforts to yourself:

No adverse effects are anticipated from this research.

Benefits should you be included in this research:

- As remuneration for your participation, you will be given a free educational “watch your back” pamphlet.

A copy of the end results of this research will be made available to the principal of your high school and to your parents at their request.

Persons to Contact in the Event of Any Queries:

Kimera Reddy, Researcher: 0834419271/ (031)3732205

Dr H. Kretzmann, supervisor: (031)2055520

Dr P. Maharaj, co-supervisor: (031)2627490

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

LETTER OF CONSENT

Statement of Agreement to Participate in this Research:

- I hereby confirm that I have been informed by the researcher, Kimera Reddy, about the nature, conduct, benefits and risks of this research - Research Ethics Clearance Number: IREC 011/14.
- I have also received, read and understood the above written information (Participant Letter of Information) regarding this research
- I am aware that the results of this research, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into this research report.
- In view of the requirements of research, I agree that the data collected during this research can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in this research.
- I have had sufficient opportunity to ask questions and (of my own free will) hereby permit the participation of myself in this research.
- I understand that a copy of the end results of this research will be made available to the high school principal and my parent at their request.

_____	_____	_____
Full Name of scholar	**Date**	**Signature**

I, Kimera Reddy herewith confirm that the scholar has been fully informed about the nature, conduct and risks of this research.

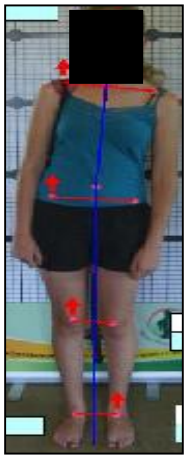
_____	_____	_____
Full Name of Researcher	**Date**	**Signature**
_____	_____	_____
Full Name of Witness	**Date**	**Signature**
_____	_____	_____
Full Name of Supervisor	**Date**	**Signature**
_____	_____	_____
Full Name of Co-Supervisor	**Date**	**Signature**

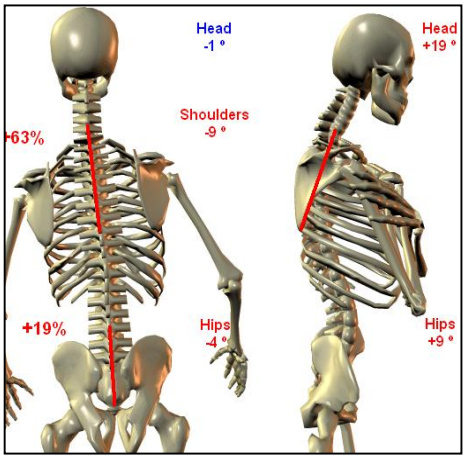
Photographic postural screening procedure

Reflective markers will be placed on the specific anatomical landmarks of your body (as shown in the flanking pictures, one marker will be placed between your eye brows and one on the outside of your ear). Photographs will be taken from the front and side views. Landmarks on which the reflective markers are applied will be the same for boys and girls. In this research the scholars will be wearing shorts and a sleeve-less top and no further exposure is required. First the photographs will be taken with no backpack, then with the school-issued backpack (A) and then with the novel backpack (B).

Example1: Photographic imaging with a school-issued backpack (A).

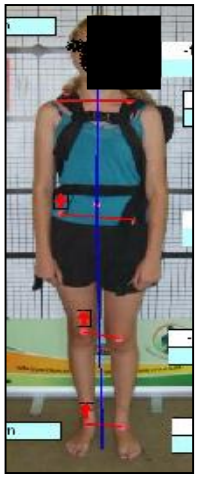
End results transferred to the Posturepro 8 Computer Postural Software System

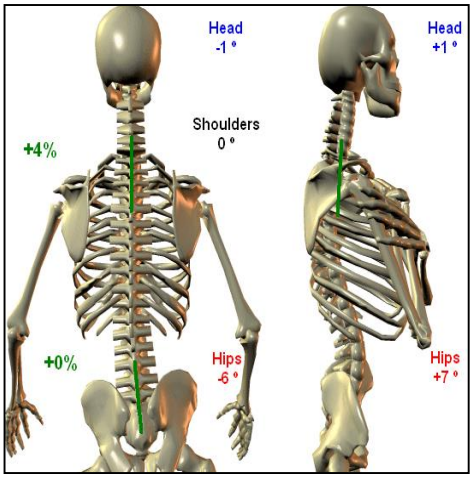




Photographic imaging with novel backpack (B)

End results transferred to the Posturepro 8 Computer Postural Software System





APPENDIX D

Ethics reference number: IREC 011/14

Durban University of Technology

Memorandum of understanding between:

The RESEARCH INSTITUTION'-Durban University of Technology (this includes the respective research student and research supervisor, Department of Chiropractic. The Faculty of Health Sciences Research Committee, The Institutional Research Committee and any other related DUT employees.

AND

The "MANUFACTURER"- IPA4U (including all members, employees, associates)

This Memorandum of Understanding pertains to the following research project and must be read in conjunction with:

APPENDIX A-Detailed Research Proposal (PG4a)

APPENDIX B-Durban University of Technology Research Committee Research Ethics Policy and Guidelines

Title of the study:

A comparative study of a novel and school issued backpack on high school adolescent posture at the New Forest High school in the eThekwini district of KwaZulu-Natal.

Research Student: Kimera Reddy Student No: 20800238

Research Supervisor: Dr H. Kretzmann (MTech: Chiropractic-Durban University of Technology)

Research Co-Supervisor: Dr P. Maharaj (MTech: Chiropractic- Durban University of Technology)

This study is a Master's Mini Dissertation conducted in partial compliance with the Master's Degree in Technology in the Department of Chiropractic-Faculty of Health Sciences-Durban University of Technology. This study will obtain ethical approval from the Faculty of Health Sciences Research & Ethics Committee (FRC) of Durban University of Technology.

Section 1-Funding of the study and financial commitment

1.1 A research allowance of R5000.00 has been awarded by the Dept. Post-graduate Development & Support –The details of the funds approved are described in Section A of the Research Proposal (PG4a) attached.

1.2 The 'MANUFACTURER'-will donate (free of charge) the respective IPA4U backpacks sufficient to meet the requirements described in the research proposal PG4a attached and the 'MANUFACTURER' will sponsor R500 to the researcher to use in the research, as stated in the PG4a attached.

1.3 The 'MANUFACTURER'-acknowledges that THE RESEARCH INSTITUTION' will have no financial obligations or commitments to the 'MANUFACTURER' what so ever as a result of conducting this study.

1.4 The 'MANUFACTURER'-(with the exception of Section 1.2) may not award or incentivize the study or its related parties in any manner what so ever, nor remunerate, award or offer any financial or other donation or gift to any of those involved with the study.

Section 2-Academic processes and outcome

2.1 The FRC has approved the above mentioned Research Supervisor who in conjunction with the Research Student is the sole contributors to the academic content, procedures, results and findings of the study based on the prescribed data analysis in the research proposal, barring amendments required by the approved research examiners appointed by the RESEARCH INSTITUTION.

2.2 The 'MANUFACTURER' acknowledges that the findings upon completion of the study (as determined by the Research Student and Research Supervisors and according to the protocol stated in the attached research proposal) will be final and non-negotiable.

The 'MANUFACTURER'-acknowledges further that it has no authority over the outcome of this study and may not influence the findings or the reporting thereof in any matter.

2.3 Any modification or deviation from the approved research proposal must be applied for in writing, endorsed by both the Research Student & Supervisors and Head of Department before serving before the FRC/IREC, the final say therein will be determined by the FRC/IREC.

2.4 The 'MANUFACTURER'-acknowledges that it may not influence or make any change to the approved research protocol/proposal.

2.5 The "MANUFACTURER"- acknowledges that use of the IPA4U name will be stated in this research.

Section 3-Publication of findings

3.1 The findings and outcome of the above mentioned study remain the intellectual property of the 'RESEARCH INSTITITION' indefinitely. The study will be published in the format of a hard bound dissertation which will be placed in the DUT library.

3.2 Publication of the findings of this study in a journal or other scholarly medium will be at the discretion of the Research student and /or Research Supervisors who will determine the appropriate medium and place of publication as well as content of the publication. Authorship of any scholarly output originating from this study of the Research Student and Research Supervisors and other collaborators appointed by the Research Student and/or the Research Supervisors. Such scholarly publication must include the names of the Researcher and the Research Supervisor as well as the 'RESEACH INSTITUTION'.

3.3 Any reference what so ever to the findings of this study if quoted or mentioned in any format must make formal reference to the respective dissertation its official title and its author(s) and the owners of the intellectual property thereof i.e. the 'RESEARCH INSTITUTION'.

3.4 Any reference what so ever to any secondary publication arising from this original study must make formal reference to the respective dissertation its official title and its author(s) and the owners of the intellectual property thereof i.e. the 'RESEARCH INSTITUTION'

3.5 The 'MANUFACTURER'-may make reference to the outcome of this study in the prescribed manner mentioned in section 3.3 and 3.4 undertaking 3.1 and 3.2.

3.6 The "MANUFACTURER" acknowledges that the IPA4U name will be stated if the results of this research are published in any medical journals.

Section 4-Indemnity

4.1 The Research Student, the Research Supervisor and the research facilities and its staff are duly covered by the 'RESEARCH INSTITUTION' insurance policy pertaining to public liability, injury or harm which may occur as a result of conducting this study.

4.2 The 'MANUFACTURER'-undertakes to indemnify the 'RESEARCH INSTITUTION' with regard to any outcome, incidents, injury or harm which occurs as a result of the conduction of this study including the results of the study and publication thereof.

Section 5

5.1 Ethical clearance of the proposed study will be granted by the DUT IREC (such ethical clearance become invalid should there be any deviation from the approved research methodology described in the research proposal attached).

5.2 The 'MANUFACTURER' undertakes to abide by the DUT Research Committee Research Ethics Policy and Guidelines (APPENDIX B).

5.3 In addition to 5.2 the 'MANUFACTURER should note and refer to **Section 1.4,2 & 3** of this document.

I Ms/ Mrs. Rita Botha hereby in my official capacity as representative of IPA4U hereby agree to abide by the regulations stated in this memorandum of understanding between the 'MANUFACTURER' and the 'RESEARCH INSTITUTION'

_____ _____

Signature of official representative of the 'MANUFACTURER' Date

I **Miss Kimera Reddy** hereby in my capacity as **the research student** hereby agree to abide by the regulations in this memorandum of understanding between the 'MANUFACTURER' and the 'RESEARCH INSTITUTION'

_____ _____

Signature of Research Student Date

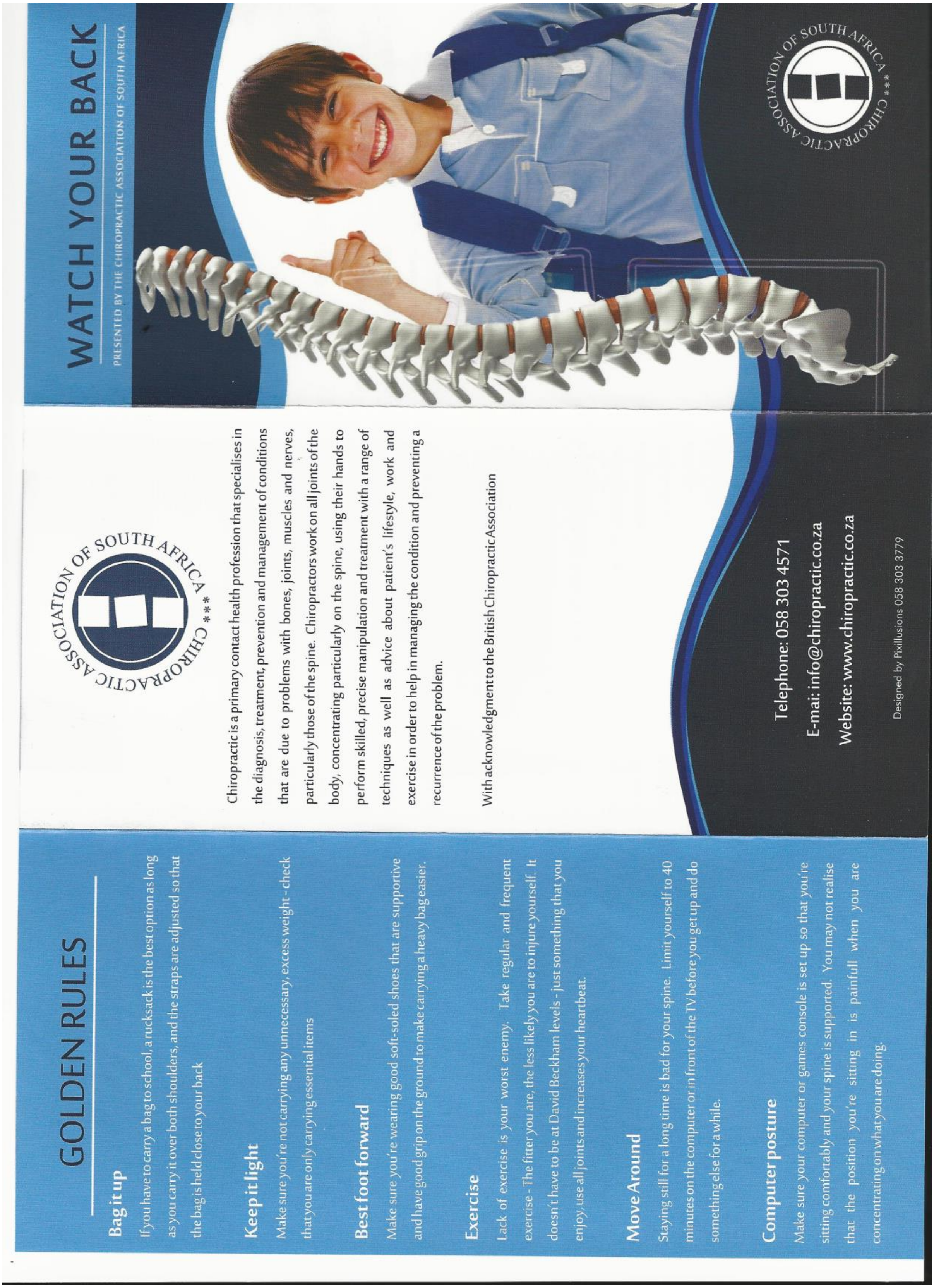
_____ _____

Signature of Supervisor Date

_____ _____

Signature of HOD Date

APPENDIX E



WATCH YOUR BACK

PRESENTED BY THE CHIROPRACTIC ASSOCIATION OF SOUTH AFRICA

CHIROPRACTIC ASSOCIATION OF SOUTH AFRICA

Telephone: 058 303 4571

E-mai: info@chiropractic.co.za

Website: www.chiropractic.co.za

Designed by Pixillusions 058 303 3779

Chiropractic is a primary contact health profession that specialises in the diagnosis, treatment, prevention and management of conditions that are due to problems with bones, joints, muscles and nerves, particularly those of the spine. Chiropractors work on all joints of the body, concentrating particularly on the spine, using their hands to perform skilled, precise manipulation and treatment with a range of techniques as well as advice about patient's lifestyle, work and exercise in order to help in managing the condition and preventing a recurrence of the problem.

With acknowledgment to the British Chiropractic Association

GOLDEN RULES

Bag it up

If you have to carry a bag to school, a rucksack is the best option as long as you carry it over both shoulders, and the straps are adjusted so that the bag is held close to your back

Keep it light

Make sure you're not carrying any unnecessary, excess weight - check that you are only carrying essential items

Best foot forward

Make sure you're wearing good soft-soled shoes that are supportive and have good grip on the ground to make carrying a heavy bag easier.

Exercise

Lack of exercise is your worst enemy. Take regular and frequent exercise - The fitter you are, the less likely you are to injure yourself. It doesn't have to be at David Beckham levels - just something that you enjoy, use all joints and increases your heartbeat.

Move Around

Staying still for a long time is bad for your spine. Limit yourself to 40 minutes on the computer or in front of the TV before you get up and do something else for a while.

Computer posture

Make sure your computer or games console is set up so that you're sitting comfortably and your spine is supported. You may not realise that the position you're sitting in is painfull when you are concentrating on what you are doing.

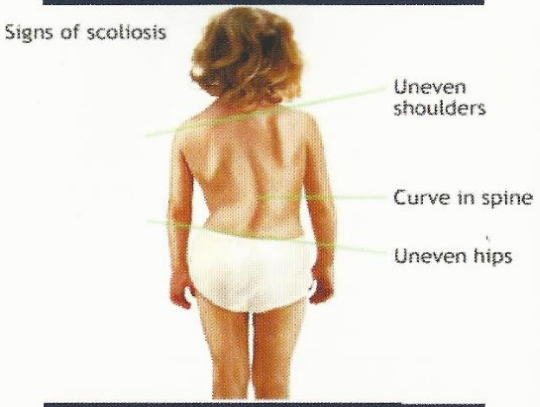
You rely on your spine
So take care of it

Your spine protects a vital part of your body - the spinal cord, which delivers the messages from your brain to your body. Almost every day you carry your schoolbag, sit for hours at your desk and work or play at your computer. You might play sports too. Are you sure you're protecting your spine?

You're not a superhero

Sad but true, lifting, carrying, sitting for too long (Particularly sitting slumped forward) and sporting injuries can all affect the proper movement of your spine if you don't actively protect it. You might not notice at first but after weeks, months, or even years, you could start getting back pain, headaches and other problems that could stop you leading a healthy life.

You don't want to end up like this



You can make sure this doesn't happen to you by following the six golden rules on this leaflet. Make sure that your parents and teachers read them too, so that they can help you to keep fit and healthy.

Chiropractors can help too

Your local CASA Chiropractor has been trained to find the cause of your pain and they can offer you care and advice to help. People of all ages are treated by chiropractors - including many parents and teachers.

According to CASA Chiropractors the common causes of joint and back pain amongst school children are.

- Lack of Exercise
- Schoolbags
- Poor Posture
- Computer games
- Ill fitting desks
- Using a PC • Sport

Your parents can make an appointment for you today !

You can also log onto www.chiropractic.co.za or call CASA 086 188 7772 if you want to know more about chiropractic

Folow the six golden rules on this leaflet

APPENDIX F

Permission letter to the founder of Posture Pro

Ethics reference number: IREC 011/14

Ms K. Reddy
11 Steve Biko Road
Ritson campus, Gate 6
Berea
Durban
4001
Tel: 031-3732205

20/05/2013

Dear Dr Ventura

PERMISSION FOR USE OF THE POSTURE PRO NAME IN THIS RESEARCH

My name is Kimera Reddy. I am a 6th year chiropractic master's degree student at the Durban University of Technology in South Africa. I humbly request permission from you, Mr Joe Ventura, to allow me the right to use the POSTURE PRO name in my study. The title of this research: **"**A comparative study of a novel and school issued backpack on high school adolescent posture in the eThekwini district of KwaZulu-Natal.

The aim of this study is to determine the effect of a novel and school issued backpack on high school adolescent posture.

This study will be using the Posture Pro grid and computer software system.

I will be grateful if you would grant permission for me to use the POSTURE PRO name in this research. Your assistance would be highly appreciated and is vital to this research.

By signing this letter, you (The founder of POSTURE PRO) permit the use of the POSTURE PRO name in this research.

_____	_____	_____
Full Name of Dr Joe Ventura	**Date**	**Signature**

I, Kimera Reddy herewith confirm that the founder of POSTURE PRO has been fully informed about the nature, conduct and risks of this research.

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

_____	_____	_____
Full Name of Supervisor	**Date**	**Signature**

_____	_____	_____
Full Name of Co-Supervisor	**Date**	**Signature**

Regards
Ms. K. Reddy (MTech Chiropractic)
Researcher
0834419271

APPENDIX G

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

20 February 2014

IREC Reference Number: **REC 90/13**

Ms K Reddy
2 Honeysucker Avenue
Yellowwood Park
4004

Dear Ms Reddy

A comparative study of a novel and school issued backpack on high school adolescent posture at the New Forest High School in the eThekwini District of KwaZulu-Natal

I am pleased to inform you that Full Approval has been granted to your proposal REC 90/13.

The Proposal has been allocated the following Ethical Clearance number IREC 011/14. 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]

Prof J K Adam
Chairperson: IREC

APPENDIX H

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

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27 August 2014

Ms K Reddy
2 Honeysucker Avenue
Yellowwood Park
4004

Dear Ms Reddy

Application for Amendment of Approved Research Proposal

A comparative study of a novel and school issued backpack on high school adolescent posture at the New Forest High School in the eThekwini District of KwaZulu-Natal

The IREC acknowledges receipt of your application for amendment to your approved research proposal. The committee expressed concern that none of the participants dressed in the appropriate attire on the day of the data collection. A reminder e-mail/ notification should have been sent to the school/ relevant participants a day or a few days before data collection, regarding the attire required for data collection.

Please note that your application for amendment to your research proposal has been Approved.

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC