An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

By

Barend Jacobus Stander

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Durban University of Technology

I, Barend Jacobus Stander, do declare that this dissertation is representative of my own work in both conception and execution (except where acknowledgements indicate to the contrary).

[redacted]

Barend Jacobus Stander

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Date

Approved for Final Submission

[redacted]

Dr Grant Matkovich, M.Tech: Chiropractic

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DEDICATION

I dedicate this dissertation to my family, Ben Stander, Berdie Stander, Nadine Stander and Ruan Stander, all of whom have provided me with strength, guidance and support through numerous trials and challenges, over many years of studies and two degrees later. There is no better family, supporting each other unconditionally and without wavering love.

Thank you for your unconditional love and the opportunity to obtain my goals and dreams.

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ABSTRACT

Background

Occupational low back pain (LBP) has been described as a significant burden to society. Although there is uncertainty and conflicting studies on the exact causes and combination of causes of LBP, it has been found that occupations which require prolonged sitting periods and have exposure to physical factors such as whole body vibration (WBV) and / or awkward posture, results in increased likelihood for LBP. Pilots are not sheltered from the development of LBP, with the lifetime prevalence of LBP varying from 31.5% to a significant 82%. Additionally, point prevalence varies significantly between 5.1% and 68%, which illustrates that individual pilot and / or occupational factors may contribute to specific pilot subgroups.

This could apply to commercial pilots, who use seats that were found to be ineffective in terms of their depth and inclination, therefore limiting the height and impact of the lumbar support. There is a paucity of studies performed on LBP relating to commercial pilots, specifically, on their unique occupational setting. Research is therefore warranted to illustrate the possible risk factors to which they are exposed to, as impeded performance may lead to catastrophic consequences if a pilot’s ability to complete actions critical to flight becomes hindered.

Aim

To determine the prevalence of low back pain (LBP) in commercial pilots and identify possible risk factors that pilots are exposed to.

Study designs

The study transpired as a cross sectional questionnaire survey.

Participants

Study comprised of 100 commercial pilots registered with the South African Civil Aviation Authority (SACAA) and affiliated with the various participating companies utilizing O.R. Tambo International Airport.

Methodology

All commercial pilots registered with the SACAA and who make use of the O.R.Tambo International Airport (operate through or from) and affiliated with the participating companies during the research study, was approached for participation. Pilots were required to sign and agree to the letter of information and informed consent, as well as the confidentiality agreement. Questionnaires were distributed and all documents were collected, following completion thereof. Pilots were not allocated to more than one group during the data collection (recording) phase of the study. Subgroup analysis was however not excluded in the analysis. IBM SPSS version 21 was used for analysis. A p value <0.05 was considered as statistically significant. Demographics of the pilots were described in the same manner as in the case of categorical variables, and using summary statistics such as mean, standard deviation and range for quantitative variables. Prevalence and characteristics of the low back pain is described using relative frequency and percentages, with 95% confidence intervals.
Associations between risk factors and low back pain was identified with log linear regression analysis and tested using Pearson's chi square test in the case of categorical variables and t-tests in the case of continuous variables.

Results

The lifetime prevalence of LBP amongst commercial pilots was 80.8%, with the annual prevalence reaching 68.7%. Majority of commercial pilots were white, married males, with nearly the entire population having reached similar educational levels. Considering the male predominance of this population, gender was significantly associated with LBP. Although the female population was much

smaller than the male population, it was also found that females were six times more at risk of developing LBP; however the risk was not statistically significant. Awkward posture such as twisting and being stressed at work were found to be significantly related to LBP. Having a history as an ex-smoker or non-smoker was found to be a risk for LBP development. BMI was also significantly related to LBP; however, an inverse relationship is indicated. Having a subjective rating of good health versus excellent health was also an indicator of risk for LBP.

Conclusion:

Commercial pilots have a significant risk for LBP development. It was found that subjective ratings of own health was a good indicator of LBP whereby good health versus excellent health, was a significant risk factor. Although greater portions of the populace are white males, normally less at risk, a significant lifetime and annual prevalence of LBP was found. Furthermore, the small female population had potentially considerable contribution to the prevalence of LBP through their significant odds ratio. Being a current smoker carried less risk in comparison to a history of an ex-smoker or non-smoker, which further complicates the so often debated contribution of this proposed risk factor. Interesting results were found through the inverse proportional relationship that exists between BMI and LBP, whereby every unit increase in BMI results in a relative decreased risk for LBP development. Majority of the proposed risk factors of LBP was not found to be significant, except stress and twisting, which were found to be common risk factors amongst commercial pilots.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	Percentage
<	Refers to a value or figure less than the value or figure shown
=	Sign implies equals to
>	Refers to a value or figure greater than the value or figure shown
ADL:	Activities of daily life
AMI:	Arthrogenic muscle inhibition
ATL:	Airline Transport License
AUD:	Australian Dollar
ANOVA:	Analysis of variance
AS290B:	Aerospace Standards and Biomechanical requirements of pilot seats
C.I:	Confidence interval
CNS:	Central nervous system
CoG:	Center of gravity
FWA:	Fixed wing aircraft
HPA:	High performance aircraft
ICD-9	International Classification of Diseases ninth revision
IOD	Injury on duty
IVD:	Intervertebral disc
LBP:	Low back pain
***n*:**	Population size
OR:	Odds ratio
***p*:**	Indicates the statistical significance of the data. The closer the *p*-value is to naught, the more significant the results (Hicks, 2004).
RWA:	Rotary wing aircraft
SACAA:	South African Civil Aviation Authority
SD:	Standard deviation
sEMG:	Surface Electromyography
Sig:	Significance
U.S.A	United States of America
WBV:	Whole body vibration
WMSD:	Work-related musculoskeletal disorders

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LIST OF DEFINITIONS

Anthropometric: Measuring the human body for the use in anthropological classification and comparison (Oxford dictionary, 2011).

Bradford Hill Criteria: The Bradford Hill criteria was developed to indicate more stringently that the associated factors in a setting of illness can be interpreted as the causation thereof, based on the meeting of several criteria including strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment and analogy (Hill, 1965).

Confounding factor: Confounding is defined as the interference of a third variable that distorts the association of the two variables being studied because of a strong relationship with both of the variables being investigated. This relationship exists in such a way that their individual contributions cannot be separated (Miller-Keane Encyclopedia and Dictionary of Medicine, 2003).

Ergonomics: Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity (International Ergonomics Site, 2014).

Low back pain: Defined as the painful sensation in the region between the 12th rib superiorly and the gluteal folds inferiorly (Galukande *et al.,* 2005).

Poor ergonomics: Backward translation of the body where the centre of gravity passes behind the ischial tuberosities resulting in an unstable position (Snijders *et al.,* 2004).

Prolonged sitting: Sitting for more than half of the working day (Liz, Korn and Black, 2007).

Risk factors: Defined according to the World Health Organization (2013) as any attribute, characteristic or exposure that leads to the increased likelihood of a person to develop a disease or injury.

WBV: Whole body vibration is mechanical energy oscillations that are passed from a surface or a seat through the body, and this risk factor is highlighted in occupations such as truck drivers, bus drivers and pilots (Ghaffari, 2007).

CHAPTER ONE
Introduction

1.1 Introduction

Low back pain (LBP) has been defined as the painful sensation that is felt in the region between the 12^{th} rib and the gluteal folds (Galukande *et al.,* 2005). It is one of the most prevalent musculoskeletal conditions, and the most common cause of disability in developing countries (Louw *et al.,* 2007; Galukande *et al.,* 2005). LBP is a condition which has a large socioeconomic burden and appears to be increasing even with the advancements made in terms of diagnosis and intervention (Dagenais *et al.,* 2008).

Mulimba (1990) showed that only 8% of global prevalence studies on LBP were conducted in Africa initially. An increase in the number of LBP prevalence studies performed, (Louw *et al.,* 2007; Galukande, 2005; Walker, 2000) may be as a result of similarities observed between Africa and developed countries. According to Louw *et al.,* (2007), the point, 1-year prevalence and lifetime prevalence of LBP in adults were 32%, 50% and 62% respectively. This indicates that the occurrence of LBP in Africa corresponds to studies undertaken in developed countries (Helfenstein-Junior *et al.,* 2010; Hoy *et al.,* 2010; Manek and MacGregor, 2005; Picavet and Schouten, 2002; Volinn, 1997; Waddell, 1994; Frymoyer *et al.,* 1983).

Within the South African population, Van der Meulen, (1997) found a 57.6% lifetime incidence of LBP in the black population of Chesterville, Durban. Docrat, (1999) showed that the incidence and prevalence of LBP in the Coloured and Indian community in greater Kwazulu-Natal is in the upper quartile (76.6% in coloureds and 78.2% in indians) and compares favourably to studies undertaken in industrialized countries. In South Africa, LBP was experienced by 35.7% of the participants at the 1 year period of which nearly 50% were Black participants, followed by 28.7% Indian and the remaining quarter divided between White and Coloured race groups (Albert, 2009). These results fell into the lower margins when compared to studies in industrialized countries (Albert, 2009) and other South African studies (Docrat, 1999;

Van der Meulen, 1997). This suggests that although slight prevalence differences are found within these studies, LBP appears to affect all ethnicities and so indicates the significance of this condition.

Significant expenses are incurred as a result of LBP in industrialised countries indicated by van Leeuwen *et al.,* (2006) in Australia. According to van Leeuwen *et al*., (2006) the yearly loss as a result of work absenteeism may be as much as 2.1 billion Australian dollar (AUD) and when reduced work effectiveness was included, resulted in a rise to AUD 7.1 billion. In order to address the loss in productivity and increased health care costs, numerous epidemiological studies have been performed in an attempt to isolate specific, personal and occupational factors in the development of LBP (Ozguler *et al.,* 2002).

Although there is uncertainty as to the exact causes of LBP (Dagenais *et al.,* 2008), this is more evident in occupational circumstances (Roffey *et al.*, 2010a). Occupational LBP is a massive burden to both the industry and health care. Numerous factors affect the development of LBP, including ergonomics, occupational and personal risk factors (Smith *et al.*, 2006; Manek and MacGregor, 2005; Pope, Goh and Magnusson, 2002; Manchikanti, 2000; Holder *et al*., 1999; Docrat 1999; Van der Meulen 1997; Pope *et al*., 1991).

According to Roffey *et al.,* (2010(a)) occupations requiring adaptation to awkward positions were not an independent contributory agent in LBP development. Additionally, Wai *et al.,* (2010(a)) revealed that occupational bending or twisting is unlikely to be an independent cause in the development of LBP in workers. Even though there is uncertainty on the exact causes of LBP development, it has been found that occupations which require prolonged sitting (characterised by sitting for more than half of the working time) and had exposure to whole body vibration (WBV) and/or awkward posture; have an increased likelihood for developing LBP (Bernard *et al*., 2011; Leelavathy *et al.,* 2011; Lis, Korn and Black, 2007; Ramroop *et al.*, 2006).

Considering ergonomics and prolonged sitting, Koskelo *et al*., (2007) assessed commonly used chairs which make use of a 90º angle between the trunk and the thighs at the hips. Due to the relative inflexibility of the hip joints forward flexion is limited to 60º in the hip joints. This results in the straining of the illiolumbar ligament particularly in the "slouching" or "relaxed" position and without lumbar support (Snijders *et al.,* 2004). It has, however, been found that adjustable relationships between desks and chairs improved sitting postures along with trunk muscle strength and decreased muscle tension in the lumbar muscles. This indicates that specific ergonomic and person specific changes are vital to correct sitting posture and decreasing sequelae of incorrect posture (Koskelo *et al.,* 2007).

Prombumroong *et al*., (2011), Okunribido *et al.,* (2008) and Goosens *et al*., (2000) evaluated the occupational settings of pilots in order to determine if pilots are exposed to similar risk factors. These studies found that factors such as prolonged sitting, poor ergonomics and WBV are present within piloting occupations and are some of the main contributing factors in the development of LBP in pilots.

Poor ergonomics were found in commercial pilot seats, which were evaluated in five different types of civil aircrafts. Shortcomings were found in the depth and inclination of the seat including the height of the lumbar support (Goossens *et al.,* 2000). The lack of adequate ergonomic support from the chair for the pilot may further be complicated by WBV, which has been shown to result in adverse effects on the lumbar spine following prolonged exposure (International Organization for Standardization, 2004). Leelavathy *et al.,* (2011) and Okunribido *et al*., (2008) found similar results in their study, indicating that WBV is as a common risk factor for the development of LBP.

Bridger *et al.,* (2002) looked into the predominate postures of pilots when flying, with the aid of a self-rating postural assessment. Within a sample population of 246 pilots, Bridger *et al.,* (2002) found a 80% prevalence of low back pain. Their study reported that, the forward flexed trunk posture common in pilots when flying could be associated with a higher prevalence of low back pain.

This supports the findings of Froom *et al.,* (1986), who determined from a questionnaire on LBP, given to commercial pilots, that nearly 15% of the 165 commercial pilots had suffered with LBP. This has more recently been confirmed by

Okunribido *et al.,* (2008) whose study showed that the prevalence of LBP was the highest in helicopter pilots, with 80.6% reporting on previous LBP and a total of 41.9% with current LBP. These results compare favourably with data indicating the prevalence of LBP globally (Helfenstein-junior *et al.,* 2010; Hoy *et al.,* 2010; Manek and MacGregor, 2005; Picavet and Schouten, 2002; Waddel, 1994). Similar conclusions were reached by Pelham *et al.,* (2005) who stated that poor in-flight posture and exposure to WBV were identified as high risk factors for the development of LBP.

Comparison to global literature (Helfenstein-junior *et al.,* 2010; Hoy *et al.,* 2010; Manek and MacGregor, 2005; Picavet and Schouten, 2002; Volinn, 1997; Waddel, 1994; Frymoyer *et al.,* 1983) places the prevalence of LBP in pilots in the upper quartile of the reported findings, which is higher than most reported LBP prevalence found in epidemiological studies (Louw, Morris and Grimmer-Somers, 2007;Ghaffari, 2006; Picavet and Schouten, 2002; Hillman *et al*., 1996).

With general population studies revealing lower annual prevalence ranges of 22% – 65% (Dagenais *et al*., 2008; Ghaffari, 2006; Picavet and Schouten, 2002; Walker, 2000 and Hillman *et al.,* 1996), indicates that the unique setting of pilots may be a contributory factor to higher prevalence’s than the general population. This is further validated by comparing occupational settings with similar risk factors (viz. bus drivers, taxi drivers) (Chen *et al*., 2005; Bovenzi, 1996), where it was found that pilots still have a higher annual prevalence of LBP.

With paucity of new information regarding LBP experiences in commercial pilots (Froom *et al.,* 1986) and the diverse results found on LBP in different ethnicities in South Africa (Albert, 2009; Docrat, 1999; Van der Meulen, 1997), it is necessary to conduct research to illustrate current LBP prevalence’s, possible risk factors (both known and unknown) and the demographics of commercial pilots within South Africa. This may allow appropriate future intervention strategies (Dagenais *et al.,* 2008) for the benefit of South African airlines as well as the South African pilots (Rupert and Ebete, 2004; Nyland and Grimmer, 2003).

1.2 Aims and objectives of the study

The aim of the study is to determine the prevalence of LBP in commercial pilots and to identify possible risk factors that pilots are exposed to.
The following are the objectives of the study:

- To establish the demographics (gender, ethnicity, marital status, education, dependants, age and BMI) of commercial pilots registered with the South African Civil Aviation Authority (SACAA).
- To establish the work history of the commercial pilots (piloting years, current aircraft used, previous aircrafts used, type and longest period of aircraft flown, average hours in cockpit seat per day, average days per week in cockpit seat, average rest period between flights).
- Establish the point, period and lifetime prevalence of LBP amongst commercial pilots in South Africa.
- To determine the nature, severity and clinical presentation of LBP in commercial pilots.
- To identify possible risk factors that may contribute to low back pain in commercial pilots.
- To establish if a correlation between demographics, work history and risk factors exists in the contribution to LBP in commercial pilots.

1.3 Hypothesis of the study

The Alternate Hypothesis (H_a) formulated state that LBP will be prevalent amongst commercial pilots registered with SACAA and that these pilots are exposed to risk factors for LBP development.

1.4 Rational for the study

There is a limited amount of research available indicating the prevalence of LBP in commercial pilots. Furthermore, to date no study has been performed which determines the incidence and prevalence of LBP in pilots within South-Africa with:

1. Froom *et al.,* (1986) having looked at commercial pilots in industrialised countries.
2. Goosens *et al.,* (2000) having looked at commercial pilot seats in industrialised countries
3. Bridger *et al.,* (2002) having looked at helicopter pilots in the Royal Navy
4. Okunribido *et al.,* (2008) having looked at helicopter pilots of different class in developed countries.
5. Prombumroong *et al.,* (2011) having looked at commercial pilots in a developing country.

Further compounding the limitation found on the amount of research on commercial pilots, include the availability of recent research specifically designated to commercial pilots and the prevalence of LBP within this population (Prombumroong *et al*., 2011; Froom *et al*., 1986). As most previous studies on occupational LBP do not meet the Bradford-Hill criteria[1] which assess possible causal factors of LBP, no conclusive evidence exists in terms of the exact cause of LBP development (Roffey *et al.,* 2010b), which in effect nullifies the reliability of the proposed risk factors for LBP development. Furthermore, there is a paucity of knowledge around the combination of factors that are unique to pilots, as most of the information regarding factors which predispose to the development of LBP, has been inferred from general population studies.

The uniquely diverse ethnicity found within South Africa (Albert, 2009; Docrat, 1999; Van der Meulen, 1997) has revealed significant variation in LBP prevalence. This limits the ability to develop a pilot specific intervention strategy in order to reduce the high levels of reported LBP in this population (Okunribido *et al.,* 2008; Cherkin, 2002; Coulter *et al.*, 2002; Froom *et al.,* 1986). This may negatively impact the pilot's personal and occupational life, increasing cost to themselves, their company and the healthcare system in general (Dagenais *et al.,* 2008).

[1] The Bradford Hill criteria was developed to indicate more stringently that the associated factors in a setting of illness can be interpreted as the causation thereof, based on the meeting of several criteria including strength, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment and analogy (Hill, 1965).

1.5 Conclusion

The prevalence of LBP in developing countries may be as significant as in developed countries (Albert 2009; Docrat, 1999; Van der Meulen, 1997). Sub groups may however be present (commercial pilots) within developing populations which are different to what is expected and would need investigation to establish the reasons why. This will stimulate further studies, which may with greater accuracy indicate the unique causative factors within the circumstances of developing countries.

There is paucity of information on the prevalence of LBP in commercial pilots in South Africa, because of their unique occupational circumstances. Further research is warranted to identify LBP causative factors within commercial pilots registered within South Africa.

CHAPTER TWO

Literature Review

2.1 Introduction

Chapter Two presents the current literature around low back pain (LBP), including incidence, prevalence and the risk factors for the development of LBP especially those relevant to commercial pilots. In addition, the anatomy and biomechanics of the lumbar spine will be discussed.

2.2. Anatomy of the low back

According to the anatomical description, LBP is defined as the painful sensation experienced in the region between the 12th rib superiorly and the gluteal folds inferiorly (Galukande *et al.*, 2005).

2.2.1 Osseous structures of the low back

The lumbar region depicted in **Figure 2.1** consists of five vertebrae, bounded superiorly by the thoracic spine and inferiorly by the sacrum. The remaining nine inferior vertebrae are made up of five sacral vertebrae, which form the sacrum, and four coccygeal vertebrae, which form the coccyx. Lastly, the two os coxae are formed by the ilium, ischium and pubic bones bilaterally (Standring, 2008; Moore and Dalley, 2006).

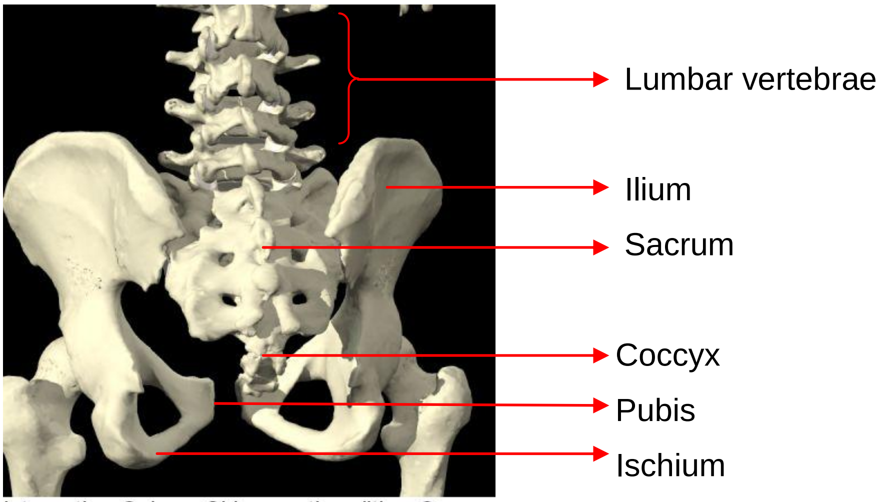


Figure 2.1: Osseous structures (Reprinted with permission from Primal Pictures, 2003).

2.2.1.1 Lumbar vertebrae

The lumbar vertebrae consist of a vertebral body, a vertebral arch and seven processes (viz. spinous process, two transverse processes and four articulating processes) (Bergman and Peterson, 2011; Standring, 2008; Moore and Dalley, 2006) as seen in **Figure 2.2** and **Figure 2.3**

The zygopophyseal joints result from four articular processes, two superior and two inferior facets which when articulating result in two joints between succeeding vertebrae. These zygopophyseal joints together with the transverse processes act in unison to determine the types of movement allowed between adjacent vertebrae (Moore and Dalley, 2006).

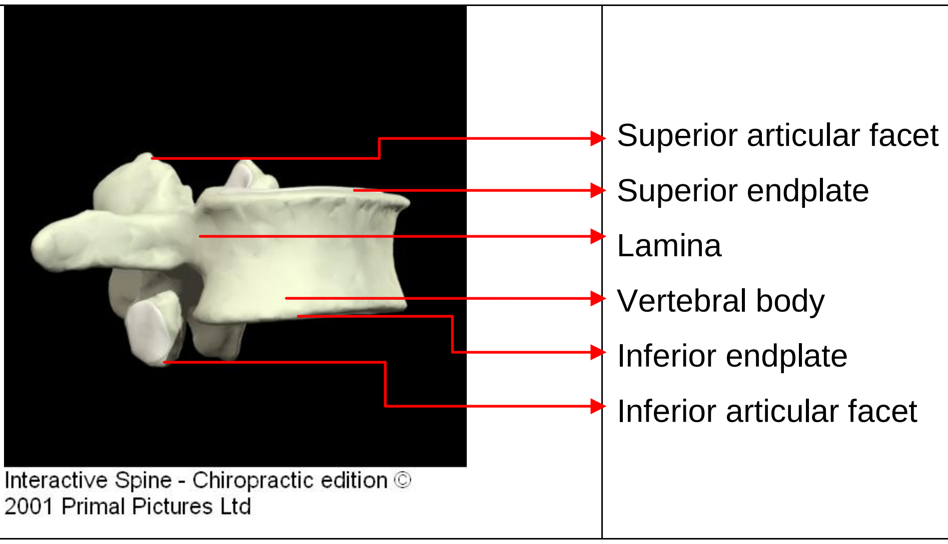


Figure 2.2: Lumbar vertebra, oblique view (Reprinted with permission from Primal Pictures, 2003).

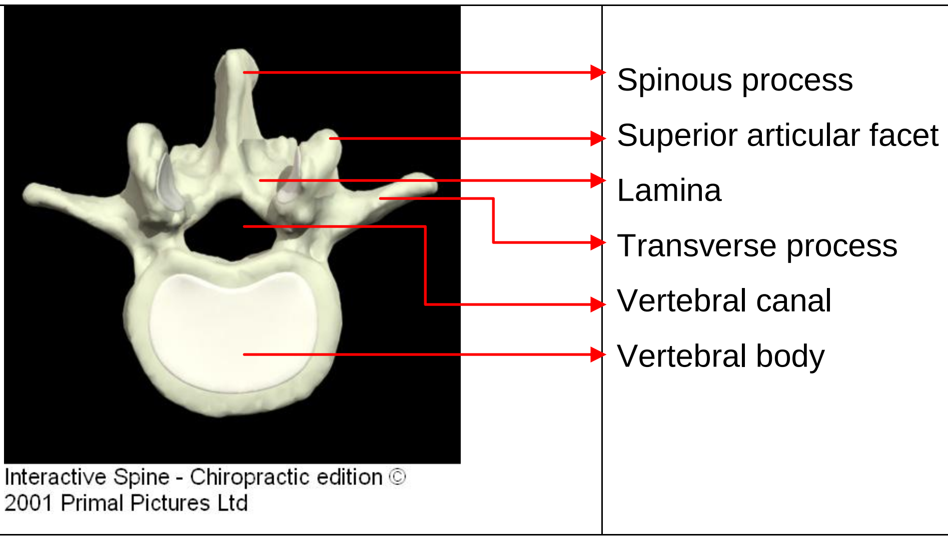


Figure 2.3: Lumbar vertebra, superior view (Reprinted with permission from Primal Pictures, 2003).

Flexion and extension is the major movement in the lumbar spine, with some lateral flexion. Rotation is prohibited due to the orientation of the facets, which are orientated from a more sagital position to a coronal position as the column descends. Further changes as the column descends include an increase in the size of the vertebral bodies, with L1 being the smallest and L5 the largest of the lumbar vertebrae which is attributed to the increase in weight bearing (Standring, 2008; Moore and Dalley, 2006).

2.2.1.2 The Sacrum

The sacrum forms through the fusion of five sacral vertebrae with ever decreasing lateral masses resulting in a large triangular shaped bone (Moore and Dalley, 2006).

The sacrum is situated between the two hipbones (os coxae), and acts as the posterosuperior wall of the pelvic cavity. At the caudal aspect, this bone articulates with the coccyx, whilst the superior wide base articulates with the fifth lumbar vertebra (Bergman and Peterson, 2011; Standring, 2008).

2.2.1.3 Os Coxae

Innominate bones are formed through the fusion of three bones, namely the ilium, ischium and pubis (Bergman and Perterson, 2011; Moore and Dalley, 2006). The function of the ilium, (other than to act as a muscular attachment point), includes the initial transfer of weight from the spine to the pelvis and the stabilization of the pelvic ring through the sacroiliac joints (Morris, 2006; Moore and Dalley, 1999).

The ischium forms the posteroinferior body of the innominates, contributing to acetebular formation. Between the inferior end of the body of the ischium and its ramus lies a bony projection known as the ischial tuberosity. This bone enables the body to carry its weight while seated and serves as an attachment point for the tendons of the posterior thigh (Morris, 2006; Moore and Dalley, 1999).

The pubis forms the last part and anteromedial aspect of the innominates, which contributes to the anterior part of the acetabulum. The abdominal muscles are attached to the anterosuperior border of the pubic crest, whilst the pubic tubercles found at the lateral aspect of the crest, are small projections, which are the main attachment points for the inguinal ligament (Morris, 2006; Moore and Dalley, 1999).

2.2.2 Articulations and Ligaments

2.2.2.1 Three joint complex

A spinal motion segment, also known as the three joint complex, consists of two zygopophyseal joints and an intervertebral disc (IVD) at each successive vertebral level. This close relationship between these structures forms the functional unit or motion segment of the spine (Gatterman, 2005).

The vertebral column is strengthened by the functional unit of the spine through the attachments the IVD provide with its associated vertebral bodies, creating a continuous, semi-rigid column designed for weight bearing and strength (Moore and Dalley, 2006).

The IVDs vary in terms of their thickness depending on their location and weight bearing function within the spinal column. For example, within the lumbar spine, the vertebral discs are thicker anteriorly, contributing to the anterior convexity or lordotic curve. On average, IVDs accounts for 20-25% of the total height of the vertebral column. Each disc has an inner nucleus pulposus and an outer lamellated annulus fibrosus (Standring, 2008).

The annulus fibrosus has an outer narrow collagenous zone that surrounds a wider inner zone of fibrocartilage arranged in a lamellar pattern. Variations are found within the posterior fibers of the lamella, with some orientated in a more predominate vertical position which may predispose to herniation (Standring, 2008; Drake, Vogl and Mitchell, 2005).

The nucleus pulposus or centre of the IVD is gelatinous in nature and allows absorption of compressive forces between adjacent vertebrae. With ageing the discs becomes less differentiated from the annulus fibrosus resulting from decreased hydration levels and increased fibrous structure (Standring, 2008; Moore and Dalley, 2006; Drake, Vogl and Mitchell, 2005).

The second component of the three joint complex are the zygopophyseal joints, which are classified as a simple synovial joint. The articular joint surfaces assume a curved shape allowing interlocking with adjacent processes, which limits the range of motion, but spares flexion and extension movements (Drake, Vogl and Mitchell, 2005).

Further reinforcement of the articular processes is given through the support of ligamentous attachments that pass between the vertebral bodies and neural arches. One such example is ligamentum flavum, a thin broad ligament of mostly elastic tissue, which passes from the anterior surface of the lamina above to the posterior surface of the lamina below of adjacent vertebrae. This ligament resists separation of the lamina in flexion and assists in extension (Drake, Vogl and Mitchell, 2005).

Other ligaments include:

- Those related to the posterior neural arch (viz. supraspinous ligament), (Moore and Dalley, 2006; Drake, Vogl and Mitchell, 2005), interspinous ligament (Moore and Dalley, 2006; Drake, Vogl and Mitchell, 2005) and intertranverse ligament (Moore and Dalley, 2006; Drake, Vogl and Mitchell, 2005) as well as the mamillo-accesory ligament which is classified as a false ligament.
- Those related to the anterior vertebral structures (viz. the anterior longitudinal ligament, posterior longitudinal ligament and the true and false transforminal ligaments (Moore and Dalley, 2006).

2.2.2.2 Sacrum and sacroiliac joint

The sacroiliac joint is formed through the articulation of the sacrum with the ilium. Although this joint does permit some degree of movement, its principle function is to maintain stability. This function is reinforced by ligament attachments such as the posteriorsacroiliac, anterior sacroiliac and interosseous ligaments (Drake, Vogl and Mitchell, 2005). The illiolumbar ligament acts as an accessory ligament to this action (Moore and Dalley, 2006), but binds the sacroiliac joint indirectly by connecting the ilium to the fifth lumbar vertebra. Of the ligaments stabilizing the sacroiliac joint, the interosseous ligament is largest and the strongest and primarily involved in transferring weight from the upper body to the two ilia of the appendicular skeleton (Moore and Dalley, 2006; Drake, Vogl and Mitchell, 2005).

Accessory ligaments to the bony pelvis include the sacrotuberous ligaments and the sacrospinous ligaments, both providing stability, attachments for musculature and routes for weight transfer from the body to the extremities (Drake, Vogl and Mitchell, 2005).

2.2.2.3 Pubic symphysis

The final stabilization of the pelvic ring is executed through the articulation formed by the pubic symphysis, which closes the pelvic ring anteriorly (Standring, 2008; Moore and Dalley, 2006).

2.2.3 Muscles involved with low back pain

Muscles involved in the movements associated with the low back, include those that have been itemized in **Table 2.1** and illustrated in **Figure 2.4** to **Figure 2.7**. The information in **Table 2.1** outlines the muscles name, location, action and innervations. The latter being one of the root causes of pain and pain distribution in the low back region.

Table 2.1: Main muscles causing movement in the lumbar spine

Muscle	Origin	Insertion	Innervation	Action
External oblique	External surface and inferior borders of the inferior 8 ribs	attaches to anterior half iliac crest, linea alba, pubic tubercle	Supplied by thoraco-abdominal nerves (T7-T11) and subcostal nerve	**Bilaterally**: Compress abdomen and flexion **Unilaterally**: Lateral flexion
Internal oblique	Thoracolumbar fascia, anterior two-thirds of iliac crest and inguinal ligament	Cartilage of the inferior 3-4 ribs, linea alba and pecten pubis via conjoint tendon	Thoraco-abdominal nerves (T8-T12), illiohypogastric nerve and illioinguinal nerves	**Bilaterally:** Compress abdomen and flex vertebral column. **Unilaterally:** Lateral flexion and rotation
Transversus abdominus	Internal surfaces of 7^{th} – 12^{th} costal cartilages, iliac crest, lumbar fascia and lateral third of inguinal ligament	Linea alba with aponeurosis of internal oblique, pubic crest and pubis	Thoraco-abdominal nerves (Anterior rami of inferior 6 thoracic nerves) and first lumbar nerves	Compresses and supports abdominal viscera
Rectus abdominus	Pubic crest and pubic symphysis	5^{th} – 7^{th} costal cartilages and xiphoid process	Thoraco-abdominal nerves(Anterior rami of inferior 6 thoracic nerves)	Flexes trunk, compress abdominal viscera and controls pelvic tilt.
Quadratus lumbroum	Illiac crest and iliolumbar ligament	Inferior border of the 12^{th} rib and first four lumbar vertebrae	Thoracic spinal nerve (T12) and lumbar spinal nerves L1-L4	**Bilaterally:** Assists in Lumbar extension and inferior pull of 12^{th} rib during forced exhalation **Unilaterally:** Lateral flexes vertebral column
Multifidus	Inferior tip of spinous process	Extends 2-4 vertebral segments to attach to transverse process	Posterior rami of spinal nerves.	Stabilizes vertebrae during local movements.

Table Compiled from Moore and Dalley, 2006; Tortora and Derickson, 2006; Trivell and Simons, 1999

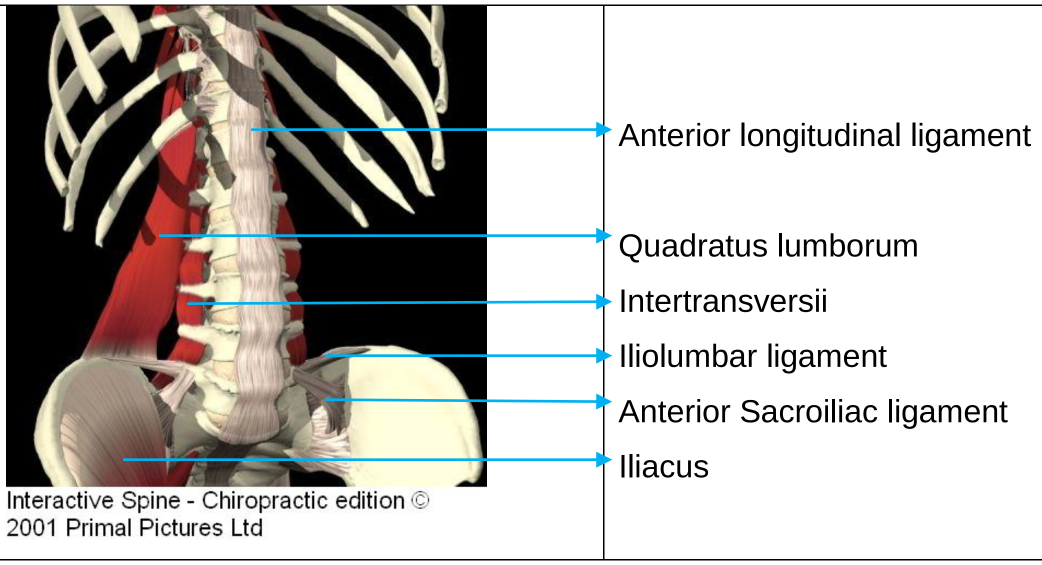


Figure 2.4: Lumbar musculature (1) (Reprinted with permission from Primal Pictures, 2003).

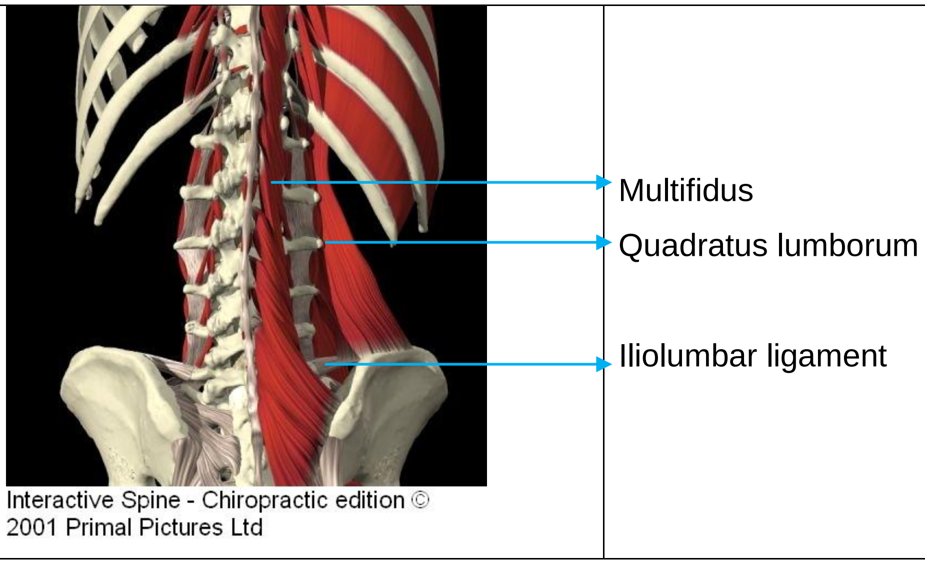


Figure2.5: Lumbar musculature (2) (Reprinted with permission from Primal Pictures, 2003).

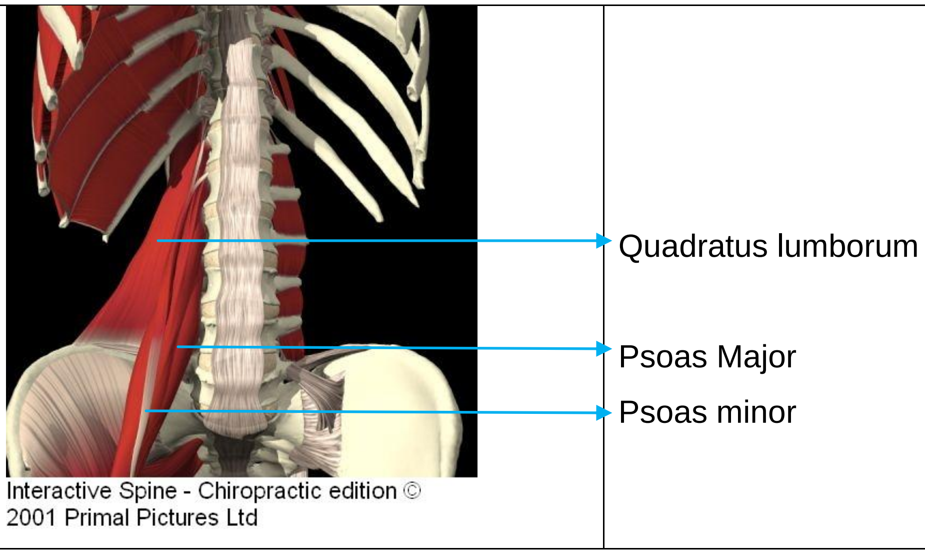
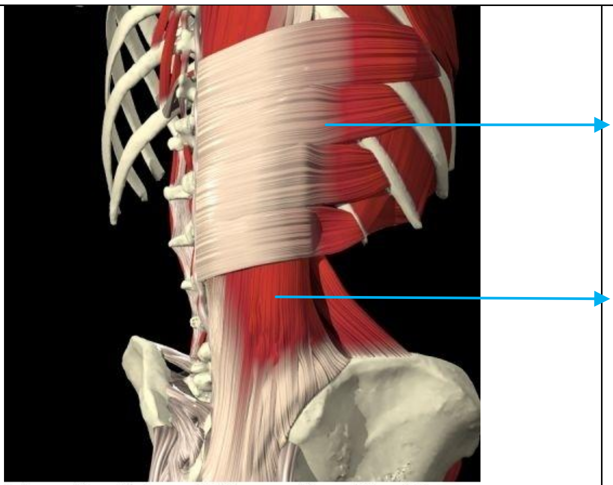


Figure 2.6: Lumbar musculature (3) (Reprinted with permission from Primal Pictures, 2003).



Interactive Spine - Chiropractic edition © 2001 Primal Pictures Ltd

Figure 2.7: Lumbar musculature (4) (Reprinted with permission from Primal Pictures, 2003).

2.2.4 Innervations of the lumbar spine structures

Two enlargements are found within the spinal cord, the first being in the cervical spine (brachial plexus) and the second in the lumbar spine (lumbosacral plexus). The latter extends form T11 through to S1 segments. The lumbosacral plexus, which innervates the lower limbs, is formed from the anterior rami of the spinal nerves in this plexus (Moore and Dalley, 2006). By contrast, the dorsal rami of the spinal nerves are not part of the plexus formation, but rather divided into medial, median and lateral branches, innervating posterior structures of the low back at each of the lumbar and sacral levels. The last division is the segmental sinuvertebral nerve, which forms as a branch of the spinal nerve root as it exits the intervertebral foramina, supplies the structures internal to the vertebral canal (Standring, 2008).

From the lumbosacral plexus, the brain receives important information regarding (Bergman and Peterson, 2011; Bergman, Peterson and Lawrence, 1993):

- Continuous monitoring around joint movement and spatial relationships, in order to allow coordinated motor control and smooth movement through kinesthetic perception.
- External nociceptive input.
- Internal nociceptive input (viz. the presence, nature and location of the source of LBP). This monitoring and reporting is actioned through the Wyke receptors, which enable the brain to receive information through a variety of

receptors ensuring that it has sufficient information to ensure appropriate function of the low back (Leach, 2004).

2.2.4.1 Intra-articular receptors

These intra-articular receptors include (Freiwald, Reuter and Engelhardt, 1999):

a. Type 1 receptors – (Ruffini bodies/ Ruffini end organs)

These receptors are, after free nerve endings, the second most common receptor type. They are usually arranged in sets or clusters of 3 to 6 bodies (Freiwald, Reuter and Engelhardt, 1999). Research shows that the Ruffini bodies are slow-adapting receptors within joint capsules and peri-articular tissue. Generally, these receptors have a low threshold and respond to slight changes in ligament tension and capsular pressure (Hopkins *et al*, 2000). In addition, the fibers are slow adapting, allowing for the effect of change within the joint to last for an extended period. Cessation of firing comes about as the joint nears end approximation (Bergman and Peterson, 2011; Bergman, Peterson and Lawrence, 1993).

b. Type 2 receptors – (Vater- Pacini bodies)

These receptors are found within the deeper layers of the joint capsule, these mechanoreceptors are stimulated similarly with minor changes in the joint. Although they are low threshold fibres, sensitive to tension, stimulation of the fibres quickly ceases when joint motion discontinues and are completely inactive when no motion occurs or the motion in the joint is at a constant acceleration or deceleration (Bergman and Peterson, 2011; Bergman, Peterson and Lawrence, 1993). Therefore, they only become active only with acceleration or deceleration. Vater-Pacini bodies have a low mechanical stimulation threshold and thus adapt rapidly, acting as dynamic mechanoreceptors (Freiwald, Reuter and Engelhardt, 1999).

c. Type 3 receptors – (Golgi tendon organs)

The Golgi tendon organs which are found in the musclulotendinous junction are similar to the Ruffini bodies. These receptors assist by providing information about joint position (Bergman and Peterson, 2011; Freiwald, Reuter and Engelhardt, 1999; Bergman, Peterson and Lawrence, 1993).

d. Type 4 receptors – (Free nerve endings)

These nerve endings are non-specialized, non-encapsulated, generally unmyelinated receptors, with a variety of perception possibilities, including pain perception and they provide a crude awareness of initial joint movement (Hopkins and Ingersoll, 2000). They are classified as very high threshold receptors which may become stimulated when nociceptive changes occur (e.g. fractures of the vertebral body, dislocation of zygopophyseal joints or chemical irritation stimulates them) (Bergman and Peterson, 2011; Redwood and Cleveland, 2003; Bergman, Peterson and Lawrence, 1993).

2.2.4.2 Extra-articular receptors

Muscle spindles are classified as extra-articular receptors, and are located in skeletal muscle. The fibres in the centre of the muscle spindle are known as intrafusal fibres, whilst the skeletal muscle fibres surrounding the muscle spindle are known as the extrafusal fibres. The intrafusal fibres are supplied by Type I alpha nerve fibres, and they stimulate motor neurons. The afferents of the muscle spindle are Type II nerve fibres that synapse with spinal ganglia cells. Type II afferents also stimulate the motor neurons but their effect is multi-segmental. They have a promoting effect on the agonist and an inhibitory effect on the antagonist muscle (Freiwald, Reuter and Engelhardt, 1999).

A stimulation of the muscle spindle due to stretching of the muscle causes a reflex contraction. This reflex phenomenon is known as the stretch reflex and returns the tension in the muscle back to normal. Mechanoreceptors and central nervous system input can also stimulate the muscle spindle fibres. Hence, muscle spindles either directly or indirectly influence the motor neurons of both agonistic and antagonistic musculature (Freiwald, Reuter and Engelhardt, 1999).

Thus, in essence, a relationship created between the mechanoreceptors and nociceptors are such that when mechanoreceptors function normally, inhibition of nociceptors transpires which overide pain sensations. However, the converse is also true (Bergman and Peterson, 2011; Leach, 2004; Bergman, Peterson and Lawrence, 1993; Melzack and Wall, 1965). Significant pain and immobility may result in arthrogenic muscle inhibition (AMI), where AMI is a presynaptic and ongoing reflex inhibition of musculature surrounding a joint following its distension or damage. AMI is a natural response, which is designed to protect the joint and surrounding structures from further damage (Hopkins and Ingersoll, 2000). As a result, the response may be an arthrogenic muscle response as opposed to an inhibition. Effusions induced experimentally within the ankle joint have been shown to increase muscles tone of the leg muscles. This resulting spasm may assist and protect the ankle joint from further injury. Without other means of protecting a joint, AMI is the body's method of choice to protect injured extremities (Ingersoll, Palmieri and Hopkins, 2003).

Thus, when looking at the structure, function and innervations of the lumbar vertebrae, its associated motion segments and the sacroiliac joint, it shows that LBP could be as a result of isolate or multiple tissue changes within the anatomical region of the low back. Furthermore, many different aetiological factors may predispose to injury, damage or changes in these structures resulting in LBP (Mirtz and Greene, 2005; Portenoy *et al*, 2004; Melissas, 2003; Green *et al*., 2003; Crook *et al.*, 2002; BildtThorbjornsson *et al.*, 2000; Dempsey *et al.,* 1997; Buckwalter *et al*., 1993; Frymoyer *et al*., 1983). The following section will therefore discuss the epidemiology of LBP before occupational LBP is reviewed.

2.3 Epidemiology of low back pain

LBP has been identified as a common cause of health problems and is often referred to as a major cause of disability (Coole *et al.,* 2010; Woolf and Pfleger, 2010; Chen *et al.*, 2009; Dagenais *et al.*, 2008; Cassidy *et al,* 2005). This condition is of great importance to public health as it has a significant impact on social and economic status, with numerous possible causes and no discretion towards ethnicity (Ghaffari, 2005). Although there is uncertainty (Dagenais *et al.,* 2008) as to the exact causes of LBP generally, this is more evident in occupational circumstances (Roffey *et al.*, 2010).

From a comprehensive systematic review performed by Hoy *et al.,* (2010), results reveal that the annual incidence of LBP varies from 6.3% to 15.4%. The study further indicated that first recurrent annual incidence has been reported as 1.5% to 36%.

Dagenais *et al.*, (2008), Ghaffari (2006), Waddell (2004), Picavet and Schouten (2002), Walker (2000), Loney and Stratford (1999) and Hillman *et al.,* (1996) previously showed that LBP has a significant influence on public health with the studies investigating either the point, period, lifetime or combination prevalence of LBP.

2.3.1 Point prevalence of LBP:

Walker (2000) found that the point prevalence of LBP ranged from 12% to 33%. Previous studies compiled by Looney and Stratford (1999) and Hillman (1996) found similar results with data indicating that the point prevalence of these studies ranged from 19% to 29%. This falls within the range indicated by Walker's (2000) systematic review. A more recent study by Dagenais (2008) similarly revealed a point prevalence of 15%.

2.3.2 Period (annual) prevalence of LBP

The annual prevalence of LBP has been investigated by Ghaffari, (2006); Picavet and Schouton, (2006); Van Vuuren *et al*., (2005); Walker, (2000) and Hillman *et al*., (1996), where it was found collectively that the annual prevalence of LBP ranged from 22% to 65%. A more recent and contextual study conducted by Louw, Morris and Grimmer-Somers (2007) within Africa revealed that the annual prevalence may be even greater with a range of 14 to 72%. This may indicate that the annual prevalence within a developing country may be slightly higher than indicated by literature within developed countries (Picavet and Schouton, 2006; Ghaffari, 2006; Walker, 2000 and Hillman *et al*., 1996).

2.3.3 Lifetime prevalence of LBP

The commonality of LBP is evident through recent studies indicating that the lifetime prevalence of LBP may be as high as 80% within the general population as depicted by Helfentstein-Junior *et al*., (2010). Bell and Burnett, (2009) found a 90% prevalence of LBP within occupations which are mostly labour intensive. Their study indicates that occupations, which require adaptation to strenuous workloads, may have a more significant role in the high prevalence and development of LBP.

The unique circumstances, such as the diverse ethnicities, found in South Africa may influence the variations of LBP prevalence (Albert 2009; Docrat, 1999; Van der Meulen, 1997). In South Africa, there is limited amount of research to indicate the total cost of musculoskeletal disorders (including LBP) and its effect on occupational continuity. To date, no research has been performed to indicate the difference in LBP cost being experienced in the different ethnic groups (Raad, 2011). These ethnic variations indicate the need for further studies in developing countries as the paucity of literature prevents conclusive evidence from being reached.

2.4 Occupational LBP

2.4.1 Occupation related risk factors of LBP

Evidence-based healthcare has become an increasingly important factor within the work place, as LBP has developed into one of the most common and difficult occupational health problems in this sector (Waddell and Burton, 2001). Although information and clinical guidelines exist in the management of LBP, there is a paucity of literature guiding the management of LBP within occupational settings (Waddell and Burton, 2001). Considering that LBP carries a psychosocial and financial burden for the individual patient, its impact on the economy of a nation is magnified when 80% of the population is deemed to present with LBP at any one time. Therefore, it is essential that effective interventions are developed (Kirkaldy-Willis and Burton, 1992). However, an initial intervention should aim to identify work related risk factors as this would be a precursor to what may cause LBP (Bell and Burnett, 2009).

This concurs with the cohort study by Ghafarri, (2007), which suggested that research should group the risk factors of LBP development. He suggested the inclusion of individual and lifestyle factors, workplace factors (viz. biomechanical and physical factors), and finally psychosocial factors. The study further revealed specific biomechanical factors such as manual material handling (viz. lifting tasks, bending and twisting), and whole body vibration and / or immobilization (e.g. sitting positions) as factors for LBP development. As a result, attempts have been made to identify, categorize and measure the extent of LBP precursors in the workplace and how these translate into workers developing common work-related musculoskeletal disorders (WMSD),(such as LBP), within specific occupations as seen in **Table 2.2.**

Through this process, the establishment of conclusive links between LBP and its aetiology will allow for these etiologies to be ameliorated. This may result in decreased work related LBP (Leelavathy *et al.,* 2011; Roffey *et al.,* 2010(a); Roffey *et al.,* 2010(b); Wai *et al* 2010(a) and Wai *et al.,* 2010(b); Koskelo *et al.,* 2007; Snijders *et al.,* 2004).

Table 2.2: Review of occupational studies with WMSD

AUTHOR	YEAR	COUNTRY	OCCUPATION TYPE	SAMPLE SIZE	PREVALENCE OF LBP %	AGGRAVATING FACTORS
Bovenzi	1996	Italy	Bus drivers	234	83.8	Shock jerking movements
			Tractor driver	1155	8.13	Shock jerking movements
Omokhodion *et al.,*	2000	Nigeria	Hospital staff	80	69.0	Heavy physical labour, poor posture and prolonged sitting and standing
Latza *et al.,*	2000	Germany	Construction workers	571	50.1	Carrying heavy loads, lifting, bending over
Teitz *et al.,*	2002	U.S.A. - New York	Intercollegiate rowers	1 632	32.0	Changes in training, rowers physique, equipment
Rugelj *et al.,*	2003	Slovenia	Physiotherapists	133	73.7	Lifting and handling patients
Hoy *et al.,*	2004	UK	Forklift truck drivers	46	65.2	Lifting tasks
Smith *et al.,*	2005	Korea	Nurses	330	72.4	Bending, twisting or stretching
Holmberg *et al.,*	2005	Sweden	Farmers	1 013	64.0	Manuel handling, whole body vibration
Chen *et al.,*	2005	Taiwan	Taxi drivers	1 242	51.0	Bending and twisting, job dissatisfaction, job stress
Van Vuuren *et al.,*	2007	South Africa	Plant workers	109	71.6	Long hours, hard manual work
Okunribido *et al.,*	2007	Scotland	Bus drivers	80	59.0	Shock jerking movements
Wynne-Jones *et al.,*	2007	UK	Primary care consultants	935	37.0	Ergonomics
Spyropoulos*et al.,*	2007	Greece	Public office workers	771	61.6	Ergonomics
Lui *et al.,*	2008	USA-Columbus	Farmers	2 045	38.4	Manual handling, whole body vibration, mechanical shock
Mattila *et al.,*	2009	Finland	Finnish military (males)	391 241	30.0	Carrying heavy loads
Pargali *et al.,*	2010	Iran	Dentists	90	33.0 - >55.0	Prolonged, static muscle contractions, muscle ischemia
Secer *et al.,*	2011	Turkey	Novice soldiers	871	74.0	Carrying heavy loads
Bernard *et al.,*	2011	France	Vineyard workers	3 974	40%	Traditional blade sharpening, manual pruning

As adapted from Dyer (2012)

The above is underpinned by studies such as that of Bork *et al*., (1996) who found that 45% of physical therapists suffered from LBP. Further investigations revealed that subjective responses indicated the mechanism of injury (MOI) was most commonly linked to lifting tasks (viz. lifting patients, and lifting of heavy objects). Similarly, a musculoskeletal occupational injury questionnaire (Holder *et al.,* 1999) revealed that 32% of physical therapists and 35% of physical therapists' assistants suffered with a musculoskeletal disorder, of which LBP had the highest prevalence at 62% and 56% for each occupation respectively. The findings of this study corresponds to Bork *et* al., (1996) and both suggest that lifting heavy objects as an activity in the work place may be implicated as a possible risk factor of LBP development.

West and Gardner, (2001) who found that fifty-five percent of therapists, suffered with some form of work related injury further supported the above findings. The area most commonly affected was the low back, because of exposure to sustained demanding postures and manual workloads. Ghaffari (2007) contributed to this knowledge stating that occupations, which require awkward postures, bending and twisting, are potentially causative in LBP development. Subsequently, Helfenstein-Junior *et al.,* (2010), illustrated that common professional risk factors not only included incorrect movements and lifting, but postural demands from an incorrect working environment.

On this basis of specific work related studies, Mendelek et al., (2011), performed a comprehensive investigation where they assessed the degree to which individual and occupational risk factors individually predisposed patients to LBP. In addition, they also assessed the quantitative contribution that these risk factors presented when combined or when assessed as confounding variables. The outcome of the study revealed that regardless of the various individual risk factors and occupational risk factors, poor body posture over a prolonged period increased the risk of LBP development. According to Mendelek *et al*., (2011), the correct sitting posture is needed because prolonged sitting causes a loss of the lumbar lordosis, which results in strain being placed on the lumbar vertebrae and discs. Pillastrini *et al*., (2012) therefore suggested that improved work related posture through ergonomic intervention within the workplace would be an effective mechanism in lowering LBP complaints, as this would directly address Mendelek *et al*'s., (2011) assertion that prolonged sitting leads to LBP.

The above illustration is borne out in previous research such as that of Bovenzi *et al*., (1996) who indicated that there may be a positive association between life time exposure to occupational whole body vibrations (WBV) and health problems related to the low back. Okunribido *et al*., (2007) and Xu *et al*., (1997) found a positive relationship between WBV, incorrect ergonomics and prolonged sitting in causing LBP. Bovenzi *et al*., (2006), considered the importance of ergonomics and performed an investigation on persons operating heavy vehicles, and found a greater risk for the development of LBP. These studies indicated that exposure to physical factors, such as poor ergonomics and WBV are important factors to consider in heavy vehicle operations and in the multifactorial origin of LBP.

Literature reviews performed by Leelavathy *et al., (*2011), Roffey *et al.,* (2010(a)), Roffey *et al.,* (2010(b)), Wai *et al* (2010(a)), Wai *et al.,* (2010(b)), Koskelo *et al.,* (2007), Snijders *et al.,* (2004) and Putz-Anderson *et al*., (1999) provide various critical summaries evidencing / not evidencing the causal relationship between proposed LBP risk factors and LBP development. These reviews have not all been consistent in their outcome, as the contexts, samples and research methodologies were varied.

Risk factors for LBP that are supported from a variety of literature sources as a result of their repeated association with LBP development have been identified by Pillastrini *et al*., 2012; Mendelek *et al*., 2011; Helfenstein-Junior *et al.,* 2010; Ghaffari, 2007; Bovenzi *et al*., 2006 and Bovenzi *et al*., 1996 (**Table 2.3)**. The identification of risk factors helps develop management, prevention and intervention strategies for LBP with the aim of reducing the high prevalence of this disorder (Bell and Burnett. 2009).

Certain duties within occupations may result in the exposure to the identified risk factors (**Table 2.3**) which places the persons at a greater risk for the development of LBP (Putz-Anderson *et al*., 1999).

Table 2.3: Evidence for causal relationship between occupational factors and WMSD.

Risk factors of LBP	Strong evidence (+++)	Evidence (++)	Insufficient evidence (+)	Evidence of no effect (-)
Lifting/forceful movements	+++			
Awkward postures		++		
Heavy physical work		++		
Whole body vibration	+++			
Static/prolonged work postures			+	

Adapted from Pillastrini *et al*., (2012); Mendelek *et al*., (2011); Helfenstein-Junior *et al.,* (2010); Ghaffari, (2007); Bovenzi et al., (2006); Bovenzi *et al*., (1996); Putz-Anderson *et al*., (1999).

2.4.2 Occupational injuries and their sequelae

Repetitive execution of occupations which possess risk factors for the possible development of LBP, may lead to recurring minor injuries and may cumulatively result in musculoskeletal disorders and therefore related functional disability (Kim *et al.,* 2010).

For example, prolonged exposure to WBV has been shown to result in adverse effects on the lumbar spine. The International Organization for Standardization (2004) revealed that various structures, including the IVD, paraspinal ligaments and muscles are at risk of injury when exposed to WBV for the following reasons:

1) Elevated mechanical stress on these anatomical structures from a seated position (Chung *et al.,* 2005; Cholewicki and McGill, 1996).
2) Alteration in the body's ability to respond to multiple load positions caused by various postures (Nelson-Wong and Callaghan, 2010; Nelson-Wong and Callaghan, 2009; Nelson-Wong *et al.,* 2008; Krajcarski *et al.,* 1999; Potvin and O'Brien, 1998).
3) Changes in pressure within different tissues (viz. tearing, buckling or softening of the IVD) (Nelson-Wong and Callaghan, 2010).
4) Postural changes to neuromuscular control system, affecting active and passive stabilization mechanisms (Nelson-Wong and Callaghan, 2010; Nelson-Wong and Callaghan, 2009; Nelson-Wong *et al.,* 2008; Krajcarski *et al.,* 1999; Potvin and O'Brien, 1998; Magnusson *et al.,* 1996).
5) Overcompensation by trunk muscles in response to unexpected and / or sudden loading (Chung *et al.,* 2005; Cholewicki and McGill, 1996).

6) Tissue buckling arising from the neuromuscular control system inability to respond effectively in a coordinated manner to sudden loading (Nelson-Wong and Callaghan, 2010; Nelson-Wong and Callaghan, 2009; Potvin and O'Brien, 1998).

Similarly, Mendelek *et al*., (2011) indicates that with prolonged sitting, a loss of the lumbar lordosis results in strain being placed on the vertebrae and discs. The anatomical structures / tissues of the lumbar vertebra and discs need to comply with the following criteria as set out by Windsor and Sullivan (2008) to be considered as a nociceptive structure (three of which are required to be present for pain to be perceived):

1) The structure must have a nerve supply that includes the Wyke IV receptors (known principally as nociceptors (Leach, 2004)).
2) The anatomical part must be prone to disease or injury, which is known to result in painful sensations.
3) The structure must result in the presentation of pain similar to that, which is seen clinically within particular pain syndromes.

The lumbar vertebrae and discs can be considered as nocicpetive structures and responsible for the production of pain. The continual exposure to external forces on the lumbar vertebrae and discs causes them to become prone to the biomechanical phenomenon of hysteresis and creep (Hermes *et al*., 2010). This can lead to the ultimate failure of the lumbar vertebrae and discs tissues. During the process of tissue failure, a nociceptive stimulus will be produced by these tissues, causing perceived pain. The perception of pain will result in the clinical presentation of LBP (White and Panjabi, 1990). Once these criteria have been met and changes within the tissues result in pain, then only will clinical provocation tests enable identification of the injured tissue / structure (Plaugher, 1993).

As an example, macroscopic degeneration of the intervertebral disc, as seen during degeneration, is initiated as a biochemical process as early as the second decade of life. However, more severe pathological developments are usually seen from the third decade and onwards. These changes can include disc bulges, herniation and spondylosis (Hermes *et al*., 2010).

LBP arising from this lumbar disc degeneration usually presents clinically with somatic referred pain (locally) and may show radiculopathic features (at a distance from the lesion). Additionally, it may also be accompanied by abnormal radiological images (Williams and Sambrook, 2011).

The extent of this clinical presentation may vary in chronicity dependent on the type, nature and combination of tissues compromised in the disc and the surrounding structures (Windsor and Sullivan, 2008). Therefore, if the lumbar disc degeneration is associated with a discitis, the LBP complaint is usually severe, acute and localized. However, with internal disc disruption, the resultant LBP usually is milder, less severe and more chronic in nature.

Kim *et al.,* (2010) noted that difficulties arise when considering which anatomical part may be responsible for the pain in the patient's LBP complaint. This is additionally complicated by the current inability to link specific work related LBP risk factors and / or recreational LBP risk factors to specific pathophysiological changes and therefore clinical presentations. Kim *et al.,* (2010) also noted that clinical investigative tools such as radiography, magnetic resonance imaging (MRI) and computed tomography (CT), commonly used to assess the extent of degeneration and damage to the body, also have limitations in that they can only identify the specific anatomical pathophysiological derangement, but are not able to link these with the causative agents.

This is made evident through Jensen *et al*., (1994) who conducted a study in which 98 asymptomatic people were examined with the aid of MRI scan. The aim of the study was to determine the prevalence of abnormalities within the lumbar spine in asymptomatic people. The results found that only 36% of participants displayed normal healthy discs. Of the remaining participants, 52% had a disc bulge at more than one spinal level, 27% showed a protrusion and 1% had an extrusion. To complicate this picture, incidental findings included that 8% of participants had facet joint arthropathy, 14% had annular defects and 19% had Schmorl's nodes.
These results suggest that LBP is a complex condition and that even asymptomatic people may have anatomical variances of healthy spines, which may mimic pathological presentations. This may complicate the clinical assessment of patients,

and the identification of precursor risk factors (Williams and Sambrook, 2011). Kim *et al*., (2010) suggest that future research should attempt to link quantitative parameters that measure recurrent abnormal external load force (e.g. WBV) to clinical findings as well as clinical investigative tools, so that a better appreciation for their qualitative relationships can be developed.

2.5 Pilot specific LBP incidence, prevalence and injuries

2.5.1 Review of pilot LBP incidence and prevalence.

Table 2.4: Review of pilot LBP prevalence and incidence studies.

Authors	Study type	Prevalence/ Correlations to LBP	Industrialized (developed)/ Non-industrialized (Developing)	Region/ population
Shanahan and Reading. (1984)	Correlation study	Insufficient results.	Industrialized (Developed)	U.S.A Helicopter pilots
Froom *et al.,* (1986)	Prevalence study	Lifetime 31.5% Point 5.1%	Industrialized (Developed)	Unknown Commercial pilots
Simon-Arndt *et al*., (1996)	Case control study	Positive correlation with age. No link between LBP and aircraft type.	Industrialized (Developed)	California Naval pilots
Loomis *et al*., (1999)	Prevalence study	Lifetime 78.0% Point 68.0%	Industrialized (Developed)	U.S.A FWA (E-2C)
Goossen *et al*., (2000)	Biomechanical analysis	Positive correlation with ergonomics.	Industrialized (Developed)	Netherlands Commercial pilots
Bridger *et al.,* (2002)	Prevalence study	1 -year 80.0%	Industrialized (Developed)	United Kingdom Helicopter pilots
Aydog *et al*., (2004)	Retrospective radiographic study	Positive correlation with age and disc disorder.	Industrialized (Developed)	Turkey Rotary, HPA and transport pilots
Harrer *et al*., (2006)	Intervention study	Positive correlation to overexposure of WBV	Industrialized (Developed)	U.S.A. Helicopter pilots
Okunribido *et al.,* (2008)	Prevalence study	1-year 80.6% Point 41.9%	Industrialized (Developed)	Unknown Helicopter pilots
Balasubramanian *et al*., (2011)	Correlation study	Positive correlation with WBV.	Industrialized (Developed)	India Helicopter pilots
Hermes *et al*., (2010)	Correlation study	Positive correlation with age.	Industrialized (Developed)	Rotary, HPA and FWA
Prombumroong *et al*., (2011)	Prevalence study	1 year 55.7%	Industrialized (Developed)	Thailand Commercial pilots
Gaydos, S.J. (2012)	Literature review	Positive results	Industrialized (Developed)	U.S.A Helicopter pilots
Walters *et al*., (2012)	Prevalence study	Lifetime 82%	Industrialized	U.S.A Helicopter

The results from **Table 2.4** indicate that pilots are not sheltered from the development of LBP. This is because these results indicated that the lifetime prevalence of LBP varies from 31.5% to 82%. Additionally, point prevalence varies significantly between 5.1% and 68%, which illustrates those individual pilots and / or occupational factors may contribute to pilot LBP. The Pilot's LBP may vary due to aircrafts flown (viz. FWA, RWA,HPA).

It is noted from **Table 2.4**, that there is paucity of studies performed on commercial pilots. To date, only Prombumroong *et al*., (2011); Goossens *et al*., (2000) and Froom *et al*., (1986) have performed studies on commercial pilots or their unique occupational setting. The remainder of the studies were either preformed on pilots operating helicopter (rotary), high performance (HPA) or fixed wing aircrafts (FWA) not always associated with commercial carriers. Therefore, conclusions drawn from these collective studies may / may not consider:

1) Time exposed to WBV,
2) poor ergonomics,
3) prolonged sitting and / or
4) aircraft utilized for majority of occupational years.

Consideration of these factors is applicable to commercial pilots as they may contribute to their predisposition to LBP.

2.5.2 Unique injuries found within pilot populations.

Simon-Arndt *et* al., (1996) states that pain which arises from any anatomical structure or pathophysiological change may be sufficient to impede a pilot's performance. The effect of this impeded performance may lead to catastrophic consequences if a pilot's ability to complete actions critical to flight becomes hindered. For this reason, Hermes *et al*., (2010) and Simon-Arndt *et al*., (1996) investigated the most common musculoskeletal injuries found within pilots of various aircrafts as seen in **Table 2.5** and **Table 2.6**.

Table 2.5: Most common ICD-9-CM coding for spinal disorders in pilots according to location

ICD-9-CM	Disorder group	Cervical disorder	Lumbar disorder
722	Intervertebral Disc Disorder	87	226
723	Other disorder	9	1
721	Spondylosis and Allied disorder	7	1
724	Unspecified back disorders	0	16
738.4	Acquired spondylolisthesis	0	3
738.5	Deformity of the back	0	2
846	Sprains and strain of SI region	0	0
847	Sprains and strain of other parts	0	0

Adapted from Hermes *et al*., (2010)

Table 2.6: Most common injuries amongst pilots and aircrew

Back disorder	Pilot population	%	Aircrew population	%	Total	%
Intervertebral disc disorder	40	46.5	36	42.4	76	44.4
Other Dorsopathies	15	17.5	28	32.9	43	25.1
Curvature of the spine	18	20.9	8	9.4	26	15.2
Other injury or disease	13	15.1	13	15.3	26	15.2
Total	86	100.0	85	100.0	171	100.0

Adapted from Simon-Arndt *et al*., (1996)

According to the results illustrated in **Table 2.5** and **Table 2.6,** intervertebral disc disorders are the most common injury found in pilots, regardless of the aircraft type and related occupational requirements.

Similarly Aydog *et al*., (2004) agreed with Hermes *et al*., (2010) and Simon-Arndt *et al*., (1996) as their study revealed that there was no remarkable difference in the prevalence of lumbar changes between pilots of different crafts. The study did find, however, that according to radiological features, osteoarthritis was the most common observable change occurring within the lumbar spine of all pilots.

2.6 Risk factors of Low Back Pain

The development of low back issues may be as a result of numerous identifiable risk factors which are important personal and / or occupational stressors. The two most common risk factors seem to be postural stress (viz. ergonomics, prolonged sitting) and exposure to WBV over a prolonged period (Okunribido *et al.,* 2007).

2.6.1 Ergonomics and prolonged sitting

Ergonomics is concerned with physiological, biomechanical, anthropometric and human anatomical nature and its relationship to physical activity. Topics relevant to this matter include, but not limited to, working postures, repetitive movements, occupation-related musculoskeletal disorders and health (International Ergonomics Association Site, 2012).

In the correct ergonomic seated position vertical forces from the spinal column pass through to the pelvis in shear and compressive forces, which are then in turn, distributed through the gluteal muscles to the area around the ischeal tuberosities (Song *et al.,* 2001). From here the forces are then further distributed to the interface between the buttock and the seat. The compressive forces are opposed by the structure of the cushion (Song *et al.,* 2001). Equilibrium has to be achieved between the shear and compressive force of the seat and the ischael tuberosities. However, this shear force, which acts together with body weight, causes the discomfort from prolonged sitting (Goossens *et al.,* 2000).

From numerous studies analysed by Song *et al*., (2001), the conclusion indicates that most pilots suffering with LBP will report the aircraft seat as being uncomfortable. Further subjective reporting indicates that the main factors accounting for poor seating ergonomics include inadequate seat adjustments, angle of the seats, and shape of the sitting surface and of the backrest (Song *et al*., 2001).

Previously Goosens et al., (2000) stated that there is a presumption that pilot’s seats are comfortable because of their many adjustment options.

Snijders et al., (2004), investigated the effects of poor ergonomic positions in seated pilots with the main focus on slouching positions. Correct ergonomics will result in a stable position when the centre of gravity of the upper body corresponds to a line in front of the ischial tuberosities (coinciding with the lumbar lordosis). Posterior translation (Backward movement of the lumbar spine) will cause the centre of gravity to pass behind the ischial tuberosities, resulting in an unstable position, poor ergonomics and the slouching position (**Fig 2.9 position A**).

This slouching position with relaxed dorsal muscles results in the spine assuming a convex curve. This in turns forces the L5 vertebrae to rotate anteriorly around the illiolumbar ligament (**Figure 2.8**), and in doing so strains the ligament and opens the posterior side of the intervertebral disc.

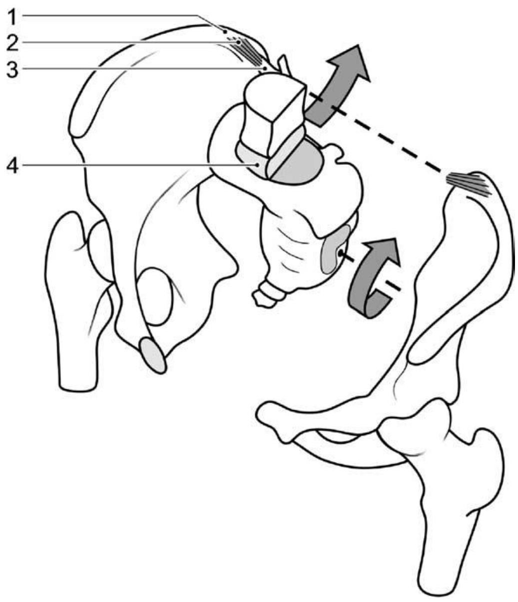


Figure 2.8: Anterior rotation of L5. Adapted from Snidjers *et al*., (2004).

Disc herniation and back sprains can occur with prolonged or sudden lumbar flexion (as in the slouching position) even when axial loading is absent (Snijders *et al.,* 2004). Further results from this study show that sitting in the slouched position with the addition of other lumbar movements at L5 and the sacrum, can cause further complications and can be reduced with the use of a lumbar support. Goosens' *et al*., (2000) study which revealed that the elimination of shear forces between the ischael tuberosities and the seat (**Figure 2.9**) can be eradicated by opting for a backrest and a seat angle between 90 and 100 degrees (**Fig. 2.9 position C**)

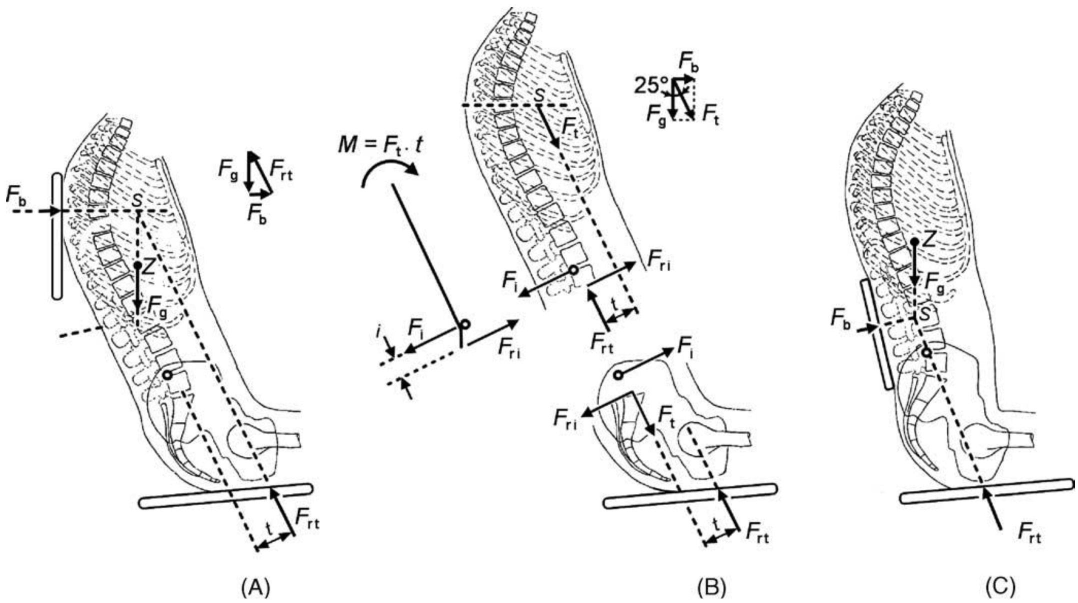
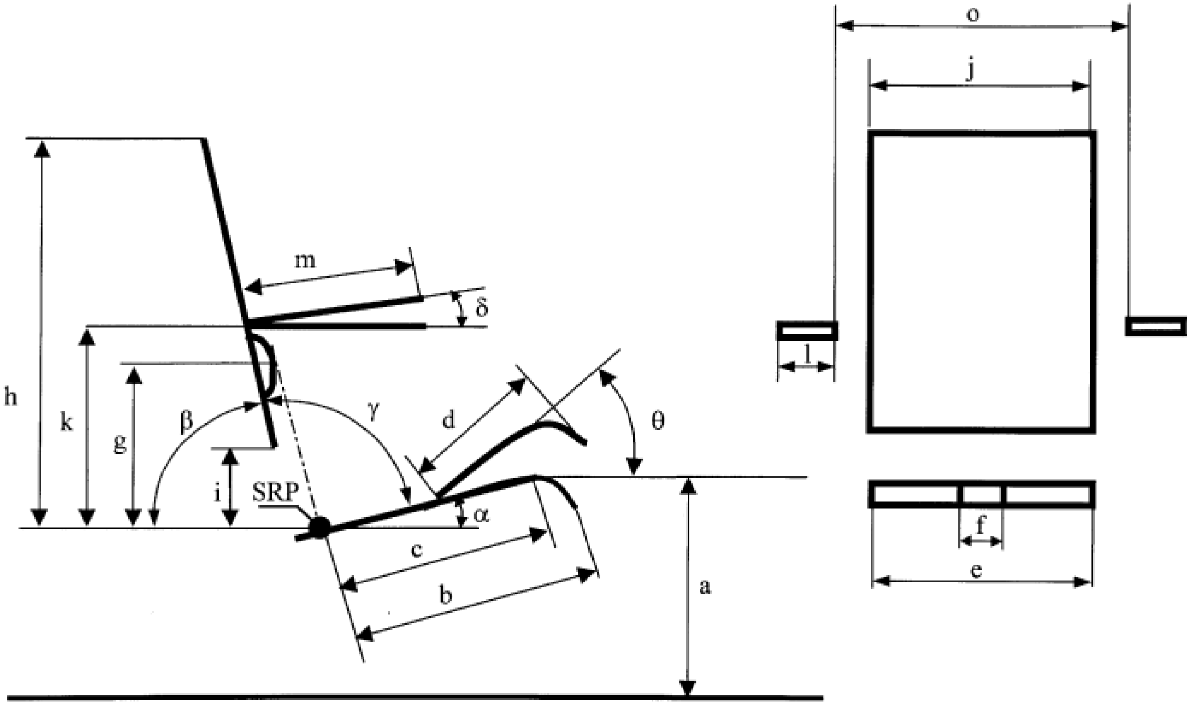


Figure 2.9 Slouching versus lumbar support. Adapted from Snidjers *et al.,* (2004).

According to Goosens et al., (2000), a good seat that supports a pilot's lumbar spine is important to the pilot's comfort and prevention of LBP.

In this context, Goosens *et al.,* (2000) evaluated commercial pilot seats (**Figure 2.10**) with focus on the dimensions and adjustability of the seats. The anthropometric and biomechanical design parameters (**Table 2.7**), as determined by Aerospace Standards and Biomechanical Requirements (AS290B), were used to compare the dimensions and adjustability of commercial pilot seats. The evaluation of the adjustable and biomechanical properties included measuring the minimum and maximum lumbar support adjustability, seat angle, height, depth and width and the height of the armrest. The study found that the seats of various commercial aircrafts (**Table 2.8**) fell short of the anthropometric standards of aviation, meeting only four to seven out of ten requirements, and when compared to biomechanical requirements of comfortable seating, only one to three out of the seven requirements were met. The shortcoming of biomechanical requirements necessary to obtain comfortable sitting postures may thus be related to discomfort of sitting reported by particular pilots and may be applicable to commercial pilots (Goosens *et al*., 2000).

Figure 2.10: Biomechanical measurements of pilot seats.



Adapted from Goosens *et al.,* (2000).

Table 2.7: Aerospace Standards and Biomechanical Requirements (AS290B) of pilot seats

Label	Description	AS290B	Biomechanical
a	Seat height	33min / 51max	-
b	Seat depth	41min / 45max	-
d	Thigh support length	13max	-
f	Column cut out width	10max	-
h	Backrest height	65min	-
j	Backrest width	43min / 46max	-
l	Armrest width	6.5	-
m	Armrest length	28min	-
o	Width between armrest	47min	-
β	Backrest inclination	65-85	-
c	Seat depth effective	-	41min / 52max
e	Seat width effective	-	43min
g	Lumbar support height	-	15-25
i	Free space pelvis	-	15min
k	Armrest height	-	20-32
α	Seat inclination at ischial tuberosities	-	5-15
δ	Armrest inclination	-	0min 5max

Adapted from Goosens *et al.,* (2000).

Table 2.8: Investigated aircraft meeting Biomechanical and/or AS290B requirements.

Aircraft	Number of measured features that meet the 10 anthropometric requirements	Number of measured features that meet the 7 biomechanical requirements
747-300 WEBER	4	2
747-400 IPECO	5	2
DC10 AMI	4	1
A310 SOCEA	7	3
737 IPECO	5	1

Adapted from Goosens *et al*., 2000.

Similar reports by Snijders *et al*., (2004), Song *et al.,* (2001) and Gossens *et al*., (2000) revealed that not only can poor seating create shear forces between the buttocks and the seat, but it may also result in LBP. These findings correspond to a much older study by Froom *et al*., (1986), who revealed that 15% of the pilots from their study suffered back discomfort because of poor seating ergonomics.

The importance of correct seating was made more evident through Balasubramanian, Dutt and Rai (2011), where the rate of muscle fatigue, prolonged sitting and the correlation to LBP was investigated through surface electromyography on the erector spinae and trapezius muscles of pilots. The study revealed a strong correlation between total flying time and pain, indicating that the prevalence of pain increases with greater time flying. This indicates that pilots who are exposed to insufficient support through cockpit seating and fly regularly long shifts are at risk of developing LBP. These latter characteristics, however, are important job requirements of a commercial pilot's occupation (Goosens *et al*., 2000).

2.6.2 Whole body vibration

Whole body vibration (WBV) is mechanical energy oscillations that are passed from a surface or a seat through the body. It has a negative effect on people in occupations such as truck drivers, bus drivers and pilots (Ghaffari, 2007). This is because WBV has an adverse reaction on a person's IVDs, paraspinal ligaments and muscles (Leelavathy et al 2011). This risk factor is highlighted in occupations such as truck drivers, bus drivers and pilots (Ghaffari, 2007).

In a study performed by Leelavathy *et al*., (2011), it was indicated that IVD's, paraspinal ligaments and muscles undergo adverse reaction to constant WBV. These changes, as depicted by the International Organization for Standardization (2004), are exacerbated when these mechanical stresses are experienced in prolonged seated positions (Leelavathy *et al*., 2011). The changes that manifest as a result of WBV include tearing, buckling or softening of the IVD's, as well as changes in the finely regulated neuromuscular system resulting in changes in the passive and active stabilization system (Leelavathy *et al*., 2011; Nelson-Wong *et al.,* 2008; Krajcarski *et al.,* 1999). This may lead to inappropriate compensation by the global trunk muscles with unexpected loading (Leelavathy *et al.,* 2011; Magnusson *et al.,* 1996).

A study of forklift drivers by Hoy (2005), found an increase in the prevalence of LBP through the exposure of WBV, even when confounding factors such as age, height and weight were taken into consideration. This supported previous results by Bovenzi (1996), on bus and tractor drivers, where a greater increase in LBP was reported amongst persons exposed to WBV irrespective of age.

The common theme among these previous studies suggests that LBP has a direct link to WBV (Leelavathy *et al.,* 2011; Okunribido *et al.,* 2008; Hoy, 2005; Bovenzi, 1996). LBP that arises from over exposure to WBV seems to result from early degeneration of the spine and its related components of discs, facet joints, ligaments and muscles (Okunribido *et al,* 2008).

In this context, WBV is a negative sequela of the commercial pilot's environment, due to the health risk posed to the pilot and the association to absenteeism and resultant loss of income to the airlines. This association needs to be investigated and understood by the pilots and airlines alike, as this association can negatively affect both.

2.7 Confounding risk factors

The following variables are mentioned as confounding risk factors to the development of LBP. Their exact contributions are ill defined and often counter-argued (Dagenais and Haldeman, 2012, Ramond *et al.,* 2010; Shiri *et al.,* 2009; Mirtz and Greene, 2005). However, their effects in contributing to pilot's LBP cannot be excluded.

2.7.1 Individual factors

2.7.1.1 Age

Cassidy *et al.,* (2005) investigated the incidence and course of LBP in the general population, and found that younger subjects suffering with LBP did not only have a better outcome when compared to older subjects, but were also less likely to have persistent LBP. Furthermore, positive results in younger subjects resulted in a lower risk of aggravation of previous LBP, indicating that age plays a substantial role in resolution of LBP and / or aggravation of LBP.

With an increase in age, there may be prolonged exposures to physical factors within personal and / or occupational circumstances that have been identified as risk factors for LBP. Within the context of this study, occupational factors (viz. sitting for prolonged hours) increase a pilots' predisposition to LBP development considering that a substantial period of daily waking hours are spent at work (Raad, 2012). An added risk, according to Plouvier *et al*., (2011), is that the age of retirement has increased which means that more pilots are older with greater periods of exposure to risk factors within their profession than before.

Similar to Plouvier's *et al*., (2011) study, Mendelek *et al.,* (2011) found that not only are the regularly investigated factors such as physical loading, overexertion and postures important in the development of LBP, but the age of the employee compounds the effects of these factors due to biomechanical age related changes.

Plouvier's *et al.,* (2011) study indicates that people below the retirement age and who had exposure to risk factors, are at greater risk for LBP development, in comparison to people who were never exposed to risk factors. This indicates that with age and exposure, comes a greater risk for the development of LBP. The above outcome concurs with the results of Dagenais and Haldeman, (2012) and Leboeuf-Yde *et al.,* (2009) who also found that a link exists between increased age and LBP prevalence.

It is, therefore, hypothesised that commercial pilots may reveal results similar to previous studies which have investigated the relationship between age and LBP in various occupations. This may be attributed to their prolonged exposure to the previously discussed risk factors for LBP development in pilots (Clays *et* al., 2007; Jacobs *et* al., 2006; Cassidy *et al*., 2005).

Table 2.9: Studies depicting relationship between LBP and age in pilots.

Author	Avg Age	Std Dev	Association to LBP
Aydog *et al.,* (2004)	32.12	5.72	Strong correlation
Desviat *et al*., (2007)	33.8	6.2	Correlated
Drew, (1999)	30.5	4.7	Strong correlation
Loomis *et al*., (1999)	29.9	3.6	Inconclusive association
Prombumroong *et al*., (2011)	40.3	9.6	Inconclusive association
Simon-Arndt *et al*., (1996)	33.0	7.69	Strong association

Studies performed on pilots, which included age as a variable is seen in **Table 2.9**. These results suggest similarities to Dagenais and Haldeman, (2012); Leboeuf-Yde *et al.,* (2009); Clays *et al*., 2007; Jacobs *et al*., 2006; Cassidy *et al*., 2005), where most studies found a strong correlation between increased age and LBP. However, these studies may not all be homogenous with regards to occupational setting (viz aircrafts utilized). Therefore, it may be deduced that regardless of occupational circumstances, with increased age comes greater and longer exposure to proposed factors that result in LBP.

The prolonged exposure to risk factors may therefore also be true for commercial pilots, however this assertion has yet to be tested. In addition, the combination of risk factors may be unique within the commercial pilot setting and therefore the outcomes of this research may contribute to the body of knowledge by highlighting similarities and dissimilarities between previously studied groups and commercial pilots within the South African setting.

2.7.1.2 Gender

The results in the literature that reflect the relationship between gender and LBP are at odds. The varied results does suggest that the female gender is more at risk, but that gender not seem to be an independent factor in the development of LBP (Shiri *et al*., 2009; Clays *et al.,* 2007; Feldman *et al.,* 2001; Balague *et al.,* 1994; Harreby *et al.,* 1999; Gunzburg *et al.,* 1999; Walsh *et al.,* 1992; Svensson *et al.,* 1988).

Shiri *et al.,* (2009) found that gender played an important role in LBP development. They found that females, who were overweight / obese, were found to be at greater risk for the development of LBP than overweight / obese males. The study by Shiri *et al*., (2009) confirmed the previous work of Balague *et al.,* (1994); Svensson *et al.,* (1988); Fairbank *et al.,* (1984); Salminen *et al.,* (1984) and Valkenburg *et al.,* (1982), which highlighted that research on both genders showed on average, that a higher prevalence of LBP was found in women than men. Similarly, Jin *et al*., (2004) indicated a higher prevalence of LBP in females (54.2%) than males (45%); concurring with Harreby *et al.,* (1999); Balague *et al.,* (1994); Brattberg (1994); Troussier *et al.,* (1994) and Viikari-Juntura *et al.,* (1991).

A suggestion for the higher levels of LBP in females compared to males, is given through the study of Wedderkopp *et al.,* (2005). The study suggests that higher levels of LBP in young females may be due to the onset of puberty (possibly related to gynaecological changes in females), even when confounding factors such as smoking and obesity have been taken into consideration.

These results contrast Clays *et al.,* (2007) study who found that overweight males were at greater risk of developing LBP when compared to females with the same weight. This result confirms the outcomes of studies by Feldman *et al.,* (2001); Gunzburg *et al.,* (1999); Burton, (1996); Newcomer, (1996); Olsen *et al.,* (1992) and Biering-Sörensen, (1989), who similarly found that overweight males were at greater risk.

In contrast, Walsh *et al.,* (1992), found a similar prevalnce rate between men and women (58.3%) in terms of LBP. This concurs with the later study Papageorgiou *et al*., (1995), whose general population study revealed a 59% prevalence rate in both genders. The results of these studies also concur with the studies of Liira *et al.,* (1996); Battie *et al.,* (1990) and Heliövaara (1989).

The literature suggests that variances in the prevalence percentages of these different studies may be as a result of the population(s) and their characteristics under study in each of the previous studies (Morris, 2006). Some of these are highlighted below for reference:

1) Age and gender: the teenage population reported on by Olsen *et al.,* (1992), found that the prevelance of LBP was lower in females than males.
2) Developmental changes: an association between the prevalence and development of LBP in women in the postpartum period (Groves *et al*., 1995) and / or during pregnancy (Bastiaanssen *et al*., 2005; Clancy and McVicar, 2002; Noren *et al*., 2002) may predispose women to increased reporting of LBP when compared to men. This may be as a result of changes within the muscular system linked to pregnancy (Sihvonen *et al*., 1998).
3) Anthropometric characteristics of the participant: body weight has been implicated as a risk factor for LBP in women (Battie *et al.*, 1990). Thus, population characteristics (e.g. weight) may affect gender prevalence’s with regard to LBP.
4) Pain disability: in contrast to the previous points, men tend to suffer more intense and disabling pain than women (Power *et al.,* 2001). This may, therefore, in some populations lead to increased male reporting of LBP, particularly if they hold the greater proportion of the sample that in that study.
5) Ratio and proportion of genders in a study: in a study by Mulimba (1988), the male : female ratio 1:2 (Mulimba, 1988), whereas other studies, with no differences in gender representation, have different outcomes. Thus, the effect of the population demographics confounds LBP data (Reigo *et al*., 1999 and Waddell, 1994).

Despite the conflict in the literature, it is generally accepted that LBP is more often found in females than in males (Morris, 2006; Andersson, 1999). This may be as a reuslt of what Bildt Thorbjornsson *et al.*, (2000) reported through the effect that social relations, work type (sedentary versus active) and participation in exercise may have in females.

In order to fully understand LBP, it is essential to use longitudinal studies as there may be a variety of factors, which influence a specific pain condition during a certain age period for either gender. LeResche's (1999) study concluded that although there is a common trend of increased prevalence of LBP found in females, this may not be pathognomonic for every condition at every stage of life.

Table 2.10: Studies depicting male/female ratios of pilots and relationships to back disorder

Author	**Male**	**Female**	**Total population**	**Back Disorders**
Aydog *et al.*, (2004)	732	0	100% male population	11.3%
Drew, (1999)	39	5	88.6% male population	Approx 22%
Hermes *et al.*, (2010)	18 841	832	95.77% male population	1.2%
Loomis *et al.*, (1999)	72	6	92.3% male population	78%
Simon- Arndt , (1996)	5 018	77	98.48% male population	1.7%

Considering the male predominance found within piloting populations (Hermes, *et al*., 2010; Aydog *et al*., 2004) [**Table 2.10**], it would stand to reason that this population group would suffered less severe and less frequent bouts of LBP as compared to another profession that would be predominated by women. However, with limited studies actually depicting whether the above assertion is based on evidenced publication, the single effect that gender may have on LBP in this population cannot effectively be commented on.

2.7.1.3 Body mass index (BMI) / obesity

Body mass index is calculated as the weight of a person in kilograms divided by their height in meters square (Holmberg and Thelin, 2010). BMI levels are a standard measure of obesity (Seaman, 2013; Mirtz and Greene, 2005). An increase in the adipose tissue of a person which is classed as "normal", "overweight", "obese" or "morbidly obese" (Seaman, 2013) is calculated by the mathematical equation in order to categorize patients into their respective categories of healthy weight (Boon *et al*., 2006).

Obesity is a current worldwide epidemic, which has strong links to metabolic disorders (Haslett *et al*., 2001). Obesity, along with age related changes and deterioration of bones, joints, ligaments / tendons and muscles are thought to increase the likelihood of LBP (Buckwalter, Goldberg and Woo, 1993).

The link between obesity (increased BMI) and LBP has been described previously as tenuous at best, due to the paucity of reviews and studies, which conclusively depict a relationship between BMI / obesity and LBP (Shiri *et al.,* 2009). In a review of 65 studies, it was found that the association between the obesity and LBP was poor. However, according to Jensen *et al.,* (2012); Ramond *et al.,* (2010) and Mirtz and Green, (2005), the presence of a high BMI may place a person at risk for the development of LBP.

Therefore Seaman, (2013); Jensen *et al.,* (2012) and Ramond *et al.,* (2010) agree that using BMI measurements to determine the overall body mass of an individual as an indicator of general adipose levels and in essence health is effective. They do however warn that this method cannot be used as an indicator of risk to the development of LBP – at least not until such time that a clear link between obesity and LBP can be determined.

To this end, a previous study by Kostova, (2001) managed to find a positive congruency between musculoskeletal conditions in males over 40, who were obese and smoked. It was found that the predisposition to LBP was affected by age, weight and smoking. This implies there are many factors that may predispose to the development of LBP. These results agrees with Mirtz, (2005) and Melissas' *et al.,* (2003) studies that reported patients with a BMI less than 30 had a decreased chance of developing LBP, compared to those with a BMI of over 40. Thus, it would seem that increased BMI, in addition to other lifestyle factors may be among the predisposing factors for the development of LBP (Heneweer *et al.,* 2010).

Table 2.11: BMI associated with LBP in pilots

Author	BMI	Std Dev	Association to LBP
Aydog *et al*., (2004)	23.71	1.94	Inconclusive association
Desviat *et al*., (2007)	24.4	1.8	Inconclusive association
Drew,(1999)	23.25	-	Inconclusive association
Prombumroong *et al*., (2011)	24.3	2.8	Inconclusive association

The BMI of commercial pilots does not seem to influence the likelihood of them experiencing LBP, as an inconclusive association exists (**Table 2.11**). This may, however, be affected by the high male predominance in this industry which has previously been shown to place them at decreased risk of developing LBP. This characteristic may be unique to the commercial pilot group that is under study, because it is likely that different pilot groups may have different predispositions to LBP because of their personal and psychosocial factors unique to them and the aircrafts that they may use.

2.7.1.4 Ethnicity

Hurwitz and Morgenstern, (1997) noted that there is an increased prevalence of LBP in non-white ethnic groups. The literature seems to suggest that this is related to "cultural influencers" that are unique to specific ethnic groups. One such factor could be access to health care for LBP, with the possibility of white ethnic groups more likely to access and receive care for LBP. This results in increased reporting of their LBP statistics as compared to any other ethnic group (Dagenais and Haldeman, 2012; Hurwitz and Morgenstern, 1997; Heliövaara, 1989; Deyo, 1987). Other possible influencers might be by geographical access to care or monetary / medical scheme cover (Dyer, 2012).

These factors have been discussed in epidemiological studies on populations with LBP and their ethnicity in South African populations that revealed the following:

1. Black population reported a 53,1% lifetime prevalence of LBP (Van der Meulen, 1997);
2. Coloured population reported a 76.6% lifetime prevalence of LBP (Docrat, 1999);

3. Indian population reported a 78.2 % lifetime prevalence of LBP (Docrat, 1999);
4. White population reported 47.5% lifetime prevalence, with 34% point prevalence (general population) and 35.9% point prevalence in high-income groups (Dyer, 2012).

Albert, (2009) conducted an epidemiological study on fire fighters and revealed comparable results to Van der Meulen, (1997). The study of Albert, (2009) found the prevalence of LBP was 35.7% (12-month prevalence) of which 50% of the participants was black. A study conducted by Galukande *et al*., (2005) in Uganda revealed results which, although higher than Van der Meulen, (1997), remains lower than Docrat (1999). However, collectively, the results reveal that the white population has the lowest prevalence of LBP within the South African community. This is confirmed by Louw *et al*., (2007) through a systematic review performed in Africa, where collectively the LBP statistics reported are generally lower for Africa than the global statistics reported by Walker (2000) [including countries such as Australia and United States of America].

2.7.1.5 Education / Income

Dionne *et al.,* (1997); Viikari-Juntura *et al.,* (1991); Heliövaara, (1989); Bergenudd and Nilsson (1988) and Salminen, (1984) indicated in their studies that low levels of education predisposed all population groups to an increased likelihood of LBP along with an increased chance of disabling pain (Hurwitz and Morgenstern, 1997; Deyo *et al.,* 1987). By contrast, the studies by Power *et al.,* (2001); Riihimaki *et al.,* (1991) and Bigos *et al.,* (1986) show that there is no relationship between education levels and the likelihood of LBP in any population group.

There may be an indirect association between the level of education and LBP. An indirect association is suggested, because factors of employment (viz. unemployment, increased employment or job stress) could be a possible consequence of levels of education with an effect on LBP (Hurwitz and Morgenstern, 1997; Cheadle *et al.,* 1994; Volinn *et al.,* 1988). Volinn *et al*., 1997 suggests that LBP is more common in high-income country populations as compared to low-income country populations. However, Volinn's (1997) results should be interpreted with caution as only a small amount of research has been done to compare disparate populations within the same country. Volinn (1997) also stated that although there is a higher likelihood for LBP in "enclosed workshops" in low-income countries, this is not comparable to the office-based environments in high-income countries, making the results incomparable.

2.7.1.6 Marital status

It was first noted by Reisbord *et al.,* (1985), that there is a higher prevalence of LBP in single or unmarried persons when compared to their married counterparts. This was later supported by Biering-Sörensen *et al.,* (1986) who characterise the single male, living alone as the most likely candidate for LBP. In addition, Cats-Baril *et al.,* (1991), Biering-Sörensen *et al.,* (1986), and Reisbord *et al.,* (1985) found that separated / divorced / widowed persons were more likely to suffer from LBP than their married counterparts were.

2.7.1.7 Medical insurance

Volinn *et al*., 1997 suggested that the availability of monetary access may affect the prevalence of LBP through the usage of health care providers in comparison to low-income populations with no access to these services. There is, however, a paucity of information regarding the effect of medical scheme / medical insurance cover / insurance and the posible outcome on the prevalcence of LBP.

2.7.1.8 Previous surgery

Chronic pain that develops after surgery is not an uncommon event. Understanding the mechanism, natural history and the possible therapies with its outcomes, is however, still eluding current investigations (Reuben, 2007). The study of Ostelo *et al*., (2005) provided a temporary explanation, stating that it may be the expectancy of treatment, which influences the outcome. The apprehension or lack of confidence in improvement following surgery may be the determining factor in the actual improvement of health (Ostelo *et al*., 2005). The study revealed further that, patients with poor functional status at the onset of surgery had poor outcomes with regards to residual pain after surgery. This, however, may be confounded by central sensitization or 'windup'(Coderre *et al*., 1993), which is a syndrome whereby pain persists past the normal expected period for an acute insult, which leads to aberrant physiology including:

1) Permanent alterations in the central nervous system (CNS),
2) decrease of inhibitory neurons responsible for control of pain,
3) new afferent excitatory neurons and
4) aberrant excitatory synaptic connections (Coderre *et al*., 1993).

These physiological changes may not be present in all cases, considering that a pathological state of the spine does not always equate to pain (Akuthota *et al*., 2003). It may be that physical and psychological factors play an important role in the presence of residual pain (Ostelo *et al*., 2005). It is noted that there is paucity of information regarding the actual influence surgery has on the development of LBP or the contribution surgery has to the prevalence of LBP.

Therefore, the effects of previous surgery in the lumbar spine may have a contributory effect to LBP in commercial pilots.

2.7.2 Psychosocial factors

2.7.2.1 Smoking and alcohol consumption

Clays *et al*., (2007) and Frymoyer *et al*., (1983) suggest that smoking is a significant risk factor predisposing to LBP. Frymoyer *et al*., (1983) noted that 53.0% of LBP patients were cigarette smokers, as opposed to 39.6% of asymptomatic patients. The authors hypothesised a twofold reason for this (Frymoyer *et al*., 1983):

1) Coughing increases the intra-discal pressure, resulting in increased likelihood for degeneration and therefore predisposition to LBP (Tucer *et al*., 2009).
2) The physiological effect of smoking on the spine, which is associated with changes in mineralisation of bone and a compromise in the nutrition of the motion segment structures resulting in an increased rate of degeneration and

a decreased rate of healing when injured (Tucer *et al*.,2009; Frymoyer *et al*., 1983).

These suggested reasons and outcomes for LBP concur with Vindigni *et al*., (2005); Harreby *et al.,* (1996); Toroptsova *et al.,* (1995); Boshuizen *et al.,* (1993); Ready *et al.,* (1993); Pietri *et al.,* (1992);Heliövaara *et al.,* (1991), Battie *et al.,* (1989) and Deyo, (1989).

The above studies have established smoking as a possible predisposing factor to the development of LBP. Smoking may be an indirect association to factors of lifestyle and sociodemographic factors (e.g. alcohol, income) (Heneweer *et al.,* 2010; Skillgate *et al.,* 2007; Walker *et al.,* 2004; Heliövaara *et al.,* 1991; Vallfors, 1985)

In contrast Kaaria *et al.,* (2011), found that smoking was not statistically associated with LBP in males, but was rather associated with the female participants with habitual smoking (Dyer, 2012), thus highlighting the possible confounding factor of gender. These outcomes were however, contextualised in a small sample size and Kaaria *et al.,* (2011) who suggested that their study be repeated with a larger sample.

Table 2.12: Studies illustrating the relationship between smoking and LBP in pilots

Author	**Smoking population**	**Association to LBP**
Aydog *et al*., (2004)	16%	Inconclusive association
Drew, (1999)	0%	No association
Prombumroong *et al*., (2011)	Unknown population size	Inconclusive association

With paucity of studies revealing the effect of smoking on the development of LBP in pilots (**Table 2.12**), it may be that the paucity of literature results from the stringent health requirements placed on pilots and minimizing this habit within this population.

2.7.2.2 Stress

Stress is defined as those factors at home or at work that are considered to negatively affect a person in that environment resulting in physical overstraining and, job strain as well as psychological disturbances / distress and / or total mental exertion. Whilst numerous studies have attempted to indicate that stress is a contributing risk factor in the development of LBP, the results from Hartvigsen *et al.,*(2004) systematic review show that there is no clear evidence to suggest stress from occupational circumstances can be linked to the development of LBP.

This confirms and coincides with the results found by Hoogendoorn *et al.,* (2000), whose comprehensive systematic review found strong evidence for low social support and job satisfaction as factors predisposing to LBP. But, insufficient evidence was seen for occupational stressors (viz. high work pace, job content, occupational demands) and psychosocial factors that can result in LBP.

However, according to Heneweer *et al.,* (2010), evidence exists in supporting the assertion that psychological factors (such as stress, and/ or depression) are related to the development of future episodes of LBP and related disability levels. (Heneweer *et al.,* 2010; Hoogendoorn *et al.,* 2000; Linton and Ryberg, 2000; Bongers *et al.,* 1993). In general, the literature suggests that this may be linked either to apprehension about a previous injury or concern about perceived damage to the low back and possible re-injury (Morris, 2006).
Stress related to a pilot's occupation may be high and could be further influenced by being away from home and support structures, which may place them at risk for higher stress levels as a result of these different and unique circumstances.

2.7.2.3 Exercise

There is agreement that activity is generally protective of the development of LBP (Dagenais and Haldeman, 2012; Bell and Burnett, 2009; Morris, 2006; Haldeman, 2005; Hildebrandt *et al*., 2000). This is, however, not without debate, as Heistaro *et al.,* (1998); Harreby *et al.,* (1996); and Salminen *et al.,* (1984) seem to suggest that an increasingly sedentary lifestyle predisposes populations to developing LBP. By contrast, authors such as Power *et al.,* (2001); Holmstrom *et al.,* (1992); Magnusson *et al.,* (1992) and Riihimaki *et al.,* (1991) disagree, arguing that no relationship between LBP and levels of activity exists.

A more recent systematic review by Heneweer *et al.,* (2010) showed that high load activities as well as home do-it-yourself activities seemed to be associated with the development of LBP, (Heneweer *et al.,* 2010; Hoogendoorn *et al.,* 2000). Similar findings showed that women, who performed high intensity physical activity, were predisposed to LBP (Heneweer *et al.,* 2010).

A factor that might influence the relationship of exercise to LBP, is that of patient knowledge and exercise execution. As Sargant and Bachman (2010) noted that although specific exercises may be complicated and should be taught by a physical therapist, with progressive strengthening of back extensors, hip flexors and abdominals, some alleviation of pain can occur (Sargant and Bachman, 2010).

2.8 Conclusion

Numerous studies have shown the complexity of LBP, which is a multi-factorial condition with various aetiologies. The impact of LBP on the general population validates that this condition is one of the most common musculoskeletal problems and a major debilitating condition. The significance of LBP, within an occupational setting, is evident with numerous studies attempting to isolate occupational risk factors. However, due to the multi factorial influences for the development of LBP, personal factors as well as occupational factors need to be considered.

Previous studies have shown that commercial pilots have a high prevalence of LBP (Prombumroong *et al*., 2011, Okunribido, *et al*., 2008; Goossens, *et* al., 2000). Studies of pilots in different occupational circumstances have identified major occupational risk factors within the commercial pilot environment (viz. Prolonged sitting, WBV, poor ergonomics) (Prombumroong *et al*., 2011, Okunribido, *et al*., 2008; Harrer *et al*., 2006; Goossens, *et* al., 2000; Simon-Arndt *et al*., 1996). Added to these occupational risk factors, the commercial pilots may also be exposed to personal risk factors (age, gender, BMI, ethnicity, education / income, marital status, medical insurance, previous surgery) and psychosocial factors (smoking and alcohol consumption, stress, exercise) that can further contribute to LBP.

This study will attempt to isolate the risk factors found within commercial pilots in South Africa, as there may be similarities to previous studies, but also differences when the South African context is taken into account.

CHAPTER THREE
Research Methodology

3.1 Introduction

This chapter explains the methods and instruments used to conduct the study and include the statistical methodology utilized. Topics discussed within this chapter include the study design, sampling method, research procedures, the research tool, ethical consideration and statistical methodology used.

3.2 Research Design

This study was a cross-sectional survey, which was performed with the aid of a self-administered questionnaire (Salant and Dillman, 1994; Mouton, 2002). The use of a questionnaire based study allows for data to be collected from a large diverse population and results in descriptive and statistical information which can be analysed (Hicks, 2004). The researcher formulated the original questionnaire with the aid of the literature pertinent to this study. This questionnaire was then subjected to an expert group to ensure that bias was kept at a minimum, and misinterpretations of the questions were reduced. An expert group was required to certify and add validity to the questionnaire (Mouton, 2002).

The research topic was approved for the Faculty of Health Science, Durban University of Technology, by the Institutional Research and Ethics Committee (IREC) (Appendix O).

3.3 Ethical consideration

A Letter of Information and Informed Consent (Appendix L) ensured that all participants had full knowledge of the study. The Confidentiality Statement (Appendix M) and Questionnaire format ensured complete confidentiality. All completed questionnaires were separately placed in boxes and coded to protect their identity, which is only known to the researcher and the supervisor (Helsinky, 1964)

3.4 Advertising and permission

This study did not require any advertising; however, permission from relevant agencies was required. A letter from a fleet manager from a participating company (Appendix B) explained the internal procedures of acquiring permission to conduct this research at O.R. Tambo International Airport. Internal protocol of OR Tambo International Airport required that all companies that would be asked to participate in this research give permission. In this regard the researcher personally approached all company personnel with the authority to grant permission for their staff and their designated private areas to be used in the execution of this study. The letters of authority from the companies are attached (Appendix A). In this regard, permission was requested from the authority figure of each company within O.R. Tambo International Airport to approach their pilots.

3.5 Sampling

3.5.1. Sample characteristics

All participants in this study had to comply with the following criteria:

3.5.1.1 Inclusion criteria:

- Pilots were required to be registered with South African Civil Aviation Authority (SACAA).
- Pilots, who at the time of data collection were over the age of 18 years, were eligible to participate.
- Pilots were required to fly aircrafts defined as fixed wing to qualify for participation in the study.
- Short, medium and long haul pilots were included in the study.
- Pilots were required to read and sign the Letter of Information and Informed Consent (Appendix L) and the Confidentiality Statement (Appendix M) to partake in the study.

3.5.1.2 Exclusion criteria:

- Commercial helicopter pilots were not eligible for participation in this study.
- Any member of SACAA present at the expert group or pilot study was excluded from the study.
- Pilots who held two or more occupations in aviation (i.e. moonlighting for other companies were excluded from the study).

3.5.2. Sample method and size

Due to the studies inclusion and exclusion criteria it was determined from the 2010 / 2011 Civil Aviation Authority annual report that 631 pilots made up the possible sample population of the study. Of the total population of 631 pilots, 308 commercial pilots were of foreign nationality and registered with their respective National Civil Aviation Authority. Only 323 were South African National registered pilots, making them only eligible for inclusion in the study. A response rate of 30% was set to ensure that adequate provision was made for attrition within the total pilot population (Esterhuizen, 2013). In addition, this minimum would allow possible trends to be detected for the entire population (Lapane *et al.,* 2007). A response rate of 30% for this study would require 96.7 completed questionnaires (323 x 30% = 96.7). This was rounded off to a minimum of 100 completed questionnaires in the sample size. The first 100 correctly completed questionnaires received by the researcher were used for this study. The sampling technique utilized in this study was convenient sampling determined from the availability of pilots during questionnaire distribution.

Participation in the study was purely voluntary (Mouton, 2002) based on the participants willingness to complete the questionnaire (Appendix K), the Letter of Information and Informed Consent (Appendix L) and the Confidentiality Statement (Appendix M), noting that all participants had to meet the inclusion / exclusion criteria. Participants were not placed in groups during the data collection phase as this was not a comparative study.

3.6 Procedure:

- After the study's approval from the DUT Faculty of Health Sciences Research and Ethics Committee the study commenced.
- All fleet managers of the companies at O.R Tambo Airport were notified electronically and the proposed research was explained. This included the final approved research protocol, procedures, and logistics of the study.
- A meeting was scheduled with the fleet managers of all participating companies to organize security accreditation for the airport building and to establish a suitable date to start data collection.
- Security clearance was obtained, in the form of a personnel key card, to ensure access to all necessary regions of the airport companies.
- Pilots were approached personally by the researcher and given the Letter of Information and Informed Consent (Appendix L) and Confidentiality Statement (Appendix M), after which time was allowed for any questions the pilots may have.
- Once a pilot had signed the Letter of Information and Informed Consent (Appendix L) and Confidentiality Statement (Appendix M), they were included as participants in the study.
- Questionnaires (Appendix K) were then distributed to the pilots that had become participants in the study.
- The pilots required about 15 minutes to complete the questionnaire, as determined by the pilot study (section 3.6.3) before handing it back to the researcher.
- The completed Letter of Information and Informed Consent (Appendix L), Confidentiality Statement (Appendix M) and Questionnaire (Appendix K) were placed in separate sealed boxes to ensure confidentiality. All the Letters of Information and Informed Consent (Appendix L) and Confidentiality Statements (Appendix M) were collected in one box. All completed Questionnaires were places in a separate box.
- The separate sealed boxes allowed for collection of the Letter of Information and Informed Consent (Appendix L), Confidentiality Statement (Appendix M)

and the Questionnaires (Appendix K) respectively. This allowed for the confidentiality to be maintained as stipulated by the research procedure.

- Once the target of one hundred questionnaires was reached, the researcher opened the boxes and captured the data onto an excel spreadsheet to allow for preparation of data analysis.
- After the data was captured, the completed Letter of Information and Informed Consent (Appendix L), Confidentiality Statement (Appendix M) and the Questionnaires (Appendix K) were kept in a locked cabinet at the Durban University of Technology: Department of Chiropractic and Somatology. For security and confidentially reasons, these questionnaires are to remain in the possession of the Chiropractic and Somatology Department for a period of 15 years before all data will be destroyed.

3.7 Research tool

3.7.1 Questionnaire development.

For this study, the questionnaire method was used to gather data. Whilst variations of questionnaires do exist, the most common type is those of interviewer administered questionnaires and self-administered questionnaire (Struwig and Stead, 2001). Different styles of questioning were purposefully used in this study's Questionnaire, to increase the likelihood of respondents accurately answering the questions. The types of questions used varied from open-ended questions, multiple choices, dichotomous (yes / no options) and scaled response. This allowed for a structured and unstructured questionnaire, which ensured validity and reliability to the questionnaire (Struwig and Stead, 2001). The questionnaire was developed from articles, books and publications which are listed in **Table 3.1**.

Table 3.1: References used to create the questionnaire

Roffey *et al.,* 2010(a); Roffey *et al.,* 2010(b); Wai *et al* 2010(a); Wai *et al.,* 2010(b); Ginanneschi *et al*., 2006; Ramroop *et al*., 2006; Smith *et al.*, 2006; Glover *et al.,* 2005; Manek and MacGregor, 2005; Vieira, Kumar and Narayan, 2005; Rupert and Ebete, 2004; Sjolie, 2004; Van den Heuvel *et al*., 2004; Pope, Goh and Magnusson, 2002; West and Gardner, 2001; Cromie, Robertson and Best 2000; Davis and Heaney, 2000; Manchikanti, 2000; Holder *et al*., 1999; Docrat 1999; van der Meulen 1997; Bork *et al*., 1996; Tim, 1996; Pope *et al*., 1991

Some of the information from the above mentioned literature was then translated into pilot specific questions with the emphasis placed on occupational low back pain and possible factors related to the development thereof (Roffey *et al.,* 2010(a); Roffey *et al.,* 2010(b); Pope, Goh and Magnusson, 2002). The Bradford-Hill criteria was then considered during the structuring of questions to allow gathering of data which may better fulfil the criteria when assessing the proposed risk factors of LBP and the causal relationship that may exists. The questions were structured according to the following Bradford-Hill criteria: 1) strength 2) consistency 3) specificity 4) temporality 5) Biological gradient 6) plausibility 7) coherence 8) experiment 9) analogy.

3.7.2. Expert group

The contributions that the expert group provided, aided the researcher in highlighting areas of importance, with regards to the participants of the study and their occupational situations. During the expert group meeting, all members were encouraged to develop, discuss and alter ideas surrounding the topic in order to allow the questionnaire (Appendix C) to be critically assessed and reach a uniform streamlined format which corresponds to the aims and objectives of the study. The feedback from the expert group members helped establish the relevance of the questionnaire to the future participants (Silverman, 2001; Morgan, 1998(c); Streiner and Norman, 1995; Salant and Dillman, 1994).

All members of the expert group were representatives of the specific areas of expertise highlighted by the research in order to achieve face validity of a questionnaire (Mouton, 2002; Morgan 1998) and content validity (Mouton, 2002; Morgan, 1998) by identifying any discrepancies, uncertainties, ambiguity and deficiencies (Bernard, 2000).

The expert group consisted of the following persons:

- Two pilots who :
    - are registered with SACAA.
    - are over the age of 18 years.
    - flew aircrafts which are defined as fixed wing.

- One researcher who had completed a questionnaire study.
- One student completing a research study.
- One statistician and/or supervisor of Chiropractic research.
- Two Chiropractors.

It was required for all participants of the Expert Group to sign all the required forms, which included the Letter of Information and Informed Consent (Appendix D), Code of Conduct (Appendix E) and the Confidentiality Statement (Appendix F). Failure to sign above mentioned documents meant immediate exclusion from the expert group as this was an exclusion criterion. Participants of the expert group were given an opportunity to ask any questions before discussions of the questionnaire began. The pre-expert group questionnaire (Appendix C) was then distributed to the respondents.

All questions were addressed sequentially by the researcher and the expert group, allowing for additions, alteration or omission based upon general consensus of all members. Changes to the pre-expert group questionnaire (Appendix C) that were discussed and agreed upon were documented and are listed in Appendix N. These changes resulted in the post expert group, pre pilot study questionnaire (Appendix G). The entire expert group meeting was documented with a video recording device for record keeping, to ensure the process transpired as planned and to resolve any questions regarding alterations of the questionnaire, if so missed, by the researcher following the expert group meeting.

3.7.3 Pilot study

This post expert group/ pre-pilot study questionnaire was subjected to a pilot study, which served as a preliminary or “trial run” of the main study (Trochim, 2001). The intent of the pilot study was to establish the member’s understanding of the questionnaire and to raise any other discrepancies or errors (Fink and Kosecoff, 1985).

For the pilot study, the following participants were:

- Two pilots who:
  - are registered with SACAA.
  - are over the age of 18 years.
  - fly aircrafts which are defined as fixed wing.

No changes were requested by the pilot study participants, which resulted in the final format of the research Questionnaire (Appendix K). Once the pilot study questionnaire was completed, the pilot study respondents were required to complete the pilot study evaluation form (Appendix J), which ensured that feedback, regarding the efficiency of questions, stipulated on the questionnaire was obtained (Fink and Kosecoff, 1985).

3.7.4 Final questionnaire

The final questionnaire (Appendix K) was created as a result of the discussions and recommendations from both the expert group and pilot study. This document was divided into 4 sections to meet the aim and objectives of the study:

Section A: Demographics
Section B: Social history
Section C: Occupation
Section D: Characteristics of pain

3.7.5 Measurement and statistical analysis

IBM SPSS version 21 was used for analysis (as supplied by SPSS Inc., Marketing Department, 44 North Michigan Avenue, Chicago, Illinois, 606611). A *p* value <0.05 was considered as statistically significant. The demographics of the pilots were described using categorical variables and summary statistics such as mean, standard deviation and range for quantitative variables.

Prevalence and characteristics of the LBP was described using relative frequency and percentages, with 95% confidence intervals. Associations between risk factors and low back pain was identified with log linear regression analysis and tested using Pearson's chi square test in the case of categorical variables and t-tests in the case of continuous variables (Esterhuizen, 2012).

CHAPTER FOUR

Results and discussion

4.1 Introduction

This chapter will provide the results of the statistically analysed data, and a discussion and interpretation of the results. The results, discussion and interpretation of results are not normally discussed in one chapter, but to allow for ease of access, continuity, and to eliminate cross referencing of the information it was decided to combine the ‘results’ and the ‘discussion of the results’ into one chapter.

4.2 Data Sources

This chapter was compiled using the data from both the primary and secondary data sources.

4.2.1 Primary data source

Participants of this study provided information following the completion of a questionnaire (Appendix K) which was used to collect data.

4.2.2 Secondary data sources

The secondary data was compiled using the information gathered through literature, as depicted in Chapter Two, which was obtained from journals, research dissertations, articles, library books, internet sources and communication with the statistical analyst (Esterhuizen, 2013) and supervisor.

4.3 Abbreviations

%	Percentage
<	Refers to a value or figure less than the value or figure shown
=	Equals to
>	Refers to a value or figure greater than the value or figure shown
ADL:	Activities of daily life
AMI:	Arthrogenic muscle inhibition
ANOVA:	Analysis of variance
AS290B:	Aerospace Standards and Biomechanical requirements of pilot seats
C.I:	Confidence interval
CNS:	Central nervous system
CoG:	Center of gravity
FWA:	Fixed wing aircraft
HPA:	High performance aircraft
IOD	Injury on duty
IVD:	Intervertebral disc
LBP:	Low back pain
***n*:**	Population size
OR:	Odds ratio
***p*:**	Indicates the statistical significance of the data. The closer the *p*-value is to naught, the more significant the results (Hicks, 2004).
RWA:	Rotary wing aircraft
SACAA:	South African Civil Aviation Authority
Std Dev:	Standard deviation
sEMG:	Surface Electromyography
Sig:	Significance
WBV:	Whole body vibration
WMSD:	Work related musculoskeletal disorders

4.4 Response rate

A total population size of 323 commercial pilots was eligible for participation. Based on the minimum response rate at 30%, as approved by the Institutional Research and Ethics Committee, the researcher was required to attain a minimum number of 96.9 commercial pilots. The minimum required study participants was calculated by multiplying 323 by 30% which equalled to 96.9. In order to attain this, a minimum response of 100 pilots was sought for this study. Approximately 320 questionnaires were distributed to commercial pilots, from which 115 questionnaires were obtained. Of the returned questionnaires, 13 had to be excluded as a result of participants failing to sign the Letter of Information and Informed Consent (Appendix L) and / or Confidentiality Statement (Appendix M). A further two questionnaires were excluded as a result of failure to complete the questionnaire to an acceptable state. This produced 100 questionnaires eligible for statistical analysis (**Figure 4.1**).

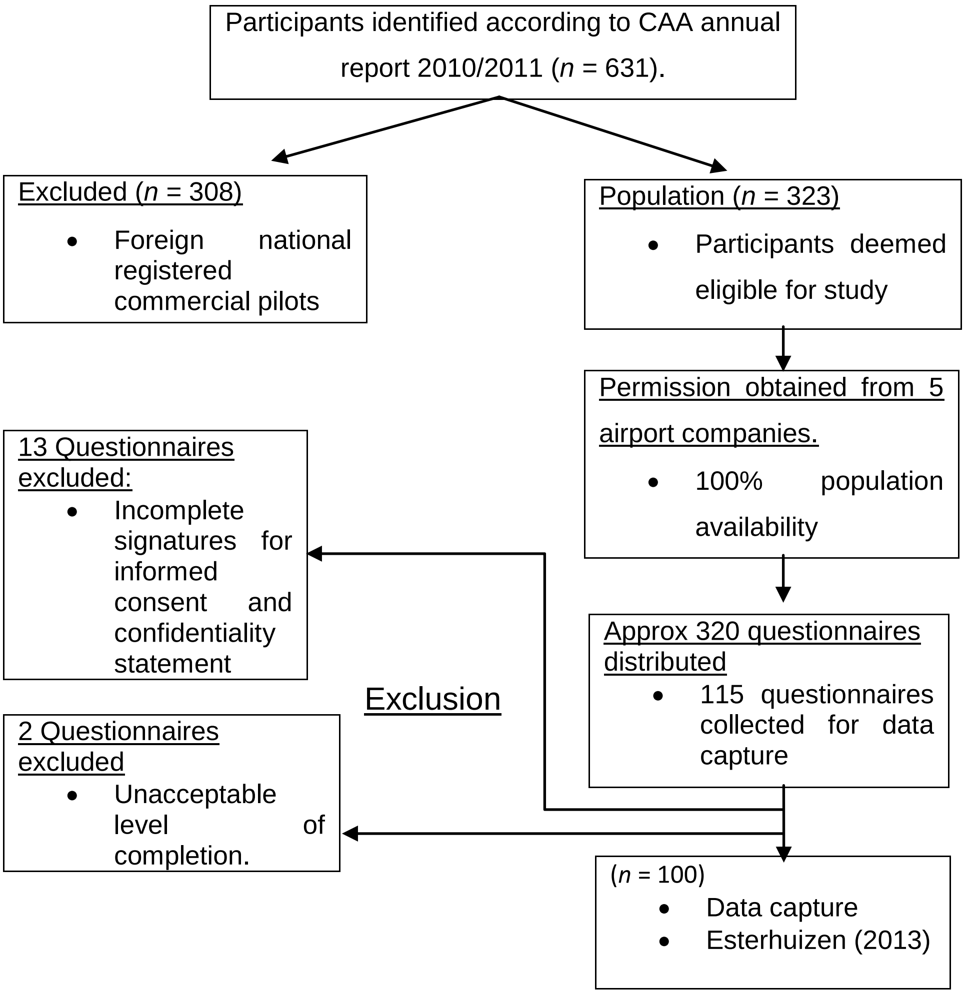


Figure 4.1: Diagrammatic representation of research process.

4.5 Objectives

Objective One:

To establish the demographics (gender, ethnicity, marital status, education, dependants, age and BMI) of commercial pilots registered with the South African Civil Aviation Authority (SACAA).

Objective Two:

To establish the work history of the commercial pilots (occupational years, work history, medical history, total flying hours, cockpit seat description, daily experiences in cockpit seat).

Objective Three:

To establish the point, period and lifetime prevalence of LBP amongst commercial pilots in South Africa.

Objective Four:

To determine the nature, severity and clinical presentation of LBP in commercial pilots.

Objective Five:

To identify possible risk factors that may contribute to LBP in commercial pilots.

Objective Six:

To establish if a correlation between demographics, work history and risk factors exists in the contribution to LBP in commercial pilots.

4.6 Results

4.6.1 Objective One: Demographics and personal profile

To establish the demographics (gender, ethnicity, marital status, education, dependants, age and BMI) of commercial pilots registered with the South African Civil Aviation Authority (SACAA).

4.6.1.1 Demographics

Table 4.1: Personal profile of participants

Q1.4 - 1.8		Count	Column %
Gender	Male	84	84.0%
	Female	15	15.0%
	Missing	1	1.0%
Ethnicity	White	85	85.0%
	Black	6	6.0%
	Coloured	6	6.0%
	Indian	2	2.0%
	Other	1	1.0%
Marital	Married	70	70.0%
	Single	16	16.0%
	Divorced	8	8.0%
	Missing	3	3.0%
	Other	3	3.0%
	Separated	0	0.0%
Education	ATL	92	92.0%
	Commercial license	8	8.0%
No of dependents	0	37	37.0%
(Mean = 1.3)	1	23	23.0%
(Std Dev = 1.3)	2	20	20.0%
	3	16	16.0%
	4	2	2.0%
	5	2	2.0%

The demographic profiles of the participants, as illustrated in **Table 4.1**, show that the majority of the pilots for this study were male (84%), White (85%), married (70%) and similarly educated. The dependants of the pilots for this study were varied.

The Male gender was in the majority for this study's sample. Under gender, one pilot did not answer the question on gender, this account for the one percent missing.

By far the largest ethnicity was represented by Whites, followed by Black and Coloured (6% each). The Indian and 'other' ethnicities represented the remaining three percent.

The marital status revealed most were married. Those that were not married reported 16% being single, eight percent divorced and six percent either ‘missing’ or ‘other’.

As expected the educational levels of pilots were significantly similar with 92% of participants having obtained Airline Transport Licences (ATL).

Nearly 60% of the pilots had between one and three dependants, in comparison to nearly 40% of pilots having no dependants. However, the average (mean 1.3) for the sample was over one dependant.

4.6.1.2 Discussion of demographic data

In comparison to previous global studies on pilots (Hermes *et al*., 2010; Aydog *et al*., 2004; Drew, 1999; Loomis *et al*., 1999; Simon- Arndt 1996), this study, conducted within South Africa, yielded similar findings with regards to the male predominance in commercial pilots.

This study found significance in the number of White pilots. The larger representation by White pilots may be attributable to the historical South African context of Apartheid. During which the educational system of schooling (primary and secondary education) and pilot training (tertiary education) would have favoured the White ethnic group (Pirie, 1990). Initiatives to address ethnic discrepancies have been implemented, which should have corrected the white predominance found within this study. However, the average age (reported later in Chapter four, heading 4.6.1.3) of this study was found to be middle age. So when the average age of this study is taken into consideration and that the pilots’ education would have occurred during Apartheid, the White predominance in the study is explained (Pirie, 1990).

This study showed a big range in the number of dependants. The range in dependence can possibly be attributable to the travelling required as a commercial pilot which could affect family life and hence the number of dependants. This could explain 40% of the sample having no dependants. However it was found that the majority of pilots in this study were married. This indicated that there is the presence of a family life, but that occupational requirements (viz. travelling) may affect the decision to have children. Conversely the high amounts of travelling and time away from home could explain the pilots that are unattached due to being single or divorced as the extended time away from home could make establishing relationships difficult (Biering-Sörensen *et al.,* 1986; Reisbord *et al.,* 1985).

The educational levels of the pilots showed that the majority had obtained ATL status. This level of education is higher than commercial pilot status and the highest SACAA rating (Model Civil Aviation Regulations, 2007), which require a minimum of 1500 hours of flight. This may also be linked with greater experience as more flying hours are required to obtain ATL status. Therefore, it is expected that the average pilot age and piloting years of this study should be comparable to a population that show mid to older age pilots.

4.6.1.3 Anthropometric data

Table 4.2: Anthropometric data

Q1.1-1.3 and 1.7	Mean	Standard Deviation
Age (yrs)	39.8	10.8
BMI (kg/m^2)	25.7	3.3
Height (m)	1.8	0.1
Weight (kg)	82.7	13.9

BMI is calculated as the weight of a person in kilograms divided by their height in meters square (Holmberg and Thelin, 2010)

The average age of pilots (**Table 4.2**) within this population was 39.8 years, with an average weight of 82.7 kg and average height of 1.8 m (resulting in an average BMI value of 25.7 kg/m^2).

4.6.1.4 Discussion of anthropometric data

The average age of South African commercial pilots in this study (**Table 4.2)** is greater than pilots operating rotary wing aircraft (RWA) and high performance aircraft (HPA) outside of South Africa (Aydog *et al*., 2004; Drew, 1999; Simon-Arndt *et al*., 1996). The study of Desviat *et al*., (2007); Aydog *et al*., (2004); Drew, (1999); Loomis *et al*., (1999) and Simon-Arndt *et al*., (1996) reported that on average their participants' ages ranged between 30 – 33.8 years. A significant relationship was found between the pilots' age and LBP in these studies. In comparison, the commercial pilots investigated by Prombumroong *et al*., (2011) revealed comparable average ages (40.3 years). The commercial pilots in Prombumroong *et al*., (2011) had a 55.7 % annual prevalence of LBP. This would suggest that the average age of the commercial pilots investigated in this study could place them at similar risk for LBP development.

There is paucity of literature that discusses the association between height/weight to LBP. As such, BMI will be used as an alternative to discuss these two factors and its association to LBP. The average BMI for this study was calculated to be 25.7 kg/m^2, which fall just over the normal BMI range of 18.5 – 24.9 kg/m^2 and into the overweight category of 25.0 – 29.9 kg/m^2 (Boon *et al*., 2006). The study of Prombumroong *et al*., (2011) included BMI of commercial pilots as a potential factor of LBP development. However no conclusive link between BMI and LBP was established. Noted however is that the population of pilots investigated in the studies of Prombumroong *et al*., (2011); Desviat *et al*., (2007); Aydog *et al*., (2004); Drew, (1999); Loomis *et al*., (1999) and Simon-Arndt *et al*., (1996) all fell within the normal range of 18.5 – 24.9 kg/m^2. A BMI within normal limits in these studies could explain why no link between BMI and LBP could be established. According to literature, an elevated BMI is usually associated with increased prevalence of LBP (Jensen *et al.,* 2012; Ramond *et al.,* 2010; Mirtz and Green, 2005).

4.6.1.5 Summary of Objective One.

The demographic data from this study showed the average pilot in this sample to be a White, male, middle aged, educated and married.

Comparing this study's demographic data against demographic data with a strong association with LBP, could help identify/ explain these pilots' likelihood of LBP:

The following demographic data is likely to cause a higher prevalence of LBP in pilots in this study:

- The pilot's level of education: Similarity seen in the level of education of pilots within this study indicates that majority of pilots have flown for an extended period. The minimum hours (1500) required to obtain ATL level may suggest that majority of pilots are experienced in flying. This may also show that exposure to risk factors of flying (Desviat *et al*., 2007; Aydog *et al*., 2004; Goossens *et al*., 2000) have occurred for an extended period.

- Age: Mendelek *et al.,* (2011); Plouvier *et al.,* (2011) and Cassidy *et al.,* (2005) states that there is an increased risk of LBP development with increased age, especially if the populace had exposure to risk factors of LBP development, due to the compounding effect of prolonged exposure to the risk factors.

In contrast, factors protecting the pilots against the development of LBP include:

- Ethnicity: This is supported by research which indicates that the prevalence of LBP is lower in Whites when compared to other races (Dyer, 2012; Louw *et al*., 2007).
- Marital status: It was noted by Cats-Baril *et al.,* (1991); Biering-Sörensen *et al.,* (1986) and Reisbord *et al.,* (1985), that there appears to be a higher prevalence of LPB amongst single or unmarried persons when compared to their counter parts that are married.
- Number of dependants: This may be as a result of the responsibility that comes with dependants as depicted in **Table 4.1**, whereby 60% of pilots had either one, two or three dependants. For this reason, a more stable occupation maybe sought out by the pilots in order to provide stability for their dependants. In doing so, job stability and financial security is ensured, which may minimize exposure to psychosocial stressors (Clays, 2007).

LBP prevalence's may indicate that males have a lower risk for the development of LBP in comparison to females (Morris, 2006; Battie *et al.,* 1990). This has however been confounded by results depicting the opposite result, especially when there is an uneven proportions of males versus females (Reigo *et al*., 1999 and Waddell, 1994).

Finally, there is ambivalence in the literature with regards to the height, weight and its indicator (BMI) as a risk factor for LBP. This may be related to the fact that seems to require the presence of other independent risk factors in order for it to contribute to increasing the likelihood of LBP (Heneweer *et al.,* 2010).

Therefore, based on the pilots' characteristics, to the exclusion of work related LBP risk factors, it would seem that the pilots in this study should on average have a lower LBP prevalence, than the general population.

4.6.2 Objective Two: Work history of commercial pilots

To establish the work history of the commercial pilots (occupational years, work history, medical history, total flying hours, cockpit seat description, daily experiences in cockpit seat).

4.6.2.1 Occupational years

Table 4.3: Years in current occupational setting

	Mean	Standard Deviation
Q3.2 Occupational years	14.7	9.7
Q3.3 Working years at current company	9.4	8.2

The average working years of the participants as a commercial pilot is 14.7 years (**Table 4.3**). In addition, the average years of working at the current company was 9.4 years, nearly two thirds of the average occupational years.

4.6.2.2 Discussion of occupational years

The pilots in this study have a longer period in their current occupation and have been flying for more years when compared to pilots of previous studies conducted outside of South Africa (Desviat *et al*., 2007; Aydog *et al*., 2004; Drew, 1999; Loomis *et al*., 1999; Simon-Arndt *et al*., 1996).

The findings of longer occupational years can be explained by the older average age of pilots in this study (**Table 4.2**), as its stands to reason the older the pilot the more years they have been exposed to flying.

The older average age of this study's sample may also account for the longer period of employment at the current company, because as pilots get older they are more likely to seek job stability (Simon-Arndt, 1996). A further explanation for the longer period of employment at their current company could also be attributable to there being only limited airline carriers in SA and by extension less jobs available.

Desviat *et al*., (2007); Aydog *et al*., (2004); Drew, (1999); Loomis *et al*., (1999) and Simon-Arndt *et al*., (1996) indicated that younger pilots with less occupational experience had less LBP than the general populace / older pilots (Prombumroong *et al*., 2011). It is likely that occupational factors could play a role in LBP in pilots in this study because our sample is older and have more years flying. These are factors that could lead to the development of LBP. This will further be investigated in Objective Four.

4.6.2.3 Work history of commercial pilots

Table 4.4: Work history of commercial pilots

Q3.1: Work status of pilots		Count	Column N %
Captain Short range (SR)		42	42.0%
Co-pilot SR		33	33.0%
Co-pilot Long range (LR)		10	10.0%
Instructor LR		6	6.0%
Captain LR		3	3.0%
Instructor SR		2	2.0%
Single Pilot Operation		2	2.0%
Training Captain SR		2	2.0%
Q3.4 – 3.5: History of flying			
Partake in other flying	Yes	18	18.0%
	No	82	82.0%
Ever been a chartered pilot	Yes	58	58.0%
	No	42	42.0%
Q3.8 and 3.10: Average of weight lifted and repetitiveness			
Weight lifted	1-10 kg	16	61.5%
	11-20 kg	9	34.6%
	21-30 kg	1	3.8%
Average repetitiveness	0-10 times	24	92.3%
	11-20 times	2	7.7%
Q3.12 – 3.13: Average hours seated in cockpit during duty period and weekly			
Duty period	3-5 hours	38	38.0%
	5-7 hours	35	35.0%
	7-9 hours	16	16.0%
	1-3 hours	7	7.0%
	>9 hours	2	2.0%
	0	1	1.0%
	6 (missing?)	1	1.0%
Weekly	15-25 hours	38	38.0%
	25-35 hours	29	29.0%
	5-15 hours	20	20.0%
	35-45 hours	10	10.0%
	missing	2	2.0%
	>45 hours	1	1.0%

Table 4.5: Average hours seated daily

Q3.11 Average hours seated daily		
n	Valid	100
	Missing	0
Mean		3.945
Std. Deviation		3.4596
Minimum		.0
Maximum		15.0

Of the populace investigated, it was noted that 75% of pilots (**Table 4.4**) had reached a captain or co-pilot status in short range travels. Long range travels was performed by Captains and co-pilots who had a 13% share of the populace.

Majority of pilots (82%) indicated that they do not take part in other flying roles. Having been a charted pilot before their current occupation was nearly equally divided, with the trend leaning slightly more towards a history as a chartered pilot.

It is noted further that pilots had the necessity to carry/ lift weight within their current occupation. A total weight of one to ten kilogram was mostly indicated and repeated within the range of one to ten times per day. It was reported that the most common object lifted, was carry-on luggage of approximately eight kilogram, which was required for stop-over's in a different city or country.

The most reported average hours seated daily in the cockpit was three to five hours (38%) and five to seven hours (35%). This is congruent with majority of pilots having a short range status. The remainder of the population reported one to three hours (7%), seven to nine hours (16%) and more than nine hours (2%) as the average hours seated daily.

The duty period in a week, calculated as the average work hours per day multiplied by working days per week, were predominantly 15-25 hours (38%), followed by 25-35 hours (29%) and 5-15 hours (20%).

The most common hours seated daily is validated through the similarity seen in the mean average hours of 3.945 hours spent seated daily as depicted in **Table 4.5.**

4.6.2.4 Discussion of commercial pilots' work history.

The higher number of pilots operating short range flights may be explained by the responsibility pilots have to their spouses and/or dependents (**Table 4.1**). Due to the majority of pilots in this study being married could account for the higher percentage of pilots doing short range flights. Married pilots may avoid long range flights which would take them away from their families, and family responsibilities. Long periods of time away from families could place extra burdens on themselves and their family units. Considering that 82% of pilots do not take part in other flying roles (viz. small craft, microlight), it is further hypothesized that pilots may minimize the risk of personal injury due to family responsibilities.

The average lifting requirements depicted in **Table 4.4** show that pilots in this study lift eight kilograms between one to ten times per day. This finding is in keeping with other studies that have investigated the total lifting tasks of commercial pilots during duty periods (Prombumroong *et al*., 2011). The lifting tasks required by South African pilots in performing their duties would be similar to pilots operating outside of South Africa, so this similar finding is expected.

The study of Prombumroong *et al*., (2011) revealed that those pilots that lifted personal baggage more than four times during a duty period were at greater risk of developing LBP. This would indicate that the lifting task performed by the participants in this study (which ranges between one to ten times per day) may be an occupational factor contributing to LBP prevalence.

The South African pilots used in this study, of which the majority had short range status, flew on average one to three legs per trip per day. Although this was not directly asked in the questionnaire it has been calculated from the data gained by the questionnaire. It was calculated by using the average hours seated daily (3.945 hours) at an average cruise speed of +-850km/h (737 Family, 2014), allowing a maximum flight distance calculated at roughly 3 350 km.

Considering the geographic's of South Africa, it is calculated that the longest flight within South Africa, being 1,270 km (Cape Town to Durban) (Timeanddate, 2014), allows for one to three legs per sitting (3 350km/ 1270km = one to three flights). Since South African pilots can average one to three legs per trip per day, this would expose the pilot to more frequent landings/ take offs, loading and carrying of personal luggage and a higher frequency of different aircrafts used, which could predispose them to LBP.

4.6.2.5 Medical history of pilots

4.6.2.5.1 Medical aid

Table 4.6: Medical history of commercial pilots: Medical aid

	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Q3.14: Do you have medical aid?					
Yes	Yes	100	100	100	100.0
No		0	0	0	100.0
Total		100	100.0	100.0	
Q3.15: Do you have comprehensive medical aid?					
Unanswered	No	1	1.0	1.0	1.0
Yes	Yes	83	83.0	83.0	84.0
No		16	16.0	16.0	100.0
Total		100	100.0	100.0	

100 % of the pilots reported to have medical aid cover, of this 83 % claim that their medical aid cover is comprehensive (**Table 4.6**).

4.6.2.5.2 Discussion of medical aid

The entire sample reported to have medical aid cover. This finding is to be expected as all pilots, participating in this study, were employed by a South African airline. It is common for corporate companies and by extension South African corporate companies to offer employees medical aid cover, either partial or full (Dembe and Harrison, 2006).

Large portions (83%) of the pilots report access to comprehensive medical aid cover. Medical aid cover within South Africa is expensive, especially comprehensive cover (Dembe and Harrison, 2006). As pilots are in the high income bracket (Statistics South Africa, 2010), it is plausible they can afford comprehensive medical aid cover. This can explain why a large portion of the sample have comprehensive medical cover, as compared to the general population of South Africa where only 16% can afford comprehensive medical cover (Rowe and Moodley, 2013).

4.6.2.5.3 Surgery

Table 4.7: Medical history of commercial pilots: Surgery

	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Q3.16: Have you had any surgery?					
Yes	Yes	46	46.0	46.0	46.0
No		54	54.0	54.0	100.0
Total		100	100.0	100.0	
Please list any surgical procedures performed/ body part involvement.					
No surgical procedure	No	54	54.0	54.0	54.0
Unanswered procedures	Yes	8	8.0	8.0	62.0
Ankle fracture		1	1.0	1.0	63.0
Ankle and knee		1	1.0	1.0	64.0
Appendix		2	2.0	2.0	66.0
Arm fracture		1	1.0	1.0	67.0
Augmentation		1	1.0	1.0	68.0
Back operation		1	1.0	1.0	69.0
Broken jaw		1	1.0	1.0	70.0
C-section		2	2.0	2.0	72.0
Cholecystectomy		1	1.0	1.0	73.0
Disc operation		2	2.0	2.0	75.0
Ear		1	1.0	1.0	76.0
Eye surgery		1	1.0	1.0	77.0
Finger operation		1	1.0	1.0	78.0
Gallbladder and Hernia		1	1.0	1.0	79.0
General		2	2.0	2.0	81.0
Heart surgery		1	1.0	1.0	82.0
Hernia		1	1.0	1.0	83.0
Hernia, fractured arm and knee		1	1.0	1.0	84.0
Hernia and fractured arm		1	1.0	1.0	85.0
Hiatus Hernia		1	1.0	1.0	86.0
Inguinal hernia		1	1.0	1.0	87.0
Knee op		1	1.0	1.0	88.0
Left humeral fracture and right clavicle fracture		1	1.0	1.0	89.0
Minor operation		1	1.0	1.0	90.0
right thumb		1	1.0	1.0	91.0
rotator cuff op		1	1.0	1.0	92.0
Ribs, leg and C2 vertebral fracture		1	1.0	1.0	93.0
Ruptured Achilles Tendon		1	1.0	1.0	94.0
Tennis Elbow		1	1.0	1.0	95.0
Tonsillectomy		1	1.0	1.0	96.0
Tonsillectomy and UTI		1	1.0	1.0	97.0
Vasectomy, appendectomy		1	1.0	1.0	98.0
Wisdom teeth		2	2.0	2.0	100.0
Total		100	100.0	100.0	

Nearly half of the pilots in this study reported on receiving previous surgery (**Table 4.7**). Significant procedures are noted (viz. heart surgery, disc repair, cholecystectomy, eye surgery). Of those pilots that have indicated previous surgery, it is noted that eight pilots did not indicate the type of surgery received. Surgery to the low back was only performed in three pilots ('Back operation' for one pilot, 'Disc operation' for two pilots).

4.6.2.5.4 Discussion of surgery

Pertaining to the entire population, 54% have not received any form of surgery. In contrast, 46% of the population have received some form of surgery, some which may be described as significant surgery (viz. heart surgery, disc repair, ear and eye surgery).

Considering the strict health regulations that would accompany an occupation such as commercial piloting, the results in **Table 4.7** reveal pilots are not immune to degenerative and physiological changes or injurious events. For this reason, the surgical history of pilots, may further illustrate the importance of comprehensive coverage for pilots in order to ensure return-to-work and financial coverage.

Further noted is that surgery to the low back region was only present in three pilots, which may allow for the assumption to be made that significant injury to the low back has not occurred in the majority of pilots.

In comparison to Hermes *et al*., (2010); Desviat *et al*., (2007) and Aydog *et al*., (2004), it is noted that this population had less injury and / or surgery to the low back.

The link that has been suggested between surgery and LBP (Reuben, 2007; Ostelo *et al*., 2005) would in effect not contribute to a major extent in the prevalence of LBP in this study.

4.6.2.5.5 Trauma

Table 4.8: Medical history of commercial pilots: Trauma

	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Q3.17 Have you had any trauma?					
Trauma	Yes	30	30.0	30.0	30.0
	No	70	70.0	70.0	100.0
Total		100	100.0	100.0	
Please list the trauma experienced.					
No trauma	No	70	70.0	70.0	70.0
Unanswered trauma	Yes	1	1.0	1.0	71.0
Amputated thumb		1	1.0	1.0	72.0
Ankle fracture		1	1.0	1.0	73.0
Ankle Sprain		1	1.0	1.0	74.0
Arm Fracture		1	1.0	1.0	75.0
Arm fracture and collar bone		1	1.0	1.0	76.0
Arm fracture and compressed vertebrae		1	1.0	1.0	77.0
Back injury -crash helicopter		1	1.0	1.0	78.0
Broken nose		1	1.0	1.0	79.0
Car accident		1	1.0	1.0	80.0
Clavicle fracture		1	1.0	1.0	81.0
Coccyx injury		1	1.0	1.0	82.0
Collar bone, arm and hand fracture		1	1.0	1.0	83.0
Collis fracture		1	1.0	1.0	84.0
Disc herniation		1	1.0	1.0	85.0
Dislocated elbow		1	1.0	1.0	86.0
Finger and collar bone		1	1.0	1.0	87.0
Fractured knee		1	1.0	1.0	88.0
L5 Fracture		1	1.0	1.0	89.0
Left humeral fractures and right clavicle fracture		1	1.0	1.0	90.0
Left knee Cartilage fracture		1	1.0	1.0	91.0
Leg fracture		1	1.0	1.0	92.0
Motor Vehicle Accident		2	2.0	2.0	94.0
MVA and Rugby injury		1	1.0	1.0	95.0
Rib fractures and MVA		1	1.0	1.0	96.0
Rib, leg and vertebra C2 fracture		1	1.0	1.0	97.0
Ruptured Achilles		1	1.0	1.0	98.0
Shoulder		1	1.0	1.0	99.0
Vertebral fracture		1	1.0	1.0	100.0
Total		100	100.0	100.0	

The sample of pilots (**Table 4.8**) reported that 30% have received some form of trauma. This indicates that 70% have not received some trauma. The type of trauma varies significantly. The sites that were injured during a traumatic event, ranged throughout the body (viz spine, shouders, upper and lower extremities).

The traumatic injuries described by the pilots that involved the lower back were compressed vertebrae (1 pilot), back injury (1 pilot), disc herniation (1 pilot), fractured 5th lumbar vertebrae (1 pilot), vertebral fracture (1 pilot). Answers for question 3.17 by the pilots included the mechanisms of injury (viz. MVA, car accidents, helicopter crash, rugby). These answers were considered ambiguous and not specific to a bodily site.

4.6.2.5.6 Discussion of trauma

Traumatic experiences of pilots indicate that pilots, through daily life, are not immune to injury, with 30% of pilots stating their experience of some form of previous trauma. Although some of the traumatic experiences may have resulted in surgical procedures, this amount remains significant considering the strict regulations that would be coupled with occupations such as piloting and transport.

In keeping with trauma, the information in **Table 4.8** further reveals that of the traumatic experiences, five percent of pilots indicated some injurious event to their low back. Previous trauma and previous surgery to the lumbar spine has been linked to increased prevalence to LBP (Reuben, 2007; Ostelo *et al*., 2005).

The pilots in this study have reported a low incidence of trauma or surgery to the lower back. Therefore, we could suspect that a higher prevalence of LBP in the sample would not be due to previous trauma or surgery on the lower back. Reasons for this may include majority of pilots stating discomfort from cockpit chairs (Snijders *et al*., 2004, Song *et al.,* 2001; Gossens *et al*., 2000), have significant and comparable LBP prevalence (Walters *et al*., 2012; Okunribido *et al.,* 2008; Bridger *et al.,* 2002) and have revealed that that merely 6% had an injurious event to the low back region. Therefore, the relevant LBP prevalence of this study may result, to a greater extent, from the occupational setting rather than daily life

4.6.2.5.7 Emotional trauma

Table 4.9: Medical history of commercial pilots: Emotional trauma

	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Q3.18 Have you had any emotional trauma?					
Unanswered	No	2	2.0	2.0	2.0
Yes	Yes	19	19.0	19.0	21.0
No trauma		79	79.0	79.0	100.0
Total		100	100.0	100.0	
Please list emotional trauma.					
Unanswered	No	3	3.0	3.0	3.0
No emotional trauma	Yes	79	79.0	79.0	82.0
Death of father		1	1.0	1.0	83.0
Death of family member		2	2.0	2.0	85.0
Death of mother		1	1.0	1.0	86.0
Depression		1	1.0	1.0	87.0
Divorce		9	9.0	9.0	96.0
Family feud		1	1.0	1.0	97.0
Hijacked		1	1.0	1.0	98.0
Sexual abuse		1	1.0	1.0	99.0
Son (MVA) coma		1	1.0	1.0	100.0
Total		100	100.0	100.0	

Emotional trauma was reported in 19% of the pilots. The majority of pilots (79%) had no emotional trauma with two percent not stating if emotional trauma was ever experienced (**Table 4.9**).

Of the 19% of pilots reporting on emotional trauma, it is noted that divorce has the largest share at nine percent. This is followed by four percent reporting a death of a family member (death of family member, death of mother, death of father). The remainder of the reported emotional trauma each accounted for one percent respectively and were listed as depression, family feud, hijacked, sexual abuse and son (MVA) coma. However three percent did either not describe the experience of an emotional trauma or the type of emotional trauma experienced.

4.6.2.5.8 Discussion of emotional trauma

Numerous researchers have stated that emotional trauma (viz. stress, depression) is relevant in LBP development (Heneweer *et al.,* 2010; Hoogendoorn *et al.,* 2000; Linton and Ryberg, 2000; Bongers *et al.,* 1993). Therefore, it may be that these factors of emotional trauma (viz. divorce, loss of family member) have an influence on LBP prevalence. However due to only 19% of the sample reporting emotional trauma, it is assumed that emotional trauma may not be a major contributor to LBP in this sample.

4.6.2.5.9 Back braces/ Lumbar support

Table 4.10: Medical history of commercial pilots: The use of back braces and lumbar support

Q3.19 Do you wear a back brace during flying roles?					
Unanswered	No	1	1.0	1.0	1.0
Yes	Yes	2	2.0	2.0	3.0
Do not wear		97	97.0	97.0	100.0
Total		100	100.0	100.0	
Please specify why.					
Not worn	Yes	98	98.0	98.0	98.0
Prior to operation		1	1.0	1.0	99.0
Lumbar support		1	1.0	1.0	100.0
Total		100	100.0	100.0	
Q3.20 Do you wear a back brace during non-flying roles?					
Unanswered	No	2	2.0	2.0	2.0
Yes	Yes	3	3.0	3.0	5.0
Do not wear		95	95.0	95.0	100.0
Total		100	100.0	100.0	
Please specify why.					
Do not wear	Yes	97	97.0	97.0	97.0
Lumbar support		3	3.0	3.0	100.0
Total		100	100.0	100.0	

The use of a back brace during flying roles (**Table 4.10**) was present in only two percent of pilots. The remainder of the pilots stated either no use of back braces (97%) or did not indicate whether back braces was utilized (1%) during flying roles. According to the two pilots, a back brace was required prior to a low back operation for one pilot and the other for lumbar support.

During non-flying roles, three pilots stated the use of a back brace in comparison to 95 pilots not utilizing a back brace and two pilots not answering whether a back brace is used. All three pilots further revealed that the back brace is used for lumbar support during non-flying roles.

4.6.2.5.10 Discussion of back braces/ lumbar support

The use of a back brace during flying roles was mostly not indicated by pilots (97%). Two percent of pilots indicated the use of back braces during flying roles. One pilot had not stated if a back brace was used during flying. This two percent of the pilots using back braces may be as a result of the six percent of pilots that indicated previous trauma to the low back. Considering that lumbar support was needed and a back brace was utilized until such a time that surgery was performed may indicate that significant difficulties were experienced by the two pilots.

In contrast, it may be hypothesised that the minimal usage of back braces during flying roles may be due to pilots' not experiencing uncomfortable seating, or have lumbar conditions requiring the use of lumbar stabilisers such as back braces. This would suggest that pilots in South Africa may either have good sitting ergonomics, or are more resilient to pain, possibly due to the health worker effect (Shaw, 2011).

4.6.2.5.11 Pregnancy

Table 4.11: Medical history of commercial pilots: Pregnancy

Q3.21: Have you ever been pregnant?					
Yes	Yes	6	6.0	6.0	6.0
No		94	94.0	94.0	100.0
Total		100	100.0	100.0	
Please specify number of pregnancies					
Pregnancy	0	94	94.0	94.0	94.0
	1	4	4.0	4.0	98.0
	2	2	2.0	2.0	100.0
Total		100	100.0	100.0	
Q3.22: Did you experience any complications whilst being pregnant?					
Unanswered	No	4	4.0	4.0	4.0
Yes	Yes	1	1.0	1.0	5.0
No		95	95.0	95.0	100.0
Total		100	100.0	100.0	
Please list any complications.					
None		99	99.0	99.0	99.0
Ruptured membrane, Six weeks premature		1	1.0	1.0	100.0
Total		100	100.0	100.0	

Related to pregnancy (**Table 4.11**), six female pilots have previously been pregnant in a total female population size of 15. Of the six female pilots, four female pilots had been pregnant only once, with the remaining two pilots having been pregnant twice. Of the six female pilots with a history of pregnancy, four pilots did not state whether any complication were experienced during pregnancy. One pilot did state a complication, whilst the remainder (one pilot) had no complication.

4.6.2.5.12 Discussion of pregnancy

Traumatic events may include pregnancy and complications of pregnancy (Sihvonen *et al*., 1998). Although the population of pilots were predominantly male, it has been noted that pregnancy may predispose and result in increased risk of LBP (Bastiaanssen *et al*., 2005; Clancy and McVicar, 2002; Noren *et al*., 2002). It is noted that six percent of the total population were females with a history of pregnancy or multiparity. A complication of pregnancy was only seen in one female pilot who revealed early ruptured membranes resulting in premature delivery of six weeks. Although studies have shown a link between pregnancy and LBP (Bastiaanssen *et al*., 2005; Clancy and McVicar, 2002), the actual contribution of this condition, to the overall LBP prevalence of pilots in this study, may be considered limited due to the small female population.

4.6.2.5.13 Loss of pilot licence

Table 4.12: Medical history of commercial pilots: Loss of pilot licence

	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Q3.23 Have you ever temporarily lost your pilot license due to a condition?					
Yes	Yes	8	8.0	8.0	8.0
No		92	92.0	92.0	100.0
	Total	100	100.0	100.0	
Please list why.					
Licence not lost	Yes	92	92.0	92.0	92.0
Unanswered		1	1.0	1.0	93.0
Disc operation		1	1.0	1.0	94.0
Divorce		1	1.0	1.0	95.0
Ejected burning aircraft		1	1.0	1.0	96.0
Myocardial Infarct		1	1.0	1.0	97.0
Pulmonary embolism		1	1.0	1.0	98.0
Ruptured Achilles		1	1.0	1.0	99.0
Vertigo		1	1.0	1.0	100.0
	Total	100	100.0	100.0	

Of the 100 pilots in the study (**Table 4.12**), eight pilots stated that they previously had temporarily lost their flying licence. Of those pilots, one pilot refrained from stating the reason for the loss of their licence. The remainder of the pilots indicated factors such as health related conditions (Disc operation, myocardial infarct, vertigo and pulmonary embolism, ruptured Achilles tendon), emotional trauma (Divorce) and finally physical factors (Ejected burning aircraft).

4.6.2.5.14 Discussion of loss of pilot licence

Considering that continual medical screening would occur in an occupation such as air transport, the proposed strict health requirements of a commercial pilot may be seen through eight percent of pilots having previously lost their licence due to a health / physical related condition. The necessity of comprehensive medical cover becomes more evident.

It is, however, considered that eight percent is a fairly low amount, as the loss of the pilot's licence would be documented throughout each pilot's career. Thus it must be considered, with the majority of pilots having comprehensive medical aid, it may be a factor in decreasing the amount of health related condition experienced by pilots. In doing so, this may minimize the number of pilots that may be at risk of losing the pilot's licence.

4.6.2.6 Total flying hours

Table 4.13: Statistics related to total flying hours

Q3.24: Total time logged on aircraft (Hours)		
n	Valid	92
	Missing	8
Mean		8952.8815
Std. Deviation		6745.14059
Minimum		197.00
Maximum		33 300.00
Percentiles	25	4533.2500
	50	6915.0000
	75	12487.5000

Of the total 100 pilots that were studied, 92 had completed questions regarding total flying hours accumulated as a commercial pilot (**Table 4.13**). The total flying time had a wide range, with the minimum hours flown as a commercial pilot being 197 hours, in comparison to the maximum figure of 33 300 hours. This resulted in a mean of 8 952.9 hours, and a standard deviation of 6 745.14 hours.

Further analysis, however, could not provide information regarding the most commonly used aircraft as this was not sufficiently indicated by the pilots to allow for any trend to be established. Furthermore, previous aircrafts utilized by pilots, both in their current occupational years and as a training pilot, had too many variations to allow for any conclusion to be established with any confidence regarding aircrafts most commonly associated with LBP (Goossens *et al*., 2000). A description is given however of the most common cockpit setup for each pilot as depicted in **Table 4.14**.

4.6.2.7 Discussion of the total flying hours.

In comparison to the population of commercial pilots investigated by Prombumroong *et al*., (2011), similarities are seen with regards to total flying hours. In their study, the population had performed an average of 9 201 hours with a standard deviation of 7 903 hours, which is similar to the average of 8 952.9 hours and standard deviation of 6 745.14 of this study.

As a result of this close approximation of total flying averages, previous indicated factors such as age and BMI (**Table 4.2**), which were also of similar values, are better explained through these similarities in population characteristics (total flying time) and anthropometric statistics.

The average age of the population in Prombumroong *et al*., (2011) was 40.3 years, in comparison to 39.8 years found in this study. Comparing the pilots BMI in this study (25.7kg/m^2) versus the pilots BMI (24.3kg/m^2) in Prombumroong *et al*., (2011), may indicate some dissimilarity, such as the different ethnicities. However, both populations may have similar occupational settings and therefore may reveal similar prevalence's of LBP.

From the total flying hours may be deduced that the pilots have been sitting in aircrafts for a prolonged period during their lifetime. With Goossens *et al*., (2000) illustrating the shortcomings of anthropometric and biomechanical requirements in aircraft seats, this extended period of flight, may also contribute to LBP in the pilots of this study, similar to that of Prombumroong *et al*., (2011).

According to Prombumroong *et al*., (2011), an annual prevalence of LBP of 55.7% was found in commercial pilots. This value will then be further discussed under Objective Three, regardless of similarities or dissimilarities.

4.6.2.8 Cockpit seat description

Table 4.14: Description of cockpit seat used most frequently

Q3.25 Seat description in aircraft flown the most (More than one applicable)					
Armrest present	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
No	Yes	8	8.0	8.0	8.0
Yes		92	92.0	92.0	100.0
	Total	100	100.0	100.0	
Armrest absent					
No	Yes	91	91.0	91.0	91.0
Yes		9	9.0	9.0	100.0
	Total	100	100.0	100.0	
Armrest inclination present					
No	Yes	31	31.0	31.0	31.0
Yes		69	69.0	69.0	100.0
	Total	100	100.0	100.0	
Adjustable back inclination					
No	Yes	13	13.0	13.0	13.0
Yes		87	87.0	87.0	100.0
	Total	100	100.0	100.0	
Adjustable back inclination absent					
No	Yes	92	92.0	92.0	92.0
Yes		8	8.0	8.0	100.0
	Total	100	100.0	100.0	
Seat height adjustable					
No	Yes	5	5.0	5.0	5.0
Yes		95	95.0	95.0	100.0
	Total	100	100.0	100.0	
Seat height not adjustable					
No	Yes	94	94.0	94.0	94.0
Yes		6	6.0	6.0	100.0
	Total	100	100.0	100.0	
Low back support					
No	Yes	22	22.0	22.0	22.0
Yes		78	78.0	78.0	100.0
	Total	100	100.0	100.0	
No low back support					
No	Yes	87	87.0	87.0	87.0
Yes		13	13.0	13.0	100.0
	Total	100	100.0	100.0	
Sheep skin cover (Padded chair)					
No	Yes	15	15.0	15.0	15.0
Yes		85	85.0	85.0	100.0
	Total	100	100.0	100.0	
Unpadded chair					
No	Yes	94	94.0	94.0	94.0
Yes		6	6.0	6.0	100.0
	Total	100	100.0	100.0	

The structure of the questionnaire used in this study, allowed for multiple options to be selected. For this reasons, the presence and absence of adjustability factors are shown in **Table 4.14.**

The result found in **Table 4.14** would suggest that most cockpit chairs have adjustable settings to ensure a comfortable sitting position for the pilot. This is seen in **Table 4.14** whereby the majority of the features (viz. the ability to adjust the seat) has been indicated as present, with minor differences regarding the low back support, armrest inclination and padded chairs.

This study found that the most common cockpit seat used by pilots had an armrest (92%) and of those with an armrest, 69% had an armrest with adjustable inclination. Conversely, 31% of the cockpit chairs were fitted with armrests which were immobile. Adjustable back inclination was present in 87% of chairs, with 95% allowing seat height adjustments to be made. A more important feature includes lumbar support, present in 78% of chairs, with 85% of pilots indicating a soft padded chair.

4.6.2.9 Discussion of cockpit seat description

The strict requirements of a comfortable and stable sitting position in terms of ergonomics and biomechanical specificity, such as gravity lines, movement of the lumbar spine (Snijders *et al*., 2004) and impact of lumbar support (Koskelo *et al*., 2007), cannot be determined through subjective responses. It must be noted that as these responses are subjective assessments by the participants, the actual impact of lumbar support and biomechanical adequacy is not in any way certified through this study. Although majority of pilots indicated a comfortable sitting position, it may be that pilots do not have sufficient knowledge to properly set up the cockpit chair which will ensure a correct sitting position. This is highlighted by Goossens *et al*., (2000) who stated that there is a misconception of the comfort provided through a cockpit seat due to its many adjustability options.

Although the most common aircraft used, and by extension the seats, could not be determined from this study, it must be assumed that the aircraft investigated by Goossens *et al*., (2000) are inclusive of the most commonly used commercial aircraft found with most carriers. For this reason, it is postulated that the participants of this study who stated they are comfortable, are at similar risk. A reason for this is that through many occupational years (**Table 4.3**) it must be considered that a pilot will at some point in time come into contact with similar aircrafts, which have been found to be ineffective in protecting their low back (Goossens *et al*., 2000).

4.6.2.10 Daily experiences in cockpit

Table 4.15: Description of cockpit used most frequently

Cockpit characteristics	Valid	Frequency	Percent	Valid Percent	Cumulative Percent
Side stick controller	Yes	29	29.0	29.0	29.0
Yoke controller	Yes	71	71.0	71.0	100.0
	Total	100	100.0	100.0	
Comfortable sitting position					
No	Yes	14	14.0	14.0	14.0
Yes		86	86.0	86.0	100.0
	Total	100	100.0	100.0	
Uncomfortable sitting position					
No	Yes	82	82.0	82.0	82.0
Yes		18	18.0	18.0	100.0
	Total	100	100.0	100.0	
Minimal vibration felt					
No	Yes	23	23.0	23.0	23.0
Yes		77	77.0	77.0	100.0
	Total	100	100.0	100.0	
Vibration clearly felt					
No	Yes	85	85.0	85.0	85.0
Yes		15	15.0	15.0	100.0
	Total	100	100.0	100.0	
Pain with prolonged sitting					
No	Yes	58	58.0	58.0	58.0
Yes		42	42.0	42.0	100.0
	Total	100	100.0	100.0	
No pain with prolonged sitting					
No	Yes	61	61.0	61.0	61.0
Yes		39	39.0	39.0	100.0
	Total	100	100.0	100.0	
Stretch during flight					
No	Yes	62	62.0	62.0	62.0
Yes		38	38.0	38.0	100.0
	Total	100	100.0	100.0	
Seldom stretch during flight					
No	Yes	47	47.0	47.0	47.0
Yes		53	53.0	53.0	100.0
	Total	100	100.0	100.0	
Landing impact felt					
No	Yes	76	76.0	76.0	76.0
Yes		24	24.0	24.0	100.0
	Total	100	100.0	100.0	
Landing impact softened					
No	Yes	51	51.0	51.0	51.0
Yes		49	49.0	49.0	100.0
	Total	100	100.0	100.0	

The current study (**Table 4.15**) found that yoke control was used by 71% of the population in comparison to 29% of pilots using a side stick controller. This indicates that the majority of pilots were operating a Boeing aircraft, as side stick controller[1] is not commonly adopted by Boeing, but rather by the Airbus Company. Of the total population of pilots, 86% stated having a comfortable sitting position, 77% indicated that minimal vibration is felt, with only 15% revealing that vibration through the cockpit seat is clearly felt.

Conversely, pilots did reveal some discomfort with 42% of pilots indicating they experience pain with prolonged sitting. These pilots who suffered with some discomfort have indicated stretching during flight, as this was shown to be performed by 38% of the population. Just over 75% of the pilots studied, stated that a padded chair with lumbar support minimised the impact of landing, however 24% of the populace revealed that they felt the impact of landing through the chair.

4.6.2.11 Discussion of daily experiences in the cockpit

The actual effectiveness of the cockpit chair (**Table 4.14**) is further considered and evaluated with the results from **Table 4.15**, where the majority of pilots experience a comfortable sitting position. Taking this into account signifies the fallible contribution of subjective assessment, with results which show that 14-18% of pilots have an uncomfortable experience, 15-23% feel the vibration of flight and 42% experience pain with prolonged sitting. This may be aggravated through the landing impact which is felt by 24% of the pilots.

Goossens *et al*., (2000) further notes that, as most armrests rotate about a single axis with rise at the wrist level, the support provided for the arm of a taller pilot may be negatively affected. This would become more evident for pilots using side stick controllers. For this reason, greater research is needed to clearly identify any shortcomings of the cockpit (side stick vs yoke controller) and chairs in protecting the pilot against LBP prevalence's which ranges in the upper quartile (Walters *et al*., 2012; Prombumroong *et al*., 2011; Okunribido *et al.,* 2008; Loomis *et al*., 1999).

[1] http://www.boeing.com/boeing/commercial/737family/pf/pf_technology.page

4.6.2.12 Summary of Objective Two

In summarizing Objective two, the following risk factors are likely to enable a higher prevalence of LBP in pilots of this study:

- Longer occupational years: In comparison to other pilots of various aircraft, it is noted the population in this study is older and may be exposed to occupational risk factors for larger periods of time. The study of Prombumroong *et al*, 2011 found a 55.7% prevalence of LBP in a similar population of pilots with comparable total flying time.
- Short range status: Due to the quick turnaround time in the short range status, factors such as regular exercise, stretching and mealtimes for proper nutrition may not always be available. The physical impact that regular takeoff and landing has on the body which is clearly felt, as stated by 24% of pilots, may predispose pilots to LBP (Blummen and Rinnert, 1995).
- Lifting tasks: Carrying luggage has been found to be significantly related to LBP (Prombumroong *et al*, 2011). With majority of pilots conducting short range flights, pilots may have to carry luggage more regularly.
- Stress: Occupational factors such as possible mental stress caused by the responsibility placed on pilots to transport passengers and emotional trauma experienced by a portion of the populace (Blummen and Rinnert, 1995).
- Exposure to postulated risk factors (viz. poor ergonomics, prolonged sitting, WBV) (Prombumroong *et al*, 2011; Okunribido *et al.,* 2008; Goossens *et al*., 2000; Loomis *et al*., 1999).

Factors protecting the pilots against developing LBP include:

- Other flying roles: Majority of pilots stating they do not participate in flying roles outside of their current occupation minimizes potential risk of injury.
- Long range status: This may have a more protective factor, then a LBP enabling factor (viz. prolonged sitting), as sitting may reduce the exposure to repetitive tasks such as landing (viz. WBV), safety checks (viz. stress and twisting) and carrying luggage (Blummen and Rinnert, 1995).
- Traumatic injury: A minimum number of previous traumas are listed to the region of the low back, and as such is described under the protective listing.

4.6.3 Objective Three: Prevalence of LBP

- Establish the point, period and lifetime prevalence of LBP amongst commercial pilots in South Africa.

4.6.3.1 Point, period and lifetime prevalence

Table 4.16 Point period and lifetime prevalence

	Count	Column %	95% CI
Q4.1 Lifetime LBP prevalence	80	80.8%	[71.40, 87.77]
Q4.2 Annual LBP prevalence	68	68.7%	[58.47, 77.43]
Q4.3 Weekly LBP prevalence	32	32.7%	[23.72, 42.96]
Q4.4 Daily LBP prevalence	19	19.4%	[12.36, 28.87]

The lifetime prevalence of commercial pilots (**Table 4.16**) investigated in this study shows a significant value at 80.8%. The annual LBP prevalence is 68.7%, whilst weekly and daily LBP prevalence is 32.7% and 19.4% respectively.

4.6.3.2 Discussion of lifetime prevalence:

In comparison to the global literature (**Table 4.17**) it is noted that the prevalence of LBP amongst pilots of this study falls in the upper quartile. The studies of van Vuuren, *et al*., (2007) and van Vuuren, *et al*., (2005), performed on steel and manganese workers, show 71.6% and 64% prevalence's. Although these studies were conducted in populations within a work environment requiring physical workloads, it may be that this scenario of both physical and psychological stress has an effect on the high prevalence. This may be similar in commercial pilots (particularly the short range pilots) who have occupational hazards that include both manual and psychological elements. Furthermore, results seen in the study of Dagenais and Haldeman (2012) suggest that the international prevalence of LBP may be as high as 85%, which is comparable to the pilots in this study.

Comparing studies from within similar population groups (viz. South African origin), the studies of Docrat *et al*., (1999) and Van der Meulen, (1997) reported lifetime prevalence's that are also in the upper quartiles. It must be noted however that the majority of the pilot population was white, and as such a clear link does not exist between these studies as their ethnicities are not similar. It is therefore perhaps more appropriate to compare the outcomes of this study to Dyer, (2012) who assessed the LBP prevalence in a white population and found a lifetime prevalence of 48%, which could explain the lower prevalence in the general population in comparison to pilots.

4.6.3.3 Discussion of annual prevalence:

A similar outcome is seen in the annual prevalence of LBP between Van Vuuren *et al*., (2006) and Van Vuuren *et al*., (2005) (**Table 4.17**) in which a prevalence of 69.8% and 56% respectively was found. These results are comparable to the annual LBP prevalence found in this study of 68.7%. By contrast to the above, the findings of Prombumroong *et al*., (2011), revealed that Thai pilots had a 55.7% annual prevalence. When looking at these statistics it would seem to suggest that occupational demands (viz. prolonged sitting, stress) have significant influence on the prevalence of LBP.

Commercial pilots may have a greater annual prevalence of LBP, when compared to other professions (Boonen *et* al., 2005; Jin *et al.,* 2004; Hillman *et al*., 1996). It seems possible that the monotonous activities found within the pilot occupation (Prombumroong *et al*., 2011), in conjunction with the stress (Hoogendoorn *et al.,* 2000), age (Mendelek *et al.,* 2011) and other risk factors predisposing to LBP development (Pillastrini *et al*., 2012; Mendelek *et al*., 2011), places commercial pilots at greater risk for the development LBP.

4.6.3.4 Discussion of point and period prevalence:

Galukande *et al*., (2005); Bingefors *et al.,* (2004); Ekman *et al*., (2001) and Hillman *et al*., (1996), all found similar point prevalence scores for LBP. This confirms that LBP is a global concern and may affect multiple populations, all of which have factors unique to the development of LBP.

The physical workload studies such as Van Vuuren *et al*., (2006) and Van Vuuren *et al*., (2005) reveal their dissimilarities by revealing higher point prevalence. This could indicate that, although lifetime prevalence may be similar, the daily requirements of performing heavy physical workloads may be of greater consequence in the daily experience of discomfort and pain, due to the repetitive action.

Sedentary occupations such as the study performed on computer workers (Adedoyin *et al.,* 2005) reveal the highest point prevalence at 74%. This may complicate the assumption that sedentary work may not be as high a risk in the LBP epidemic as previously stated. Considering that commercial pilots have a fairly sedentary occupational environment (similar to computer workers), the 19.4% prevalence found should then according to previous studies and their results, be of similar values.

Considering that numerous studies depict prevalence at point, three months, six months and annual intervals (Manchikanti, 2000), limited articles can be used to assess any similarities in prevalence and occupational circumstances for weekly time frames. Studies such as Nyland and Grimmer, (2003), found a weekly prevalence of 28% within physiotherapists. Within the United States of America, it is considered that 14% of the population (Manchikanti, 2000) suffer with LBP of at least two weeks. In comparison to pilots, the weekly prevalence still ranges higher, and further indicates the uniqueness of this occupation with regards to risk factors and prevalence of LBP within the occupation.

4.6.3.5 Summary of Objective Three:

In summarizing Objective three, it is determined that the LBP prevalence of commercial pilots within this study, falls in the upper quartile when compared to studies with occupational circumstances similar to those of pilots (viz. prolonged sitting, poor ergonomics, physical workloads). Comparison to global literature indicates that the significance of LBP, in South African pilots, is higher than the general population and in congruence with studies on various piloting occupations.

Table 4.17 INTERNATIONAL PREVALENCE OF LBP

AUTHOR	DATE	COUNTRY	TYPE OF STUDY	Point %	One year %	Life %
Mulimba	1990	East Africa	Orthopedic based	10		
Bwanahali *et al.,*	1992	Zaire	Rheumatology based	47		
Harris	1993	-	Cricketers	62		
Luo *et al.,*	1995	United States of America	National	-	18	-
Hillman *et al.,*	1996	United Kingdom - Bradford	National	19	39	59
Van der Meulen	1997	South Africa	Ethnic group specific	-	-	57.6
Rizzo *et al.,*	1998	United States of America	National	22	-	-
Watson *et al.,*	1998	Isle of Jersey	National	6	-	-
Docrat *et al.,*	1999	South Africa	Ethnic group specific	-	-	78.2
				-	-	76.6
Maniadakis *et al.,*	2000	United Kingdom	National	-	36	-
Worku	2000	Lesotho	National	10	-	-
Ekman *et al.,*	2001	Sweden	National	16	-	-
Nyland and Grimmer	2003	Australia	Physiotherapists	-	63	69
Stewart *et al.,*	2003	Unites States of America	National	5	-	-
Bingefors *et al.,*	2004	Sweden	National	22.7	-	-
Luo *et al.,*	2004	United States of America	National	15	-	-
Jin *et al.,*	2004	Shanghai	National	-	40-74	50-79
Walker *et al.,*	2004	Australia	National	-	-	65
Adedoyin *et al.,*	2005	-	Computer users	74	-	-
Boonen *et al.,*	2005	Netherlands	National	-	21	-
Galukande *et al.,*	2005	Africa - Uganda	National	20	-	62.3
Van Zundert *et al.,*	2005	Belgium	National	6	-	-
Van Vuuren *et al.,*	2005	-	Steel industry	36	56	64
Van Vuuren *et al.,*	2006	-	Manganese industry	37.6	69.8	71.6
Koley *et al.,*	2008	India - Punjab	National	-	-	60
Dagenais and Haldeman	2012	-	International	25	50	85
Dyer	2012	South Africa	Ethnic group specific	34	-	48

Adapted from Dyer, (2012)

4.6.4 Objective Four: Pain Characteristics of LBP

To determine the nature, severity and clinical presentation of LBP in commercial pilots.

4.6.4.1 Current episode of LBP:

Participants were omitted from analysis and by default LBP within the current section, if in this section the following two criteria were fulfilled:

1) Participants indicated they have never had LBP (said 'No' to question 4.1) and
2) Indicated they did not have LBP on Question 4.7 of the current LBP section.

Exclusion of participants fulfilling the above criteria left a total of 45 participants for analysis of current back pain. In addition, if any of the individual questions were not answered by the participant, it was coded zero and was excluded on a question by question basis.

Table 4.18: Current back pain characteristics

Q4.6: Characteristic of back pain		Count	Column %
No LBP	No	45	100.0%
	Yes	0	0.0%
Catching pain	No	41	91.1%
	Yes	4	8.9%
Sharp	No	35	77.8%
	Yes	10	22.2%
Stiffness	No	17	37.8%
	Yes	28	62.2%
Stabbing	No	40	88.9%
	Yes	5	11.1%
Dull ache	No	17	37.8%
	Yes	28	62.2%
Poking	No	45	100.0%
	Yes	0	0.0%
Shooting	No	41	91.1%
	Yes	4	8.9%
Other (Specify):	No	44	97.8%
	Yes	1	2.2%
Q4.7: Location of current LBP			
Current LBP side involvement	One side left	6	13.3%
	One side right	5	11.1%
	Both sides	34	75.6%
	No LBP	0	0.0%
Q4.8: LBP resulting in current pins and needles			
Pins and needles	Yes	10	22.7%
	No	34	77.3%

Table 4.18: Current back pain characteristics continued

Q4.9: Pins and needles referral pattern			
Sensation spread below knees	Yes	7	30.4%
	No	16	69.6%
Q4.10 Numb sensation in feet during presence of LBP			
Numbness	Yes	10	22.7%
	No	34	77.3%
Q4.11:Associated symptoms during LBP			
Symptoms	Yes	7	16.3%
	No	36	83.7%
Q4.13: LBP constant or intermittent			
LBP presentation	Constant	9	23.7%
	Intermittent	29	76.3%
Q4.14: Been absent from work as a result of LBP			
Absent	Yes	3	7.1%
	No	39	92.9%
Q4.15: Time in cockpit chair before experiencing LBP			
Time before LBP experience	10 mins	1	2.4%
	30 mins	4	9.5%
	60 mins	9	21.4%
	180 mins	16	38.1%
	360 mins	1	2.4%
	As long as I like	11	26.2%
Q4.16: Time in car seat before experiencing LBP			
Time before LBP experience	10 mins	1	2.4%
	30 mins	4	9.8%
	60 mins	8	19.5%
	180 mins	13	31.7%
	360 mins	8	19.5%
	As long as I like	7	17.1%
Q4.17: Time in armchair before experiencing LBP			
Time before LBP experience	10 mins	0	0.0%
	30 mins	5	12.8%
	60 mins	7	17.9%
	180 mins	5	12.8%
	360 mins	7	17.9%
	As long as I like	15	38.5%
Q4.18: LBP affecting daily living			
Daily living affected	Yes	18	42.9%
	No	24	57.1%
Q4.19: LBP affecting leisure activities			
Leisure activities affected	Yes	21	50.0%
	No	21	50.0%
Q4.20: Bed rest required for LBP			
Required bed rest	Yes	6	14.3%
	No	36	85.7%
Q4.21: Onset of LBP			
Onset	Gradually	24	63.2%
	Suddenly	8	21.1%
	Not Sure	6	15.8%
Q4.22: Have LBP at work only			
LBP at work only	Yes	4	9.5%
	No	37	88.1%
	No LBP At Work	1	2.4%

Table 4.18: Current back pain characteristics continued

Q4.23: Have LBP at home only			
LBP at home only	Yes	4	9.5%
	No	37	88.1%
	No LBP At Home	1	2.4%
Q4.24: Improvement of LBP during duty free periods			
Improvement during duty free	Yes	24	57.1%
	No	17	40.5%
	No LBP During Duty Free	1	2.4%
Q4.25: Do you think your LBP is related to your work			
Work related LBP	Yes	18	43.9%
	No	23	56.1%
Q4.26: Have you ever lost your job due to LBP			
Loss job due to LBP	Yes	0	0.0%
	No	42	100.0%
Q4.27: What caused or aggravated your LBP			
Bending	No	37	82.2%
	Yes	8	17.8%
Twisting	No	35	77.8%
	Yes	10	22.2%
Lifting	No	28	62.2%
	Yes	17	37.8%
Posture	No	21	46.7%
	Yes	24	53.3%
Other	No	41	91.1%
	Yes	4	8.9%
Sitting	No	19	42.2%
	Yes	26	57.8%
Standing	No	40	88.9%
	Yes	5	11.1%
Overhead movements	No	45	100.0%
	Yes	0	0.0%
Driving	No	38	84.4%
	Yes	7	15.6%
WBV	No	42	93.3%
	Yes	3	6.7%
Q4.28: Ever experienced an injury on duty (IOD)			
IOD	Yes	3	7.5%
	No	37	92.5%
Q4.29: Have you received treatment for your LBP			
Treatment	Yes	15	38.5%
	No	24	61.5%

Table 4.18: Current back pain characteristics continued

Q4.30: Treatment option for LBP			
Surgeon	No	41	91.1%
	Yes	4	8.9%
Pharmacy	No	39	86.7%
	Yes	6	13.3%
Traditional healer	No	44	97.8%
	Yes	1	2.2%
Biokineticist	No	38	84.4%
	Yes	7	15.6%
Physiotherapy	No	36	80.0%
	Yes	9	20.0%
Homeopath	No	40	88.9%
	Yes	5	11.1%
Clinic	No	43	95.6%
	Yes	2	4.4%
Chiropractic	No	36	80.0%
	Yes	9	20.0%
Other	No	42	93.3%
	Yes	3	6.7%

The subjective responses regarding the experience of LBP in **Table 4.18** reveal that 28 out of 45 pilots (62.2%) currently suffering with LBP describe the LBP as a stiffness and dull aching sensation. Most pilots (75.6%) indicated that LBP was located on both the left and right sides. Of the 44 pilots that answered Question 4.8, 34 pilots had said that there were no sensations of pins and needles associated with the LBP. This however leaves ten pilots (22.7%) that indicated they experience pins and needles concomitant with LBP. A further seven pilots indicated that pins and needles symptoms spread down below their knees. In comparisons, ten pilots (22.7%) had indicated that they have numbness in their feet during bouts of LBP. Of those pilots that had indicated current LBP episodes, seven pilots (16.3%) stated experiencing associated symptoms of LBP.

The majority of pilots (76.3%) revealed that LBP was intermittent and as a result of this 92.9% had not taken leave or been absent. The persistence of pilots to remain at work is further noted with nearly 60% indicating that they can only sit between one to three hours in the cockpit before experiencing pain. Of this amount, nearly 40% had a maximum of three hours before LBP and discomfort occurs. In comparison to time allocated in a car seat, a range of one to six hours was indicated by 70.7% of pilots, with majority (31.7%) indicating three hours is the maximum time allowed before LBP occurs. Comparing these to a chair representing rest, such as their favourite armchair, majority of pilots (38.5%) had indicated that they can be seated as long as they like without experiencing LBP. The remainder was however evenly spread between thirty minutes and six hours.

Results further indicate that activities of daily living (ADL) were affected in nearly 60% of pilots suffering currently with LBP, compared to leisure activities of which 50% were affected. Majority of pilots (85.9%) did note that they did not require bed rest. The LBP episodes were described as having a gradual onset in more than 60% of the pilots. When pilots were asked whether they have LBP only at work or only at home, an exact amount of pilots (88.1%) indicated 'No' to both question. Considering the intermittent nature of the pilot's LBP, nearly 60% of pilots with current LBP, stated having improvement of their current LBP, or no LBP during duty free periods.

All the pilots experiencing current LBP have never lost their job as a result of LBP. The possible causes for the pilots LBP were most commonly indicated as sitting (57.8%), posture (53.3%) and lifting (37.8%). The remainder of listed possible causes for LBP, had majority of pilots not believing that it was a cause in their LBP development (viz. WBV (93.3%), driving (84.4%), standing (88.9%), bending (82.2%), twisting (77.8%), overhead movements (100%)). This is illustrated by 15% of pilots (**Table 4.15**) who stated clearly feeling WBV, but that only 3 pilots out of 45 believe (**Table 4.18**) it was an aggravating factor.

Of those pilots with current LBP, 92.5% stated they have never experienced an injury on duty (IOD). However, 61.5% of pilots suffering with current LBP have received some form of treatment. Chiropractic and physiotherapy were most commonly indicated (20%), followed by biokineticist (15.6%) and pharmaceuticals (13.3%).

4.6.4.2 Discussion of current episode of LBP:

Considering that most pilots had indicated LBP to be experienced as stiffness or a dull aching sensations located bilaterally, it may be that muscle involvement, rather than nerve involvement, is most likely. This is seen through Balasubramanian, Dutt and Rai, (2011) where the rate of muscle fatigue, prolonged sitting and the correlation to LBP was investigated. With the use of surface electromyography on the erector spinae and trapezius muscles of pilots, the study determined that a strong correlation exists between total flying time and pain. The study further established that the prevalence of pain increases with greater flying time due to poor posture.

As most pilots stated no pins and needles sensation is present, it may be considered that nerve involvement and by extension impeded nerve function, had not transpired. Williams and Sambrook, (2011) and Hermes *et al*., (2010) found that disc bulges, disc herniation and spondylosis (viz. nerve involvement) usually present clinically with somatic referred pain and may show radiculopathic features.

This study found that pilots mostly experience intermittent pain, which indicates similar findings as Balasubramanian, Dutt and Rai (2011), whereby a greater time seated appears to results in more pain. Validating the hypothesis somewhat that work related factors may be causative, or at least aggravating in LBP episodes, is found through results which show that nearly 60% have improvement or no pain during duty free periods. This could suggest that pilots may be downplaying the significance of pain and concomitant disabilities during work, as a result of the health worker effect (HWE) (Shaw, 2009).

However, contrary to the above is also found in the study of Hermes *et al*., (2010) and Simon-Arndt *et al*., (1996) where the most common injury found in pilots are I.V.D. disorders and not muscular in origin. Keeping in mind that 22.7% of pilots had complained of numbness and pins and needles with LBP episodes may indicate that pilots could have developing disc disorders.

The 22.7% of pilot's currently experiencing radicular type pain in this study, is congruent with the current average age of 39.8 years and the proposed onset of disc disorders (Hermes *et al*., 2010) in the third decade of life. This may explain why 60% of pilots currently suffering with LBP stated their ADL is affected. As a result, treatment for LBP may be sought, as is seen with the use of health care providers such as Chiropractic (20%), Physiotherapy (20%), Biokineticist (15.6%) and pharmaceuticals (13.3%). Physical therapies (viz. Chiropractic) have a good outcome in the treatment of LBP (Globe *et al.*, 2008) which provides reasoning for the highest number of pilots seeking this professional care. Considering, however, that over 60% of pilots in this study have not received treatment may reveal why LBP is so prevalent within this population.

4.6.4.3 Statistics related to current LBP

Table 4.19: Statistics related to current back pain

		Pain score	Days	Days absent	Cost
n	Valid	45	36	45	45
	Missing	0	9	0	0
Mean		4.16			
Std. Deviation		2.099			
Minimum		0	1	0	0
Maximum		10	365	120	25000
Percentiles	25	3.00	10.00	.00	.00
	50	4.00	30.00	.00	.00
	75	5.50	138.50	.00	700.00

The average pain intensity, seen in **Table 4.19**, experienced by pilots is 4.16 on a scale ranging from zero to ten. The minimum days of current LBP was one day within the last year, whereas the maximum was 365, indicating those pilots had suffered with LBP the entire year. The maximum days absent was 120 days, and a maximum cost of R25 000 spent on LBP treatment.

4.6.4.4 Discussion of statistics related to current LBP

Regarding the numerical pain rating scale, a score of zero indicated no pain where as ten indicated most severe pain. This would suggest that pilots on average suffer with mild to moderate pain. Taking the standard deviation (2.099) into account, may explain the 22.7% of pilots illustrating greater injury, with potential nerve injury symptoms. This may also then account for the R25 000 which was spent in the last year on treatment (viz. Chiropractic, Physiotherapy, Biokineticist, pharmaceuticals).

4.6.4.5 Past episode of LBP:

Participants were omitted from analysis and by default LBP within the past section, if in this section the following two criteria were fulfilled:

1) Participants indicated they have never had LBP (said 'No' to question 4.1) and
2) Indicated they did not have LBP on Question 4.7 of the past LBP section.

Exclusion of participants fulfilling the above criteria left a total of 77 participants for analysis of past back pain. In addition, if any of the individual questions were not answered by the participant, it was coded zero and was excluded on a question by question basis.

Table 4.20: Past back pain characteristics

Q4.6: Characteristic of back pain		Count	Column N %
No LBP	No	77	100.0%
	Yes	0	0.0%
Catching pain	No	65	84.4%
	Yes	12	15.6%
Sharp	No	53	68.8%
	Yes	24	31.2%
Stiffness	No	46	59.7%
	Yes	31	40.3%
Stabbing	No	58	75.3%
	Yes	19	24.7%
Dull ache	No	29	37.7%
	Yes	48	62.3%
Poking	No	76	98.7%
	Yes	1	1.3%
Shooting	No	69	89.6%
	Yes	8	10.4%
Other (Specify):	No	75	97.4%
	Yes	2	2.6%
Q4.7: Location of past LBP			
Past LBP side involvement	One Side Left	14	18.2%
	One Side Right	12	15.6%
	Both Sides	51	66.2%
	No LBP	0	0.0%
Q4.8: LBP resulted in pins and needles previously			
pins and needles	Yes	13	17.6%
	No	61	82.4%
Q4.9: Pins and needles referral pattern			
Sensation spread below knees	Yes	6	15.8%
	No	32	84.2%
Q4.10 Numb sensation in feet during presence of LBP			
Numbness	Yes	11	14.9%
	No	63	85.1%
Q4.11:Associated symptoms during LBP			
Symptoms	Yes	10	14.7%
	No	58	85.3%
Q4.12b2: Have not had LBP in the past			
Past LBP	Yes	62	80.5%
	No	15	19.5%
Q4.13: LBP constant or intermittent			
Past LBP constant / intermittent	Constant	11	20.8%
	Intermittent	42	79.2%
Q4.14: Been absent from work as a result of LBP			
Absent	Yes	7	10.6%
	No	59	89.4%
Q4.15: Time in cockpit chair before experiencing LBP			
Time before LBP experience	10 mins	5	7.1%
	30 mins	7	10.0%
	60 mins	4	5.7%
	180 mins	18	25.7%
	360 mins	10	14.3%
	As long as I like	26	37.1%

Table 4.20: Past back pain characteristics continues

Q4.16: Time in car seat before experiencing LBP			
Time before LBP experience	10 mins	6	8.7%
	30 mins	4	5.8%
	60 mins	6	8.7%
	180 mins	16	23.2%
	360 mins	16	23.2%
	As long as I like	21	30.4%
Q4.17: Time in armchair before experiencing LBP			
Time before LBP experience	10 mins	5	7.4%
	30 mins	6	8.8%
	60 mins	3	4.4%
	180 mins	8	11.8%
	360 mins	11	16.2%
	As long as I like	35	51.5%
Q4.18: LBP affecting daily living			
Daily living affected	Yes	32	45.7%
	No	38	54.3%
Q4.19: LBP affecting leisure activities			
Leisure activities affected	Yes	42	60.0%
	No	28	40.0%
Q4.20: Bed rest required for LBP			
Bed rest required	Yes	14	20.3%
	No	55	79.7%
Q4.21: Onset of LBP			
Onset	Gradually	33	51.6%
	Suddenly	30	46.9%
	Not Sure	1	1.6%
Q4.22: Have LBP at work only			
LBP at work only	Yes	7	10.0%
	No	58	82.9%
	No LBP At Work	5	7.1%
Q4.23: Have LBP at home only			
LBP at home only	Yes	10	14.3%
	No	54	77.1%
	No LBP At Home	6	8.6%
Q4.24: Improvement of LBP during duty free periods			
Improvement during duty free	Yes	36	52.9%
	No	26	38.2%
	No LBP During Duty Free	6	8.8%
Q4.25: Do you think your LBP is related to your work			
Work related LBP	Yes	26	38.8%
	No	41	61.2%
Q4.26: Have you ever lost your job due to LBP			
Lost job due to LBP	Yes	1	1.5%
	No	66	98.5%

Table 4.20: Past back pain characteristics continues

Q4.27: What caused or aggravated your LBP			
Bending	No	58	75.3%
	Yes	19	24.7%
Twisting	No	57	74.0%
	Yes	20	26.0%
Lifting	No	47	61.0%
	Yes	30	39.0%
Posture	No	40	51.9%
	Yes	37	48.1%
Other	No	65	84.4%
	Yes	12	15.6%
Sitting	No	41	53.2%
	Yes	36	46.8%
Standing	No	69	89.6%
	Yes	8	10.4%
Overhead movements	No	75	97.4%
	Yes	2	2.6%
Driving	No	69	89.6%
	Yes	8	10.4%
WBV	No	73	94.8%
	Yes	4	5.2%
Q4.28: Ever experienced an injury on duty (IOD)			
IOD	Yes	9	13.0%
	No	60	87.0%
Q4.29: Have you received treatment for your LBP			
Treatment	Yes	43	58.9%
	No	30	41.1%
Q4.30: Treatment option for LBP			
Surgeon	No	72	93.5%
	Yes	5	6.5%
Pharmacy	No	63	81.8%
	Yes	14	18.2%
Traditional healer	No	77	100.0%
	Yes	0	0.0%
Biokineticist	No	68	88.3%
	Yes	9	11.7%
Physiotherapy	No	54	70.1%
	Yes	23	29.9%
Homeopath	No	75	97.4%
	Yes	2	2.6%
Clinic	No	76	98.7%
	Yes	1	1.3%
Chiropractic	No	50	64.9%
	Yes	27	35.1%
Other	No	74	96.1%
	Yes	3	3.9%
Q4.31: Any medication taken for LBP			
Medication	Yes	47	66.2%
	No	24	33.8%

Table 4.20: Past back pain characteristics continues

Q4.32: What medication was taken for LBP			
Painkillers	No	0	0.0%
	Yes	27	100.0%
Anti-inflammatory	No	32	41.6%
	Yes	45	58.4%
Rubs	No	49	64.5%
	Yes	27	35.5%
Patches	No	67	87.0%
	Yes	10	13.0%
Traditional medicine	No	77	100.0%
	Yes	0	0.0%
Don't know	No	77	100.0%
	Yes	0	0.0%
Q4.33: Did the medication help			
Medication helped	Yes	42	80.8%
	No	10	19.2%

The section discussing past LBP experiences, as seen in Table 4.20, reveals that 48 pilots out of a total of 77 (62.3%) indicate that LBP was experienced as a dull ache. A further 66.2% of pilots stated that this sensation was experienced in both sides of the spine (viz. left and right side), in comparison to 18.2% indicating left side involvement only and 15.6% right side involvement only. A high prevalence of pilots (82.4%) that suffered with previous LBP had indicated that no shooting pain was present during bouts of LBP, versus 17.6% that indicated they had shooting pain. Of these indicating shooting pains, a further six stated that the sensation spread down to below the knees. 11 pilots (14.9%) had concomitant numbness in their feet during LBP. Furthermore, ten pilots (14.7%) stated having other associated symptoms during these LBP experiences. Nearly 80% of pilots indicate that the pain was intermittent and that nearly 90% state having never been absent as a result of LBP.

Within the cockpit chair, the majority of pilots (37.1%) stated they can sit for as long as they like, followed by 25.7% of pilots indicating three hours before LBP arises. Following on this was 14.3% of pilots indicating six hours are required before experiencing LBP. In comparison to time allocated in a car seat, majority (30.4%) of pilots had indicated they can be seated for as long as they like. This is followed equally at 23.2% of pilots seated for both three and six hours before experiencing pain. The use of an armchair, before experiencing pain, revealed the maximum allocated time seated was mostly indicated as long as they like. This pool represented 51.4% not experiencing pain in the armchair, versus 16.2% that experience LBP after six hours and followed by 11.8% stating three hours before onset.

Further noted is that ADL were affected in 54.3% of pilots in comparison to leisure activities which had a greater percentage at 60% affected. Nearly 80% of past LBP sufferers did not require bed rest and that the onset of LBP was almost equally divided between gradual and sudden onset, with gradual enjoying slightly more preference. Pilots were asked whether they experienced LBP only at work or only at home. Majority of pilots answered ‘No’ to both questions, giving justification that LBP was experienced intermittently. Improved or no pain during duty free periods was indicated by 61.7% of pilots.

Only one pilot had temporarily lost his job as a result of LBP. In trying to establish what pilots believe brought on their LBP, only two factors were identified significantly by this study’s sample. These two factors had nearly equal amounts of the population stating they believe it was the causative factors, versus those that do not believe it was. These two factors are sitting (46.8%) and posture (48.1%). This may further validate the sedentary lifestyle pilots fall into, as a further 87% indicate they have never experienced an IOD however, nearly 60% of pilots had received treatment for past LBP episodes.

The most common physical therapy sought for past LBP was Chiropractic with 27 pilots (35.1%) out of 77 having seen a Chiropractor. A fair contradiction arises through 63 pilots (81.8%) stating that pharmaceutical options for LBP was not taken as a LBP treatment options, however when asked if any medication was taken and if LBP improved, nearly 60% (45 pilots) had taken anti-inflammatory medications. Of the 52 pilots who indicated if there was any benefit of medication, over 80% (42 pilots) had stated medication helped the LBP experiences.

4.6.4.6 Discussion of past episode of LBP:

It is noted that a greater number of pilots have previously experienced LBP, in comparison to current LBP sufferers. This however may be attributable to past LBP enjoying a greater period of time in which pilots may have experienced LBP. The trend lies towards pain being intermittent, felt as a dull ache and located bilaterally. Most pilots did not have shooting pains (82.4%), however for those (13 pilots) that did, a further 11 pilots had associated foot numbness, indicating a more sinister condition.

Comparing the amount of time allocated in a variety of chairs before LBP presents, reveal that a common trend exists where more pilots state they could previously be seated for a greater period before experiencing pain. This could suggest that pilots may have experienced physiological changes associated with age (Dagenais and Haldeman, 2012; Leboeuf-Yde *et al.,* 2009; Clays *et al*., 2007; Jacobs *et al*., 2006; Cassidy *et al*., 2005), which currently inhibits the total time seated before pain develops.

It may be that exposure to sitting and posture, the factors receiving most confidence for causing LBP, in conjunction with increasing age, which results in a propensity for more pilots to experience previous LBP. In contrast, factors strongly indicated in literature as LBP risk factors such as WBV which is clearly felt by 15% of pilots (**Table 4.15**), does not seem to be confidently listed as a potential cause for LBP as indicated by 4 out of 77 pilots (**Table 4.20**), potentially due to its commonality in flight.

With a wide array of treatment options used for past LBP, it must be noted that, as the past LBP prevalence of 77% (77 pilots) is lower than the current LBP prevalence of 45% (45pilots), treatment options utilized by pilots (viz. Chiropractic) may have had a positive outcome in decreasing the prevalence of LBP in this population.

4.6.4.7 Statistics related to past LBP

Table 4.21: Statistics related to past back pain

		Pain score	Days	Absent	Cost
n	Valid	77	77	66	77
	Missing	0	0	11	0
Mean		5.75			
Std. Deviation		2.237			
Minimum		2	0	1	.0
Maximum		10	365	2	150000.0
Percentiles	25	4.00	.00	2.00	.000
	50	6.00	6.00	2.00	.000
	75	7.50	20.00	2.00	2000.000

The average pain scores for LBP related to past experience, as depicted in **Table 4.21**, is 5.75 on a scale of zero to ten, with a standard deviation of 2.237. The maximum number of LBP days in the past was 365 days. The most leave days needed for LBP was two, with a minimum of one day. A total of R150 000 was spent on treatment.

4.6.4.8 Discussion of statistics related to past LBP

The average pain scores of 5.75 is a fairly significant total considering zero equals no pain and ten equals' most excruciating pain. This average is higher than the current LBP average (4.16). The maximum amount of LBP days (365) indicates that previous LBP episodes may have been of a greater intensity. Considering that pilots could previously be seated for longer in a variety of chairs, would suggest a noxious event possibly occurred, resulting in decreased sitting comfort and LBP. This initial nociception was probably unknown (Hudspith *et al*., 2008; Hantman *et al*., 2004) and as such possibly overrated in terms of its significance. It may also have been that the body, not having yet become accustomed to the pain level (Hudspith *et al*., 2008; Hantman *et al*., 2004), may have produced a greater pain sensation.

With increased age however, sensitisation occurs and the pain level experienced may be lower than previous regardless if the condition has improved, stabilized or even become worse (Hudspith *et al*., 2008). Considering that the most days ever taken off previously were two days, either indicates that body resilience was greater or HWE was at work. This may explain the total of R150 000 that was spent by South African pilots on treatment (viz. disc repair, disc fusion, private health care) similar to the study of Aydog *et al*., (2004) and Simon-Arndt *et al*., (1996).

4.6.4.9 Summery of Objective Four

In summarizing Objective four, it is evident that a trend of similarity is found in the current and past LBP experiences. When comparing both sections of pain, a tendency shows that pilots may be unaware of the injurious environment or risk factors they are exposed to. The sedentary lifestyle (Heistaro *et al.,* 1999; Harreby *et al.,* 1996; Salminen *et al.,* 1984) of pilots exposes them to weakening core strength (Sargant and Bachman, 2010) which may not be a significant factor during inactive periods; however, during twisting, lifting or exposure to risk factors such as WBV, prolonged sitting and poor ergonomics (Pillastrini*et al*., 2012; Mendelek*et al*., 2011; Helfenstein-Junior *et al.,* 2010; Ghaffari, 2007; Bovenzi et al., 2006; Bovenzi *et al*., 1996), may result in LBP development. This suggest that South African pilots have comparable occupational circumstances, LBP prevalence's and injuries such as those pilots in Prombumroong *et al*., (2011) and Aydog *et al*., (2004).

4.6.5 Objective Five: Risk factors and their contribution to LBP

To identify possible risk factors that may contribute to last 12 months prevalence of low back in commercial pilots.

4.6.5.1 Pilot characteristics:

Table 4.22: Demographics identified as risk factors

	Yes		No		
	Mean	Standard deviation	Mean	Standard deviation	*p*-value
Q1.1 Age	39.1	10.1	41.3	12.2	0.343
Q1.2 Height	1.8	.1	1.8	.1	0.394
Q1.3 Weight	80.7	13.8	86.6	13.5	0.050
(Table 4.2) BMI	25.3	3.3	26.7	3.2	0.046
Q1.7 Dependants	1.3	1.3	1.1	1.2	0.452

Following bivariate analysis it was determined that weight and BMI (**Table 4.22**) were statistically associated with LBP, however, it was the lighter pilots who tended to have a higher risk of LBP than those with greater weight averages. This could, however, have been confounded by the fact that female pilots who are generally lighter than males, were more likely to suffer from LBP.

Considering that the BMI of pilots (**Table 4.2**) falls into that category of overweight (Boon *et al*., 2006), and is of a higher average than studies on pilots within different occupational circumstances with strict anthropometric requirements (Simon-Arndt *et al*., 1996; Aydog *et al*., 2004; Desviat *et al*., 2007; Drew, 1999; Loomis *et al*., 1999), it appears that BMI may have, to an extent, a protective factor against LBP development. The exact contribution of BMI to LBP development has previously been indicated as poor (Seaman, 2013; Jensen *et al.,* 2012 and Ramond *et al.,* 2010), this is thus congruent with the results of this study, whereby a larger BMI appears to result in a lower prevalence.

Reasons for this may be that the bodyweight carried by pilots, and in essence their low back, is countered and protected by the sedentary work lifestyle. Furthermore it is postulated that the adipose tissue may in some manner prevent or minimize the effect that risk factors such as WBV and poor ergonomics have on the spine.

As the exact mechanism is not understood and definitive reasons for this inverse relationship not clearly defined, it must be postulated that the results may have been influenced through the smaller population size obtained in this study. Further research is required to establish more definitively the relationship that exists between increased units of BMI and the proposed protective factor that was found for LBP.

Table 4.23: Demographics continued

Q1.4 -1.6, 1.8		Yes		No		*p*-value
		Count	Column N %	Count	Column N %	
Gender	Male	54	79.4%	29	96.7%	0.029
	Female	14	20.6%	1	3.3%	
Race	White	61	89.7%	23	74.2%	0.157
	Coloured	4	5.9%	2	6.5%	
	Black	2	2.9%	4	12.9%	
	Indian	1	1.5%	1	3.2%	
	Other	0	0.0%	1	3.2%	
Marital Status	Married	48	71.6%	21	72.4%	0.100
	Single	13	19.4%	3	10.3%	
	Divorced	3	4.5%	5	17.2%	
	Other	3	4.5%	0	0.0%	
	Separated	0	0.0%	0	0.0%	
Education	ATL	61	89.7%	30	96.8%	0.231
	Commercial license	7	10.3%	1	3.2%	

The results depicted in **Table 4.23** illustrate the effect that gender has on the prevalence of LBP. It was found that although the number of female pilots was less than the male pilots, gender was significantly associated with LBP whereby females were more likely than males to have LBP. Furthermore, the average age of 39.8 years (**Table 4.2**) found in this population also explains the high percentage of pilots obtaining an ATL and a married status, signifying that with more years as a commercial pilot, comes a greater educational status and probability of married life. Although a *p*-value was obtained illustrating that race and marital status was not significantly linked to LBP, it is believed that with a larger sample size, a more significant result would have been obtained.

Revealing a lifetime prevalence of 80.8% (**Table 4.16**) signifies the impact that this condition has on this population. Considering that the majority of pilots were white males (**Table 4.1**) in conjunction with the high lifetime prevalence, indicates that this prevalence may have been higher, should the populace have comprised of more females, as they have a greater likelihood of developing LBP. This is confirmed through the results of Shiri et al., (2009) who further validated the results of

Valkenburg *et al.,* (1982), Fairbank *et al.,* (1984); Salminen *et al.,* (1984), Svensson *et al.,* (1988) and Balague *et al.,* (1994), where it was found that females had a greater likelihood of developing LBP. Furthermore, as it has been noted previously that whites have a lower risk of LBP (Dyer, 2012; Louw *et al*., 2007), in conjunction with the statement that females are at greater risk of LBP (Morris, 2006; Battie *et al.,* 1990), the high prevalence of LBP in this population suggest that occupational factors contribute significantly in LBP. Providing further validation for this statement is found through combining these factors/ scenarios found in the above argument, and the proposed protective cushining they have againts LBP, and including the fact that the majority of pilots (70%) are married (**Table 4.1),** it would further suggest that a lower prevalence would be present, as it was noted by Cats-Baril *et al.,* (1991); Biering-Sörensen*,* (1986) and Reisbord *et al.,* (1985), that unmarried persons have a higher prevalence of LBP in comparison to single/ unmarried persons.

It must be noted that counter argumentative results are found through Clays *et al.,* (2007) who illustrates results which depict that overweight males were at greater risk of developing LBP when compared to women with the same weight. This is also confirmed by the results of Feldman *et al.,* (2001); Gunzburg *et al.,* (1999); Burton*,* (1996); Newcomer*,* (1996); Olsen *et al.,* (1992) and Biering-Sörensen, (1989) who found similar conclusions.

4.6.5.2 Discussion of pilot characteristics:

In drawing a conclusion, it is understood that the population of commercial pilots may be unique regarding gender and LBP prevalence. As this population is mostly white males, who have a BMI in overweight class (Boon *et al*., 2006), it may be this factor which contributes to high prevalence of LBP from the male aspect and fulfilling the works of Clays *et al.,* (2007). The contribution from the female population is that they are at higher risk of developing LBP, and as such may have a greater impact on the prevalence, should the population have been larger. This then ultimately explains the high prevalence of LBP in this population, as there are contributions from both genders, whereby young, lighter weighing females and slightly heavier white males both add to this significant lifetime prevalence.

4.6.5.3 Work history:

Table 4.24: Work history related to LBP

		Yes Count	Column N %	No Count	Column N %	*p*-value
Q3.1 Working status.						
Captain SR		29	42.6%	12	38.7%	0.755
Co-Pilot SR		22	32.4%	11	35.5%	
Co-Pilot LR		6	8.8%	4	12.9%	
Instructor LR		6	8.8%	0	0.0%	
Captain LR		2	2.9%	1	3.2%	
Instructor SR		1	1.5%	1	3.2%	
Single Pilot Operation		1	1.5%	1	3.2%	
Training Captain SR		1	1.5%	1	3.2%	
Q3.4 - 3.5: History of flying						
Q3.4 Partake in other flying	No	58	85.3%	23	74.2%	0.260
	Yes	10	14.7%	8	25.8%	
Q3.5 Ever been a Chartered pilot	Yes	37	54.4%	20	64.5%	0.345
	No	31	45.6%	11	35.5%	
Q3.5b: Occupational experience as a Chartered pilot						
Prolonged sitting	No	40	58.8%	15	48.4%	0.332
	Yes	28	41.2%	16	51.6%	
Lifting	No	45	66.2%	16	51.6%	0.167
	Yes	23	33.8%	15	48.4%	
Turning	No	50	73.5%	27	87.1%	0.132
	Yes	18	26.5%	4	12.9%	
Computer work	No	57	83.8%	24	77.4%	0.444
	Yes	11	16.2%	7	22.6%	
Arms overhead	No	63	92.6%	27	87.1%	0.373
	Yes	5	7.4%	4	12.9%	
Bending	No	53	77.9%	22	71.0%	0.459
	Yes	15	22.1%	9	29.0%	
Stress	No	45	66.2%	23	74.2%	0.425
	Yes	23	33.8%	8	25.8%	
Turbulence	No	47	69.1%	18	58.1%	0.283
	Yes	21	30.9%	13	41.9%	
Pulling	No	65	95.6%	29	93.5%	0.667
	Yes	3	4.4%	2	6.5%	
Forward arm position	No	60	88.2%	27	87.1%	1.000
	Yes	8	11.8%	4	12.9%	

Divulged in **Table 4.24** are results which show that pilot status (viz. Captain and co-pilot short range), is not at a risk for developing LBP. This signifies that all pilots, regardless of their current status are at risk for LBP development. Furthermore, having a history as a chartered pilot is not a risk for LBP. This is made evident through the results which depict that occupational experiences as a charted pilot are not associated with the development of LBP.

Table 4.25 Work history related to LBP continued

		Yes Count	Column N %	No Count	Column N %	*p*-value
Q3.6: Experiences for current occupation						
Prolonged sitting	No	5	7.4%	2	6.5%	1.000
	Yes	63	92.6%	29	93.5%	
Lifting	No	64	94.1%	30	96.8%	1.000
	Yes	4	5.9%	1	3.2%	
Twisting	No	37	54.4%	25	80.6%	0.012
	Yes	31	45.6%	6	19.4%	
Computer work	No	42	61.8%	24	77.4%	0.125
	Yes	26	38.2%	7	22.6%	
Arms overhead	No	58	85.3%	28	90.3%	0.492
	Yes	10	14.7%	3	9.7%	
Bending	No	60	88.2%	26	83.9%	0.551
	yes	8	11.8%	5	16.1%	
Stress	no	26	38.2%	20	64.5%	0.015
	yes	42	61.8%	11	35.5%	
Turbulence	no	31	45.6%	14	45.2%	1.000
	yes	37	54.4%	17	54.8%	
Pulling	no	67	98.5%	30	96.8%	0.565
	yes	1	1.5%	1	3.2%	
Forward arm position	no	51	75.0%	25	80.6%	0.615
	yes	17	25.0%	6	19.4%	
Q3.7 Exposed to factors outside of work						
Prolonged sitting	no	55	80.9%	24	77.4%	0.691
	yes	13	19.1%	7	22.6%	
Lifting	no	51	75.0%	23	74.2%	1.000
	yes	17	25.0%	8	25.8%	
Twisting	no	47	69.1%	25	80.6%	0.331
	yes	21	30.9%	6	19.4%	
Computer	no	34	50.0%	19	61.3%	0.296
	yes	34	50.0%	12	38.7%	
Arms overhead	no	65	95.6%	28	90.3%	0.374
	yes	3	4.4%	3	9.7%	
Bending	no	49	72.1%	24	77.4%	0.574
	yes	19	27.9%	7	22.6%	
Stress	no	51	75.0%	27	87.1%	0.172
	yes	17	25.0%	4	12.9%	
Turbulence	no	63	92.6%	31	100.0%	0.321
	yes	5	7.4%	0	0.0%	
Pulling	no	65	95.6%	30	96.8%	1.000
	yes	3	4.4%	1	3.2%	
Forward arms position	no	61	89.7%	29	93.5%	0.537
	yes	7	10.3%	2	6.5%	
Q3.8 - 3.10: Average of weight lifted and repetitiveness						
Weight lifted	1-10 kg	11	61.1%	5	62.5%	0.789
	11-20kg	6	33.3%	3	37.5%	
	21-30kg	1	5.6%	0	0.0%	
Average repetitiveness	0-10	16	88.9%	8	100.0%	1.000
	11-20	2	11.1%	0	0.0%	

Assessing the occupational experiences pilots are exposed to on a daily basis reveals that stress and twisting are significantly associated with LBP (**Table 4.25**). Results further reveal that pilots are not significantly exposed to factors that have been indicated as risk factors for LBP development outside of work. The average weight lifted and repetitiveness of lifting objects was not found to be significant.

4.6.5.4 Discussion of work history:

An explanation for the results depicted in **Table 4.24** might be that the pilot population of this study may have been too small to detect associations between job status and LBP. Alternatively, there may be an artificial relationship that exists between job status and LBP, as the movement up hierarchy is generally concomitant with experience and thus age, which have been shown to result in LBP (Plouvier *et al.,* 2011; Cassidy *et al.,* 2005). This insignificance found in job status occurs as there is almost an even division of pilots between Captain short range and co-pilot short range. It is still postulated that the short range status may be associated with LBP prevalence, as majority of pilots suffer with back pain, and majority of pilots have a status which falls in the short range category.

Although the findings in **Table 4.24** do not show any significance with regards to the proposed factors investigated, it does allow for other conclusions to be made. These include:

- Elimination of Chartered pilot history, as a contributor of LBP prevalence, ensures any findings may be linked to current (Commercial) pilot status.
- Elimination of proposed factors of LBP development also found in charted pilot history, may not have affected the prevalence of LBP in the current population.
- Other flying roles, of which majority do not partake in, do not have an effect on the current prevalence of LBP.

The results in **Table 4.25** allow for a conclusion to be made that stress and twisting, part of the multi factorial aetiology of LBP, are found within the pilot occupational setting and contribute to the prevalence of this condition. This also allows for the confirmation of the research hypothesis, that pilots are exposed to certain risk factors within their occupation, which contributes to LBP.

Although the exact contribution that stress has on the body and LBP is yet to be clearly defined, Hartvigsen *et al.,* (2004) report that there is no evidence to suggest this factor is responsible for increased risk in LBP. However, more recent studies such as Heneweer *et al.,* (2010) report that evidence exists in supporting the assertion that psychological factors (such as stress, depression) are related to the development of future episodes of LBP and related disability levels (Heneweer *et al.,* 2010; Hoogendoorn *et al.,* 2000; Linton and Ryberg, 2000).

Considering that stress not only has a psychological impact (Heneweer *et al.,* 2010) but also physical impact on the body, its combined effect increases the likelihood of LBP development (Hoogendoorn *et al.,* 2000; Linton and Ryberg, 2000; Heneweer *et al.,* 2010). It thus stands to reason that twisting may be the physical form of stress on the body. As twisting is indicated as significantly related to LBP, the poor ergonomics found in commercial seats (Goossens *et al.,* 2000) may elevate the significance this factor has on the body especially with repetition.

The possible mechanism through which twisting causes LBP may be found through the explanation Snijders *et al.,* (2004) gives, stating that a stable position is only reached once the centre of gravity (CoG) of the upper body corresponds to a line in front of the ischial tuberosities which then coincides with the CoG just anterior to the lumbar lordosis. Twisting movements would thus negate this stable seated position, which may result in strain on the lumbar ligaments (Snijders *et al.,* 2004) and effectively cause LBP. Twisting may also occur on a regular basis during the duty period, as it has been established that most pilots are short range (**Table 4.4)**, and pre-flight checks may thus occur multiple times during a day. During the pre-flight checks, it is hypothesized that this process results in the twisting, as indicated by pilots. Considering the process of twisting, this may further be during the process of taking a seat and getting up out of a seat, as the yoke/ side stick controller and other computers may limit the space to comfortably perform these actions.

Contrary to the findings of this study Prombumroong *et al*., (2011) found that lifting contributes to LBP. Incorporating the knowledge that merely 18 pilots indicated lifting objects, the exact effect this factor has, may have been contextualised by the smaller population size. This is evident through the larger population found in Prombumroong *et al*., (2011) where the sample was 684 pilots, and significance was found between lifting and weight lifted. The study further reveals that lifting objects more than four times predisposed the pilot population to LBP. This is partially congruent with results of this study, as those pilots that indicated they perform lifting tasks, do so in the range of one to ten times per day. For this reason, this factor will have to be further investigated in a population size larger than current

4.6.5.5 Hours seated in the cockpit

Table 4.26 Hours seated in cockpit related to LBP

		Yes Count	Column N %	No Count	Column N %	*p*-value
Q3.12 – 3.13: Average hours seated in cockpit during duty period and weekly						
Duty period	0	1	1.5%	0	0.0%	0.395
	1-3 hours	3	4.4%	4	12.9%	
	3-5 hours	27	39.7%	10	32.3%	
	5-7 hours	26	38.2%	9	29.0%	
	7-9 hours	10	14.7%	6	19.4%	
	>9 hours	1	1.5%	1	3.2%	
	6	0	0.0%	1	3.2%	
Weekly	0	1	1.5%	1	3.2%	0.808
	5-15 hours	12	17.6%	8	25.8%	
	15-25 hours	25	36.8%	12	38.7%	
	25-35 hours	21	30.9%	8	25.8%	
	35 - 45 hours	8	11.8%	2	6.5%	
	>45 hours	1	1.5%	0	0.0%	

The average hours spent seated daily and weekly, as depicted in **Table 4.26**, were not found to be significantly related to LBP. This indicates that, although no criteria of total hours could be identified as the minimum or maximum time allocated in a seated position to developed LBP, the high prevalence of LBP must result from seated time over a prolonged period.

4.6.5.6 Discussion of hours seated in the cockpit

The average hours seated in the cockpit in conjunction with the results illustrated in **Table 4.3**, where the average occupational years are 14.7 years, would suggest that LBP develops from the proposed factors (viz. stress and twisting) throughout occupational years as a result of over exposure. This argument is supported by Leelavathy *et al.,* (2011); Lis, Korn and Black, (2007) and Ramroop *et al.*, (2006) who state that sitting, in combination with exposure to factors such as WBV, awkward positions for more than half of a working day, lead to the greatest increase in LBP development. Working on an 8-hour working day, means that majority of pilots (**Table 4.26**) fall into the criteria set out by Lis, Korn and Black, (2007), whereby majority of pilots have more than half the working day seated in the aircraft. This allows for further confirmation that identified factors, such as stress and twisting, are exposed to sufficiently, to result in an impact on LBP, and the subjective responses by pilots, as to which are the culprit factors.

Although prolonged sitting was not significantly associated with LBP (**Table 4.25**), it may be subjective responses in combination with a smaller population size, which also led to this factor not identified in the LBP saga. According to the results indicated in **Table 4.26**, majority of pilots fall into the category set out by Lis, Korn and Black, (2007), it was then expected that, as most studies indicate pilots complain of the poor seating positions (Song *et al*., 2001; Goossens *et al*., 2000), a correlation would be found between hours seated in the cockpit, LBP and prolonged sitting as an identified factor by pilots.

Considering the finding of Goossens *et al*., (2000) regarding the shortcomings of the anthropometric standards of aviation and biomechanical requirements for comfortable sitting, it can only denote two possibilities for the findings regarding seated hours daily and weekly:

- Seating has been altered into more ergonomically sound and comfortable seats.
- Aircrafts found to have poor anthropometric standards of aviation and biomechanical requirements for comfortable sitting, was not utilized by the population of pilots in this study.

As a result, further investigation is needed through a qualitative, biomechanical study, whereby aircrafts, both those found in the study of Goossens *et al*., (2000) and the current aircrafts utilised by commercial carriers in South Africa, are compared, to illustrate any differences regarding seating and ergonomic measurements.

4.6.5.7 Social history

Table 4.27: Social History related to LBP

		Yes Count	Row %	No Count	Row %	*p*-value
Q2.1 Rate your health	Good	31	81.6%	7	18.4%	0.029
	Excellent	37	60.7%	24	39.3%	
	Fair	0	0.0%	0	0.0%	
	Poor	0	0.0%	0	0.0%	
Q2.2: Presence of condition in the following systems						
Abdominal	Yes	1	100.0%	0	0.0%	1.000
	No	67	68.4%	31	31.6%	
Blood	Yes	3	100.0%	0	0.0%	0.235
	No	65	67.7%	31	32.3%	
Breast	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
CVS	Yes	6	85.7%	1	14.3%	0.429
	No	62	67.4%	30	32.6%	
Endocrine	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
Immune	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
Musculoskeletal	Yes	6	85.7%	1	14.3%	0.429
	No	62	67.4%	30	32.6%	
Neurological	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
Respiratory	Yes	1	100.0%	0	0.0%	1.000
	No	67	68.4%	31	31.6%	
Skin	Yes	1	100.0%	0	0.0%	1.000
	No	67	68.4%	31	31.6%	
Urinary	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
Q2.3 – 2.5: Stress related to work, home and time booked off.						
Stress at work	None	2	100.0%	0	0.0%	0.361
	Moderate	46	73.0%	17	27.0%	
	High	4	66.7%	2	33.3%	
	Low	16	57.1%	12	42.9%	
Stress at home	High	1	100.0%	0	0.0%	0.786
	Moderate	23	71.9%	9	28.1%	
	Low	40	67.8%	19	32.2%	
	None	4	57.1%	3	42.9%	
Booked off work	0	1	100.0%	0	0.0%	0.704
	3	1	100.0%	0	0.0%	
	yes	1	100.0%	0	0.0%	
	no	65	67.7%	31	32.3%	
Q2.6.1: Current smoking status						
Smoking status	Non smoker	51	72.9%	19	27.1%	0.047
	Ex smoker	16	66.7%	8	33.3%	
	Current smoker	1	20.0%	4	80.0%	

Table 4.27: Social History related to LBP continued.

		Yes Count	Row %	No Count	Row %	*p*-value
Q2.7.2 – 2.7.4: Sleeping habits						
Routine	No	40	69.0%	18	31.0%	0.943
	Yes	28	68.3%	13	31.7%	
Sleeping position	Back	10	83.3%	2	16.7%	0.067
	Side	53	70.7%	22	29.3%	
	Stomach	5	41.7%	7	58.3%	
Sleep away from home	Not applicable	3	100.0%	0	0.0%	0.338
	Yes	55	69.6%	24	30.4%	
	No	10	58.8%	7	41.2%	
Q2.8.1 – 2.8.3: Exercise routine						
Do you exercise	0	1	100.0%	0	0.0%	0.745
	Yes	60	69.0%	27	31.0%	
	No	7	63.6%	4	36.4%	
Regular exercise routine	No	40	74.1%	14	25.9%	0.205
	Yes	28	62.2%	17	37.8%	
Influenced by demands	Yes	27	73.0%	10	27.0%	0.751
	0	26	65.0%	14	35.0%	
	No	15	68.2%	7	31.8%	
Q2.8.4: Exercise type						
Aerobics	No	66	68.0%	31	32.0%	1.000
	Yes	2	100.0%	0	0.0%	
Cardio	No	39	66.1%	20	33.9%	0.659
	Yes	29	72.5%	11	27.5%	
Cricket	No	67	68.4%	31	31.6%	1.000
	Yes	1	100.0%	0	0.0%	
Golf	No	61	70.9%	25	29.1%	0.335
	Yes	7	53.8%	6	46.2%	
Weights	No	53	68.8%	24	31.2%	1.000
	Yes	15	68.2%	7	31.8%	
Running	No	41	66.1%	21	33.9%	0.511
	Yes	27	73.0%	10	27.0%	
Soccer	No	66	68.8%	30	31.3%	1.000
	Yes	2	66.7%	1	33.3%	
Swimming	No	57	66.3%	29	33.7%	0.220
	Yes	11	84.6%	2	15.4%	
Rugby	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
Pilates	No	64	68.1%	30	31.9%	1.000
	Yes	4	80.0%	1	20.0%	
Other	No	46	68.7%	21	31.3%	1.000
	Yes	22	68.8%	10	31.3%	
Q2.9.1- 2.9.2: Hours seated and seat type used						
Seated > 3 hours	0	1	100.0%	0	0.0%	0.528
	Yes	39	65.0%	21	35.0%	
	No	28	73.7%	10	26.3%	
Car seat	No	49	68.1%	23	31.9%	1.000
	Yes	19	70.4%	8	29.6%	
Office chair	No	50	66.7%	25	33.3%	0.444
	Yes	18	75.0%	6	25.0%	
Lounge chair	No	40	69.0%	18	31.0%	1.000
	Yes	28	68.3%	13	31.7%	
Massage chair	No	68	68.7%	31	31.3%	-
	Yes	0	0.0%	0	0.0%	
Other seat	No	66	69.5%	29	30.5%	0.587
	Yes	2	50.0%	2	50.0%	

According to **Table 4.27** it was revealed that having good health, in comparison to excellent health, was significantly linked to LBP. Furthermore, having a history as an ex-smoker or non-smoker was also associated with low back pain. Insignificant results were demonstrated between the presence of systemic conditions and LBP (*p*= 0.235 – 1.000). No significance could be established between the history of pilots related to stress at home, stress at work, time booked off for stress and LBP. Sleeping habits, exercise routine and type of exercise was also found to be insignificantly related to LBP. Being seated more than three hours, in seats other than cockpit chairs, also demonstrated insignificant results.

4.6.5.8 Discussion of social history

Considering that pilots with a subjective rating of good health was related to LBP, indicates that personal view of health includes the experiences of pain. This suggests that pilots suffering with LBP may regard their health to be good and not excellent. Contradictory results however are seen with regards to musculoskeletal disorders, where no significant result was obtained. This could indicate that pilots may either not have sufficiently indicated having a musculoskeletal disorder, validating previous theories of HWE (Shaw, 2009), did not understand what musculoskeletal disorders are, or thought that having LBP does not constitute a musculoskeletal disorder. Further conflicting results include the significance found between the causes of LBP within the pilot setting, which include stress (**Table 4.27**), and the insignificance found between feeling stressed at work (**Table 4.25**) and LBP. This may result from pilots believing they are stress free to some degree, but understand that their occupation is one of a stressful environment. Or alternatively, pilots believe stress resulted in their LBP, but do not think that they are personally stressed at work.

This may be further explained through the controversial findings of LBP related to a history of non smoking and ex-smoker. It may be that pilots suffering with LBP use tobacco to not only control their symptoms of pain, but also stress to some degree. For this reason, this variable may have become construed differently, as those currently smoking possibly perceives pain to be less or even absent. This is validated by Prombumroong *et al*., (2011); Aydog *et al*., (2004) and Drew, (1999) who all found inconclusive associations between LBP and smoking within pilots. The study of Kaaria *et al*., (2011) further reveals that smoking is not statistically related to LBP in men. Considering the majority of male participants in this study, these variations in stress and smoking history may be explained through this single gender predominance. Although no significance was found between exercise and LBP, it may be deduced that the presence or absence of LBP may occur regardless of the personal choice to perform exercise.

4.6.5.9 Medical history

Table 4.28 Medical history related to LBP

Q3.16- 3.23.		Yes Count	Column N %	No Count	Column N %	*p*-value
Previous trauma	Yes	21	70.0%	9	30.0%	0.459
	No	47	67.1%	23	32.9%	
Surgery	Yes	33	71.7%	13	28.3%	0.779
	No	35	64.8%	19	35.2%	
Emotional trauma	Yes	12	63.2%	7	36.8%	0.665
	No	54	68.4%	25	31.6%	
Wear brace during flying	Yes	2	100.0%	0	0.0%	1.000
	No	65	67.0%	32	33.0%	
Wear brace with non-flying	Yes	3	100.0%	0	0.0%	0.549
	No	64	67.4%	31	32.6%	
Ever been pregnant	Yes	6	100.0%	0	0.0%	0.173
	No	62	66.0%	32	34.0%	
Complications in pregnancy	Yes	1	100.0%	0	0.0%	1.000
	No	64	67.4%	31	32.6%	
Ever lost pilot license	Yes	5	62.5%	3	37.5%	0.708

The medical history of pilots as illustrated in **Table 4.28**, reveal that previous trauma and surgery was not significantly associated with the development of LBP. Similarly, it was established that emotional trauma, making use of back braces and pregnancy was not statistically significant in LBP development. The loss of a pilot licence was also not significantly related to LBP.

4.6.5.10 Discussion of Medical history

The significant medical history as previously depicted in **Tables 4.6 - 4.12**, reveal that the population of pilots have been exposed to numerous conditions which were thought to be potential contributors in the development of LBP. These included nearly half of the population which have received some form of surgery, 30% of the population having experienced trauma and six percent of the population with a history of pregnancy.

The locations of the conditions (viz. Surgery, trauma) may be causative of the insignificance of factors in **Table 4.28** to LBP development, as a minimal amount of surgery and trauma occurred to the low back. In keeping with the results of **Table 4.28**, it is postulated that the insignificance found between the medical history of pilots and LBP, may also be as a result of population size influence. Should the population have been larger, potential links between surgery, specific to the lumbar spine and trauma with direct interest in the lumbar spine, may have been found to be significantly related to LBP, albeit not in a direct way, but through an indirect involvement such as a contributing factor.

With literature indicating the possibility of pain persisting after surgery (Reuben, 2007), and the effect the nervous system has in amplifying pseudo-nociceptive impulses through central sensitization (Coderre *et al*., 1993) following surgery and trauma, would suggest that the potential remains for this population to still be at risk for LBP development. Reasons for this include the significant population size which have experienced some form of trauma, be it surgery, physical trauma, emotional trauma or pregnancy and concomitant complications.

4.6.6 Objective Six: Correlation between identified factors and LBP

To establish if a correlation between demographics, work history and risk factors exists in the contribution to LBP in commercial pilots

Table 4.29: Variables in the Equation

		B	S.E.	Wald	df	Sig.	OR	95% C.I. for OR	
								Lower	Upper
Step 1[a]	BMI	-.170	.089	3.636	1	.057	.844	.709	1.005
	Gender (females versus males)	1.793	1.175	2.330	1	.127	6.006	.601	60.030
	Q3.6 Twisting	1.178	.600	3.855	1	.050	3.248	1.002	10.529
	Q3.6 Stress	1.302	.587	4.926	1	.026	3.677	1.164	11.612
	Health (good versus excellent)	1.635	.596	7.518	1	.006	5.127	1.594	16.494
	Smoking (ex or non smoker versus smoker)	1.217	.509	5.725	1	.017	3.378	1.246	9.156
	Constant	-1.355	2.688	.254	1	.614	.258		

a. Variable(s) entered on step 1: BMI, Gender, Q3.6twisting, Q3.6stress, Health, and Smoking.

4.6.6.1 Variables in the equation:

Risk factors which have been found to be significantly related to LBP in previous sections were assessed in **Table 4.29** using binary logistic regression. Results indicated that following adjustment for confounding due to other risk factors with significance, BMI continued to be protective for LBP, with an 11.6% decreased risk for every unit of BMI increased.

Further determined was the risk gender played in LBP development. It was established that females were six times more likely to develop LBP in comparison to their male counterparts, however the risk was not statistically significant (p=0.127). Having good health in comparison to excellent health (odds ratio 5.12) was a significant factor in LBP risk. Furthermore, having a history of an ex or non-smoker compared to with a smoker (odds ratio 3.37) remained a risk for LBP.

Twisting (odds ratio 3.25) and being exposed to stress (Odds ratio 3.7) within the occupational setting remain a risk for LBP.

4.6.6.2 Interpretation:

The cross sectional design of this study may have led to some bias which resulted in the unexpected results. The health worker effect (HWE) (Shah, 2009) is well known in occupational studies, whereby the condition of interest is ill-represented in the cohort. This is possibly due to fear that those who have developed the condition are no longer doing the work. However, considering the current population and the requirements of this occupation, the HWE is unlikely to affect this study to a great extent. A reason for this is that LBP is probably not a condition which would lead to one giving up their job as a pilot. Nevertheless, it is critical to remember that this factor may have lead to an underestimation of the seriousness of certain cases of LBP.

Also, the design of the study, being cross sectional in nature, may not have accounted for the fact that risk factors may have occurred after the onset of LBP and therefore could be consequences of the condition rather than causes of the LBP. An example is the results surrounding the variable BMI. Common trend would suggest that having a greater BMI would be associated with having LBP, but it may be that those persons suffering with LBP have lost weight, in essence have a lower BMI compared to those without LBP. Therefore the associations found here cannot be interpreted with complete certainty as causal. The proposed significant factors may even be associated as a result of reverse causality.

4.7 Review of the objectives

The aim of this study was to determine the prevalence of low back pain (LBP) in commercial pilots and identifying possible risk factors that pilots are exposed to.

The objectives of the study were:

- To establish the demographics (gender, ethnicity, marital status, education, dependants, age and BMI) of commercial pilots registered with the South African Civil Aviation Authority (SACAA).
  - The average ages of pilots were comparable to literature (Section 4.6.1.1).
  - The male predominance found in this occupation is congruent with current literature (Section 4.6.1.1).
  - The average BMI of pilots was higher than current literature of pilots both in commercial and high performance setting (Section 4.6.1.3).
- To establish the work history of the commercial pilots (occupational years, work history, medical history, total flying hours, cockpit seat description, daily experiences in cockpit seat).
  - The piloting years corresponds to the average age of pilots which concurs with current literature (Section 4.6.2.1).
  - Short range status was more predominant than long range status (Section 4.6.2.3)
  - The average hours in cockpit seat allows sufficient time for rest which is congruent with literature (Section 4.6.2.3)
  - The total flying hours falls well within the range of comparable studies (Section 4.6.2.6).
  - Current aircraft used was not sufficiently indicated to establish any correlation between aircraft and LBP.
- Establish the point, period and lifetime prevalence of LBP amongst commercial pilots in South Africa.
  - The lifetime prevalence of LBP amongst this population falls in the upper quartile and agrees with studies on rotary wing pilots (Section 4.6.3.2).
  - The annual prevalence of LBP is higher when compared to studies of similar nature and congruent with studies on physical workloads (Section 4.6.3.3).

- Point and period prevalence is generally higher in comparison to general population studies (Section 4.6.3.4).

- To determine the nature, severity and clinical presentation of LBP in commercial pilots.
  - The results of this study found the clinical presentation, severity and cost related to treatment, are well within the expectation found in literature (Section 4.6.4).
- To identify possible risk factors that may contribute to LBP in commercial pilots.
  - Factors related to LBP as indicated by literature were found in this study and significantly related to LBP (Section 4.6.5).
  - Proposed risk factors, found within similar occupational settings, were not significantly related to LBP (Section 4.6.5).
- To establish if a correlation between demographics, work history and risk factors exists in the contribution to LBP in commercial pilots
  - Gender played a significant role in LBP development, and is in congruence with literature (Section 4.6.6.1)
  - BMI had an inverse proportional relationship to LBP as indicated by literature (Section 4.6.6.1)
  - Selective occupational factors were related to LBP (Section 4.6.6.1).
  - The absence of excellent health played a significant role in LBP risk (Section 4.6.6.1).

Considering the high prevalence of LBP found within this population and an environment which may be an aggravating factor in LBP development, it is not unconceivable that fairly regular treatment has been sought by pilots. Therefore it may be of significance introducing preventative measures such as education on work and lifestyle factors, physical therapists specialising in muscular and joint dysfunction (viz. Chiropractors, Physiotherapists) and pilot specific medical insurance (Globe *et al.*, 2008). The aim should be to further educate pilots on the protection of their low back, whilst allowing accessible treatment which accommodates their regular travels. This may potentially minimize the high prevalence of LBP in pilots, decreasing costs to pilots and the companies.

4.8 Conclusion

The LBP prevalence of commercial pilots within South Africa is higher when compared to studies of general populations within South Africa (Dyer, 2012; Docrat *et al*., 1999; Van der Meulen, 1997). Similarly, the white male predominance of this study also indicates that the prevalence of whites is higher in comparison to ethnic studies performed in South Africa (Dyer, 2012; Docrat *et al*., 1999; Van der Meulen, 1997), indicating the occupational contribution to LBP in this populace. This prevalence also falls into the upper quartile when compared to global prevalence (Van Vuuren *et al.,* 2006; Jin *et al.,* 2004; Nyland and Grimmer, 2003; Hillman *et* al., 1996). The annual prevalence of LBP is also higher in comparison to international commercial pilots of similar occupational settings (Prombumroong *et al*., 2011).
Regression analysis of demographics, work history and risk factors revealed that gender played a significant role in LBP prevalence. Whilst the majority of this population were white males, it was the female population however, who individually indicate a greater risk for LBP development. Occupational factors such as twisting and stress are significantly related to LBP and comply with literature (Heneweer *et al.,* 2010; Ghafarri, 2007; Hoogendoorn *et al.,* 2000; Linton and Ryberg, 2000). In comparison, BMI enjoys an inverse proportional relationship to LBP and further illustrates the tenuous link between LBP and BMI (Seaman, 2013; Jensen *et al.,* 2012; Ramond *et al.,* 2010). Smoking may affect the perceived intensity of LBP to some extent through possible stress and pain management, as it is indicated that a history as an ex-smoker or non-smoker is significantly related to LBP. It appears that the absence of excellent health may be an indicator of future LBP episodes.

These results assisted the researcher in establishing the significance of LBP within commercial pilots of South Africa. Risk factors have been identified which results in increased predisposition to LBP. Further research is needed within this population and in the South African context to establish and minimize the potential risk and expenses that may be incurred with this condition. This may potentially minimize the physical strain placed on pilots, decrease the consequences of identified risk factors and by extension, the financial strain placed on pilots and the economy.

CHAPTER FIVE

5.1 Conclusion:

Commercial pilots in South Africa have a significant risk of developing LBP with the lifetime prevalence noteworthy at 80.8%. The annual, period and point prevalence of LBP in this population was 68.7%, 32.7% and 19.4% respectively, further indicating the magnitude of this condition within commercial pilots. Comparing these results to studies within South Africa and globally, revealed that LBP in commercial pilots fall in the upper quartile and relate more to occupations demanding physical labour. This further validates the misconception that sedentary occupations are not a risk factor in LBP development.

Due to the nature of the population diversity, conclusions could be drawn from the regression analysis of demographics, indicating that white males, may still be less at risk of LBP development than females. Results indicated that females were 6 times more likely to develop LBP in comparison to their male counterparts. This conclusion is however drawn from the female population which was small in comparison to the white male population and as a result was not statistically significant (p=0.127). Considering the majority white male participants and the significant lifetime prevalence that was obtained, different results may have been illustrated with a greater female population. It is hypothesized that the prevalence of LBP may have been significantly higher, which can only encourage future interventional studies and research into commercial pilots as a whole.

In comparison to the diverse occupational risk factors as indicated by literature, results showed twisting and stress were the only occupational factors significantly related to LBP. Twisting (odds ratio 3.25) and being exposed to stress (odds ratio 3.7) within the occupational circumstances of a pilot, may be more significant than initially anticipated, as this occurs nearly on a daily basis, for more than half the working time of an 8 hour work day and within aberrant ergonomics as previously discovered.

The contribution from this study in determining a clear link between BMI and LBP is tenuous, with results indicating BMI enjoys an inverse proportional relationship to LBP, whereby every unit increased in BMI, results in 11.6% decreased risk of LBP development. Further confounding results may be seen with smoking which was found to be protective for LBP (p=0.017), as results showed that a history as an ex-smoker or non-smoker is significantly related to LBP (odds ratio 3.37). These results may indicate a reverse causality association, whereby LBP may have resulted in weight loss and smoking. The contribution from this relationship, whether reversed or direct, still remains noxious on either side of the spectrum, with the presence of LBP unchanging. Established from this perplexity is that inclusion of predictors for future LBP may be beneficial through not only assessing risk factors, but through the inclusion of subjective ratings of health, whereby good health in comparison to excellent health (p= 0.006) is related to LBP development.

This study has revealed the significant impact that LBP has on the commercial pilot community. Through the daily exposure of risk factors identified in this paper, pilots have become affected to a higher degree than most general populations. Future studies must assess each risk factor as indicated by through this study and literature, in order to determine the individual contribution these factors carry, and concomitantly minimize the exposure to these noxious factors. This will aid in the development of awareness and interventions for the benefit of the airlines and the pilots.

5.2 Recommendations

Recommendations arising from the results of this study include the following:

- Increasing the sample size, to allow for more distinct associations between LBP and potential risk factors to be detected as it is found in literature and minimizing the fallout possibility.
- Performing clinical trials in this population to assimilate the actual contribution of proposed risk factors and the effect of intervention through limiting exposure to factors with risk (viz. sEMG for muscle fatigue and triaxial seat pad accelerometer for WBV).

- Ergonomic assessment of cockpit chairs found within the commercial fleet of South Africa is needed to illustrate potential similarities/ dissimilarities to the results found in the ergonomic assessment of Goosens *et al*., (2000).
- Future studies should asses the presence and possible contribution of G-forces and altitude changes in alteration of physiology and LBP in commercial pilots.
- Nutrition, dietary requirements and the association to LBP should be investigated as the demands of short range flights and the amount of hours seated in the cockpit may be enabling factors for increased stress/ decreased health.
- Future studies should be conducted to determine the financial viability of employing a full time physical therapist (Viz. Chiropractor) at each of the major airports in order to address musculoskeletal health related problems and educate pilots on work and lifestyle changes.

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Appendix A: British Airways

LETTER OF INFORMATION

To whom it may concern:

Thank you for your consideration to partake in this study. Your time and knowledge is much appreciated. All information regarding this study is provided below.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

Brief Introduction and Purpose of the Study: Occupational low back pain (LBP) has been described as a massive burden to both the industry and medicine. There are numerous factors affecting the development of low back pain. These include ergonomics and personal risk factors. This is commonly seen in occupations that require prolonged sitting periods characterised by sitting for more than half of the working time. This may be further complicated by concomitant exposure to physical factors such as whole body vibration (WBV) and/or awkward posture, which lead to the highest increase in risk for developing LBP. Most studies performed on occupational LPB does in fact not meet the required standards of the Bradford-Hill criteria which is a common criteria used in assessment of possible causal factors of LBP. As a result no conclusive evidence exists in terms of the exact cause of low back pain development.

<u>Inclusion criteria: - participants:</u>

- Pilots registered with SACAA.
- Pilots over the age of 18years will be included.
- Pilots flying aircrafts defined as fixed wing.
- Short, medium and long haul pilots.
- The questionnaires will all be retained for data collection. Any missing data will be noted as such and recorded / analysed as such.

<u>Exclusion criteria: - participants:</u>

- Expert group participants.
- Any persons moonlighting for other travel companies

Outline of the Procedures: Participants of the study will be approached directly by the researcher during the log in period during which a letter of information will be given as well as a brief verbal description of the study. Upon signing the letter of information and informed consent, they will be required to complete a questionnaire. A rough estimate of 15 minutes is required to complete this

document. No follow ups will be required as this is a questionnaire survey. The first correct 100 questionnaire received back, will be utilized in the study.

Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. There is no financial expense expected to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

Research-related Injury: The study is a questionnaire survey from which no injury or adverse reaction is expected. Participation is purely voluntary and withdrawal from the study is allowed at any time.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

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

____________________ __________ __________ _______________

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

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix A: Kulula

LETTER OF INFORMATION

To whom it may concern:

Thank you for your consideration to partake in this study. Your time and knowledge is much appreciated. All information regarding this study is provided below.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

Brief Introduction and Purpose of the Study: Occupational low back pain (LBP) has been described as a massive burden to both the industry and medicine. There are numerous factors affecting the development of low back pain. These include ergonomics and personal risk factors. This is commonly seen in occupations that require prolonged sitting periods characterised by sitting for more than half of the working time. This may be further complicated by concomitant exposure to physical factors such as whole body vibration (WBV) and/or awkward posture, which lead to the highest increase in risk for developing LBP. Most studies performed on occupational LPB does in fact not meet the required standards of the Bradford-Hill criteria which is a common criteria used in assessment of possible causal factors of LBP. As a result no conclusive evidence exists in terms of the exact cause of low back pain development.

Inclusion criteria: - participants:

- Pilots registered with SACAA.
- Pilots over the age of 18years will be included.
- Pilots flying aircrafts defined as fixed wing.
- Short, medium and long haul pilots.
- The questionnaires will all be retained for data collection. Any missing data will be noted as such and recorded / analysed as such.

Exclusion criteria: - participants:

- Expert group participants.
- Any persons moonlighting for other travel companies

Outline of the Procedures: Participants of the study will be approached directly by the researcher during the log in period during which a letter of information will be given as well as a brief verbal description of the study. Upon signing the letter of information and informed consent, they will be required to complete a questionnaire. A rough estimate of 15 minutes is required to complete this

document. No follow ups will be required as this is a questionnaire survey. The first correct 100 questionnaire received back, will be utilized in the study.

Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. There is no financial expense expected to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

Research-related Injury: The study is a questionnaire survey from which no injury or adverse reaction is expected. Participation is purely voluntary and withdrawal from the study is allowed at any time.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

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- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ __________ __________ _______________

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

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix A: Mango

LETTER OF INFORMATION

To whom it may concern:

Thank you for your consideration to partake in this study. Your time and knowledge is much appreciated. All information regarding this study is provided below.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

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<u>Inclusion criteria: - participants:</u>

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- The questionnaires will all be retained for data collection. Any missing data will be noted as such and recorded / analysed as such.

<u>Exclusion criteria: - participants:</u>

- Expert group participants.
- Any persons moonlighting for other travel companies

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document. No follow ups will be required as this is a questionnaire survey. The first correct 100 questionnaire received back, will be utilized in the study.

Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. There is no financial expense expected to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

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

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_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix A: SA Express

DURBAN UNIVERSITY OF TECHNOLOGY

LETTER OF INFORMATION

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Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. There is no financial expense expected to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

Research-related Injury: The study is a questionnaire survey from which no injury or adverse reaction is expected. Participation is purely voluntary and withdrawal from the study is allowed at any time.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

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

____________________ __________ __________ _______________

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

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix A: SAA

LETTER OF INFORMATION

To whom it may concern:

Thank you for your consideration to partake in this study. Your time and knowledge is much appreciated. All information regarding this study is provided below.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

Brief Introduction and Purpose of the Study: Occupational low back pain (LBP) has been described as a massive burden to both the industry and medicine. There are numerous factors affecting the development of low back pain. These include ergonomics and personal risk factors. This is commonly seen in occupations that require prolonged sitting periods characterised by sitting for more than half of the working time. This may be further complicated by concomitant exposure to physical factors such as whole body vibration (WBV) and/or awkward posture, which lead to the highest increase in risk for developing LBP. Most studies performed on occupational LPB does in fact not meet the required standards of the Bradford-Hill criteria which is a common criteria used in assessment of possible causal factors of LBP. As a result no conclusive evidence exists in terms of the exact cause of low back pain development.

<u>Inclusion criteria: - participants:</u>

- Pilots registered with SACAA.
- Pilots over the age of 18years will be included.
- Pilots flying aircrafts defined as fixed wing.
- Short, medium and long haul pilots.
- The questionnaires will all be retained for data collection. Any missing data will be noted as such and recorded / analysed as such.

<u>Exclusion criteria: - participants:</u>

- Expert group participants.
- Any persons moonlighting for other travel companies

Outline of the Procedures: Participants of the study will be approached directly by the researcher during the log in period during which a letter of information will be given as well as a brief verbal description of the study. Upon signing the letter of information and informed consent, they will be required to complete a questionnaire. A rough estimate of 15 minutes is required to complete this

document. No follow ups will be required as this is a questionnaire survey. The first correct 100 questionnaire received back, will be utilized in the study.

Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. There is no financial expense expected to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

Research-related Injury: The study is a questionnaire survey from which no injury or adverse reaction is expected. Participation is purely voluntary and withdrawal from the study is allowed at any time.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

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

____________________ __________ __________ _______________

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

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix B

Letter of Intent for use of O.R. Tambo International facilities for Research Purposes

Dear IREC:

Please note the following regarding the use of O.R. Tambo International Airport Facilities.

Common corrections from DRC, FRC and IREC include asking to provide a letter of intent and letter of information to O.R.Tambo Airport in the aim of receiving permission to be on these premises. Permission to make use of these facilities has been requested from all Companies situated in the International Airport. A letter of intent (Appendix A) was given personally to each company by the researcher.

A favourable response regarding participation and permission to make use of facilities was obtained from 4 companies through electronic communication. The remainder of the Airport's companies did not respond to the letter of intent (Appendix A). Upon further investigation it was found by the researcher that permission could only be given through the companies situated in the O.R.Tambo International Airport as these companies are stakeholders of the said building, and thus permission to conduct the study at O.R.Tambo can only be given by the stakeholders and not the Airport. The companies from which permission was acquired and their pilots will be the source from which the study population of 100 pilots are obtained.

As such, no further permission is required to be on the premises during the research process as stipulated by the Airport's companies involved in the research.

Thank you kindly

Researcher: Berno Stander ....

Supervisor: Dr G. Matkovich ....

Please indicate a cross to mark off your answer FINAL QUESTIONNARE

Section A: Demographics

1.1) Age: (in years)		1.2) Height: (meters)		1.3) Weight: (kg)			
1.4) Gender:	Male		Female				
1.5) Race:	White	Colored	Indian	Black	Other:		
1.6) Marital Status:	Single	Married	Divorced/ Separated		Other:		
1.7) Number of children:	1	2	3	4	5	More than 5	
1.8) Highest level of education?	1. No formal education	2. Primary School	3.High School	4. Matriculated	5. Tertiary	6.NQF	7. N2/ N3
	8. Other (Specify):						

Section B: Social History

2.1) How would you rate your health, at the moment?		Excellent	Good	Fair	Poor	
2.2) How would you rate your stress levels generally?		High	Moderate	Low	None	
2.3) Are you currently taking any medication for stress?		Yes		No		
Smoking:	2.4.1) What is your smoking status?	Current smoker	Ex-smoker	Non- smoker		
	2.4.2) If yes, for current smoker or ex-smoker how many cigarettes do you/ did you smoke?					
	2.4.3) If yes, for current smoker or ex-smoker. How many years have you, or did you smoke?					
Sleeping habits	2.5.1) On average, how many hours do you sleep per night?					
	2.5.2) Do you have a routine sleeping pattern?	Yes	No			
	2.5.3) What is your predominant sleeping position?	On your side	On your back	On your stomach		
	2.5.4) During your work week, are you required to sleep in hotels?	Yes	No	N/A		
	2.5.5) If yes, how often in a working week do you sleep in a hotel?	33%	66%	100%		
Exercise:	2.6.1) Do you exercise?	Yes	No			
	2.6.2) Do you adhere to a regular exercise routine?	Yes	No			
	2.6.3) If no, do you feel it's due to your demands of your job?	Yes	No			
	2.6.4) If yes, what exercise do you do? Indicate how many times per week?	Aerobics	Cardio gym	Cricket	Golf	Pilates	Rugby
		Running	Soccer	Swimming	Weight training	Other	
Travel	2.7.1) In addition to your flying, do you spend more than 3 hours seated per day?	Yes	No			
	2.7.2) If yes, please indicate why?					
	2.7.3) If yes, please indicate the type of seat (e.g. car, office chair)					

Section C: Occupation:

3.1) What is your current work status?	Captain (Short range)	Captain (Long range)	Co-Pilot (short range)	Co-pilot(long range)	Training Captain (short range)	Training Captain (long range)

3.2) How many months/ years have you been in this occupation (Commercial pilot)?		3.3) How long have you been working for this current company?	

3.4) Does your occupation involve any of the following for majority of the day? (may indicate multiple options)	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	9.Forward positioned arms

3.5) If your job involves lifting of heavy objects, how much weight (kg) on average do you lift?	1-10kg	11-20kg	21-30kg	>31kg
3.6) If your job involves lifting of heavy objects, what is it you are lifting?				
3.7) On average, how many times a day do you repeat the lifting tasks required of you?	0-10times	11-20times	21-30times	Continuous

3.8) How many hours are you seated per day?	1-3 hours	3-5 hours	5-7 hours	7-9 hours	>9 hours
3.9) On average how many hours do you sit in the cockpit **daily**?	1-3 hours	3-5 hours	5-7 hours	7-9 hours	>9 hours
3.10) On average how many hours do you sit in the cockpit **weekly**?	5-15 hours	15-25 hours	25-35hours	35-45 hours	>45hours

3.11) Do you have medical aid?	Yes	No		3.14) Have you had any surgery?	Yes	No
3.12) Do you have comprehensive medical aid?	Yes	No		• If yes to above question please specify:		
3.13)Do you suffer with any condition in the following systems: Specify if answer yes↓				3.15) Have you had any back surgery?	Yes	No
Cardiovascular system	Yes	No		• If yes to above question please specify:		
Musculoskeletal	Yes	No		3.16) Have you had any trauma?	Yes	No
Neurological	Yes	No		• If yes to above question please specify:		
Respiratory	Yes	No		3.17) Have you had any back trauma?	Yes	No
Endocrine	Yes	No		• If yes to above please specify:		
Abdominal	Yes	No		3.18) Have you had any lower limb trauma?	Yes	No
Urinary	Yes	No		• If yes to above please specify		
Heamatological (Blood)	Yes	No		3.20) Do you wear anything that supports your back? (back brace, tapping)	Yes	No
Skin	Yes	No		• For how long have you used the back support (weeks, months or years as applicable)		
Breast	Yes	No		3.21) Have you ever been pregnant?	Yes	No
Immune	Yes	No		• If “yes” did you experience any low back pain while pregnant?	Yes	No

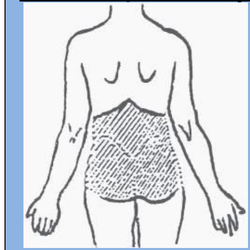
3.22) Please answer for each aircraft type	Indicate which aircraft flown with= yes not flown with= no)		Duration – total flying time per aircraft per day (Hours)	Flight days per week	Years flying aircraft	Minimum distance for a single flight (hours)	Maximum distance for a single flight (hours)	Currently flying (answer with X)
Boeing 747-400	Yes	No						
Boeing 747-300	Yes	No						
Boeing 737-300	Yes	No						
McDonnell Douglas DC10-30	Yes	No						
Airbus A 310	Yes	No						
Other (e.g. helicopter, small fixed wing) 1.	Yes	No						
2.	Yes	No						

3.23) Seat description (More than one applicable)	Armrests present	Armrests absent	Armrest inclination present	Adjustable back inclination		Adjustable back inclination absent
	Seat height adjustable	Seat not height adjustable	Low back support	Non Low back support	Sheep skin cover (padded chair)	Unpadded chair

3.24) Cockpit characteristics (May indicate more than 1)	Modern digital flight deck	Traditional analogue flight deck	Fly-by-wire design	Hydraulic control system	Side stick controller	Yoke controller	Rudder pedals

3.25) Please indicate your daily experiences at work (no limit on options)	Comfortable sitting position	Uncomfortable sitting position	Vibration is minimal	Vibration is clearly felt	Landing impact softened through chair	Landing impact clearly felt
	Pain felt with prolonged sitting	No pain felt with prolonged sitting	Regularly stretch during flight	Seldom stretch during flight	Satisfied with cockpit setup	Unsatisfied with cockpit setup

Section: D - Characteristics of pain

Low back pain history:			
	4.1) Have you ever had low back pain?	Yes	No
	4.2) At any time during the past 12 months, have you had low back pain in the area shown in the diagram? (shaded area)	Yes	No
	4.3) Did you have any low back pain in the last week?	Yes	No
	4.4) Do you have any low back pain today?	Yes	No

The following questions apply to current and/ or past low back pain.	**May fill in both if have low back pain today and in the past**																				
	Current Low Back Pain: (low back pain today)											**Past Low Back Pain experienced:**									
4.5) How would you score your low back pain? (0 being no pain, 10 being the worst pain)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10

	Current Low Back Pain		Past Low Back Pain	
4.6) Describe the pain?	Catching pain	Dull ache	Catching pain	Dull ache
	No low back pain	Poking	No low back pain	Poking
	Sharp	Shooting	Sharp	Shooting
	Stiffness	Other	Stiffness	Other
	Stabbing		Stabbing	
4.7) Is the location of the low back pain one side or both sides?	One side-left	One side -right	One side-left	One side –right
	Both sides	No low back pain	Both sides	No low back pain
4.8) Do you ever get the feeling of pins and needles in your legs when the low back pain presents?	Yes	No	Yes	No
4.9) If indicated yes to the above question, did the pain spread down your legs to below your knees?	Yes	No	Yes	No
4.10) Do you ever get a numb feeling in your legs and feet when the low back pain presents?	Yes	No	Yes	No
4.11) Any other signs and symptoms you experience when you have the low back pain? (associated changes)	(Please specify)		(Please specify)	

The following questions apply to current and/ or past low back pain.	May fill in both if have low back pain today and in the past									
	Current Low Back Pain: (low back pain today)					**Past Low Back Pain experienced:**				
4.12) Approximately how many days of low back pain have you experienced currently and in the past year?							Have not had low back pain in the past			
4.13) How many hours does the low back pain last?							Have not had low back pain in the past			
4.14) Did the low back pain last more than a day?	Yes	No				Yes	No	Have not had low back pain in the past		
4.15) Have you ever been absent from work due to your low back pain?	Yes	No				Yes	No	Have not had low back pain in the past		
• If "yes" how many days in total?										
4.16) I can only sit in my cockpit chair for "X" time before experiencing low back pain ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.17) I can only sit in an airplane chair for "X" time before experiencing low back pain ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.18) I can only sit in a car seat for "X" time before experiencing low back pain ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.19) I can only sit in my favorite armchair for "X" time before experiencing low back pain ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.20) Did the low back pain make it difficult to tie your shoe laces or put your socks on?	Yes	No				Yes	No	Have not had low back pain in the past		
4.21) Did the low back pain affect your daily activities?	Yes	No				Yes	No	Have not had low back pain in the past		
4.22) Did the low back pain affect your leisure activities?	Yes	No				Yes	No	Have not had low back pain in the past		
4.23) Have you ever needed bed-rest for your low back pain?	Yes	No				Yes	No			
4.24) How did your low back pain begin?	Gradually over time	Suddenly	Not sure			Gradually over time	Suddenly	Have no low back pain		
4.25) Do you have low back pain only at work?	Yes	No	Have no low back pain			Yes	No	Have no low back pain		
4.26) Do you have low back pain only at home?	Yes	No	Have no low back pain			Yes	No	Have no low back pain		
4.27) Does the low back pain get better over weekends?	Yes	No	Have no low back pain			Yes	No	Have no low back pain		
4.28) Do you think your low back pain is related to your work?	Yes	No				Yes	No			
4.29) Have you ever lost your job due to low back pain?	Yes	No				Yes	No			
4.30) What do you think is the cause of your low back pain?	Bending	Twisting	Lifting heavy objects	Posture	Other: (Specify)	Bending	Twisting	Lifting heavy objects	Posture	Other: (Specify)
	Sitting	Standing	Overhead movements	Driving	Whole body vibration	Sitting	Standing	Overhead movements	Driving	Whole body vibration

The following questions apply to current and/ or past low back pain.	Current Low Back Pain: (low back pain today)			Past Low Back Pain experienced:		
	May fill in both if have low back pain today and in the past					
4.31) Have you ever injured your low back at work?	Yes	No		Yes	No	
4.32) Do you feel your work activities aggravate the low back pain?	Yes	No		Yes	No	
4.33) Have you ever received treatment for the low back pain?	Yes	No		Yes	No	
4.34) If "yes" to the previous question please specify what treatment.	Public Hospital	Pharmacy	Traditional healer	Public Hospital	Pharmacy	Traditional Healer
	Private Hospital	Physiotherapy	Other (Specify)	Private Hospital	Physiotherapy	Other (Specify)
	Clinic	Chiropractic		Clinic	Chiropractic	
4.35) Are you taking any medication for the low back pain?(pain killers, muscle relaxants)	Yes	No		Yes	No	
4.36) If yes what medication are you taking?	Pain killers	Anti-inflammatory	Rubs	Pain killers	Anti-inflammatory	Rubs
	Patches	Traditional medicine	Don't know	Patches	Traditional medicine	Don't know
4.37) Does the medication help the pain?	Yes	No		Yes	No	
4.38) How much money have you spent on treatment for your low back pain?						
	Current Low Back Pain: (low back pain today)			Past Low Back Pain experienced:		
4.39) In conclusion, please can you list those things that you would change in your work area in order to decrease the chances of you getting low back pain:	1 2 3 4 5			1 2 3 4 5		

Appendix D

EXPERT GROUP
LETTER OF INFORMATION

Dear participant:

Thank you kindly for taking the time to consider taking part in my research project.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

Brief Introduction and Purpose of the Study: Occupational low back pain(LBP) has been described as a massive burden to both the industry and medicine, and that numerous factors affect the development of low back pain, including ergonomics and personal risk factors.(Pope, Goh and Magnusson, 2002). However most studies performed on occupational LPB does in fact not meet the required standards of the Bradford-Hill criteria which are the most common criteria used in assessment of possible causal factors of LBP and as a result no conclusive evidence exists in terms of the exact cause of low back pain development (Roffey *et al,* 2010). The aim of this study is to identify with greater clarity possible causes or risk factors pilots are exposed to which lead to the development of LBP. As a member of the expert group, you will be discussing and constructing recommendations regarding the proposed questionnaire.

<u>Inclusion criteria for the expert group:</u>

- Two Pilots :
  - Pilots registered with SACAA.
  - Pilots over the age of 18 years will be included.
  - Pilots flying aircrafts defined as fixed wing.
- One researcher who has completed a questionnaire study.
- One student completing a research study.
- One statistician and/or supervisor of Chiropractic research
- Two chiropractors.
- Completion of all the required forms for the expert group (Appendix E (letter of information and informed consent), F (code of conduct), G (confidentiality statement)).

<u>Exclusion criteria for the expert group:</u>

- Anyone that is unable to attend the expert group.
- Anyone unwilling to sign the required documents for the expert group, indicating that they are voluntarily participating.

Outline of the Procedures: Following the telephonic conversation, we would have scheduled this meeting in advance. The course of this meeting should last an estimated 2 hours. This will occur in the research room, MS105 at Steve Biko campus. Should you agree to partake in this meeting, you will now be asked to sign the letter of information and informed consent. The procedure of the meeting will now be explained.

Role of participants: Participants of the study is expected to firstly abide by the code of conduct as set out in Appendix E (Code of conduct). It is the role of the participants to make comments and suggestions with regards to the study. Every comment will be discussed thoroughly by the researcher, supervisor and participants until such time all parties are satisfied.

Risks or Discomforts to the Participant: Not applicable

Benefits: None to be expected from this study

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time should the participant choose.

Remuneration: You will not be rewarded for participating in this study.

Costs of the Study: The participant will not undergo any financial expense to partake in the study.

Confidentiality: All personal information will be kept confidential with the use of a coding system for data analysis and coding.

Research-related Injury: None to be expected from this study.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

DUT DURBAN UNIVERSITY OF TECHNOLOGY

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

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

______________________ ___________ ___________ ___________

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

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

___________________ ___________ ______________________

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

___________________ ___________ ______________________

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

___________________ ___________ ______________________

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

Appendix E: Code of conduct

Code of Conduct during meetings

Behaviour during Meetings

It is expected of all the members of the expert group, the researcher and supervisor to adhere to the basic rules and regulations of an expert group meeting.
Any comments may be raised during the procedure should a participant feel the need to address any of the expert group members or the researcher and supervisor of the study
Every participant of the meeting must:

- Act appropriately and treat all participants of the meeting with respect.
- Make no derogatory comments either through speech or action.
- Act in a manner that is unbiased and fair.
- Be open and honest about any action or comments and give a reason for them.
- Be clear and honest when giving a personal view of any part of the meeting or questionnaire.
- Participants should not interrupt a member during his or her addressing of the group

Declaration of interest:

Should any of the participants have a financial, personal or other material interest in the outcome of the study, it is expected that this standing will be raised to the researcher and/or supervisor.

Confidentiality:

In conjunction with the letter of information and informed consent and confidentiality agreement, it is noted that all information discussed during the expert group meeting will be kept confidential.

Breach of code of conduct:

Any participant not adhering to the above speculated rules may be asked to leave the expert group meeting with no discrimination for future attendance to meetings as such.

Please print in block letters:

Expert Group Member: ____________________________ Signature: ____________________

Witness Name: ____________________________ Signature: _____________________

Researcher's Name: ____________________________ Signature: ____________________

Supervisor's Name: ____________________________ Signature: _____________________

Appendix F

CONFIDENTIALITY STATEMENT – EXPERT GROUP

IMPORTANT NOTICE:

THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE EXPERT GROUP, BEFORE THE EXPERT GROUP MEETING CONVENES.

DECLARATION

1. All information contained in the research documents and any information discussed during the expert group meeting will be kept private and confidential. This is especially binding to any information that may identify any of the participants in the research process.
2. The returned questionnaires will be coded and kept anonymous in the research process.
3. None of the information shall be communicated to any other individual or organization outside of this specific focus group as to the decisions of this focus group.
4. The information from this expert group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Please print in block letters:

Expert Group Member: ____________________________ Signature: ____________________

Witness Name: ____________________________ Signature: _____________________

Researcher's Name: ____________________________ Signature: ____________________

Supervisor's Name: ____________________________ Signature: _____________________

Please place an "X" in the relevant box: FINAL QUESTIONNARE

Section A: Demographics

1.1) Age: (at last birthday)		1.2) Height: (meters)		1.3) Weight: (kg)	
1.4) Gender:	Male		Female		
1.5) Race:	Black	Colored	Indian	White	Other:
1.6) Marital Status:	Divorced	Married	Separated	Single	Other:
1.7) Number of dependants	1	2	3	4	5	More than 5
1.8) Highest level of education?	1.High School	2. Matriculated	3.Tertiary	4. Commercial license	5. Airline transport license(ATL)
	8. Other (Specify):				

Section B: Social History

2.1) How would you rate your health, at your last full medical?	Excellent	Good	Fair	Poor

2.2)Do you suffer with any condition in the following systems ↓ : Specify if answer yes

Cardiovascular system	Yes	No	
Neurological system	Yes	No	
Respiratory	Yes	No	
Musculoskeletal	Yes	No	
Endocrine	Yes	No	
Abdominal	Yes	No	
Urinary	Yes	No	
Haematological (Blood)	Yes	No	
Skin	Yes	No	
Immune	Yes	No	
Breast	Yes	No	

2.3) How would you rate your stress levels generally at work?	High	Moderate	Low	None
2.4) How would you rate your stress levels generally at home?	High	Moderate	Low	None
2.5) Have you ever been booked off work for stress?	Yes		No	

Smoking:	2.6.1) What is your smoking status?	Current smoker	Ex-smoker	Non- smoker		
	2.6.2) If yes, for current smoker or ex-smoker how many cigarettes do you/ did you smoke? (No of packs p.d.)					
	2.6.3) If yes, for current smoker or ex-smoker. How many years have you, or did you smoke? (Yrs)					
Sleeping habits	2.7.1) On average, how many hours do you sleep within 24 hours?					
	2.7.2) Do you have a routine sleeping pattern?	Yes	No			
	2.7.3) What is your predominant sleeping position?	On your side	On your back	On your stomach		
	2.7.4) During your roster month, are you required to sleep away from home?	Yes	No	N/A		
	2.7.5) If yes, how often in a working week do you sleep away from home? (Percentage)	%				
Exercise:	2.8.1) Do you exercise?	Yes	No			
	2.8.2) Do you adhere to a regular exercise routine?	Yes	No			
	2.8.3) If no, do you feel it's due to your demands of your job?	Yes	No			
	2.8.4) If yes, what exercise do you do? Indicate how many times per week?	Aerobics	Cardio gym	Cricket	Golf	Weight training
		Running	Soccer	Swimming	Rugby	Pilates / Other
Travel	2.9.1) Besides your flying, do you spend more than 3 hours seated per day?	Yes	No			
	2.9.2) If yes, please indicate the type of seat and include average hours (e.g. car seat, x hours)	Seat type	1) Car seat	2) Office chair	3) Lounge chair	4)Massage chair	5) Other
		Hours seated					

Section C: Occupation:

3.1) What is your current work status?	Captain (Short range)	Captain (Long range)	Co-Pilot (Short range)	Co-pilot(Long range)	Training Captain (Short range)	Training Captain (Long range)
	Instructor (Short range)	Instructor(Long range)	Single Pilot Operation	Multi crew Operation	Other	
3.2) How many years have you been in this occupation (Commercial pilot)?						
3.3) How long have you been working for this current company? (Yrs)						
3.4) Do you partake in any other flying roles outside of current occupation? Specify if Yes	Yes	No	Specify:			
3.5) Have you ever been a charted pilot?	Yes	No				
If yes to the above question, were you ever exposed to any of the following?	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead	
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	10.Forward positioned arms	
3.6) Does your current occupation involve any of the following for majority of the day? (may indicate multiple options)	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead	
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	10.Forward positioned arms	
3.7) Outside of work, are you exposed to any of the following.	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead	
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	10.Forward positioned arms	

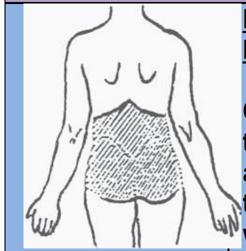
3.8) If your job involves lifting of heavy objects, how much weight (kg) on average do you lift?	1-10kg	11-20kg	21-30kg	>31kg	
3.9) If your job involves lifting of heavy objects, what is it you are lifting?					
3.10) On average, how many times a day do you repeat the lifting tasks required of you?	0-10times	11-20times	21-30times	Continuous	
3.11) How many hours are you seated per day?	Hours				
3.12) On average, how many hours do you sit in the cockpit during a duty period?	1-3 hours	3-5 hours	5-7 hours	7-9 hours	>9 hours
3.13) On average how many hours do you sit in the cockpit **weekly**?	5-15 hours	15-25 hours	25-35hours	35-45 hours	>45hours

3.14) Do you have medical aid?	Yes	No	3.21) Have you ever been pregnant?	Yes	No
3.15) Do you have comprehensive medical aid?	Yes	No	• If yes to above question please specify how many times:		
3.16) Have you had any surgery?	Yes	No	3.22) Did you experience any complications whilst being pregnant?	Yes	No
• If yes to above question please specify:			• If yes to above question please specify what complication and during which pregnancy:		
3.17) Have you had any trauma? (i.e. Falls, MVA, Fractures)	Yes	No			
• If yes to above question please specify:			3.23) Have you ever temporarily lost your pilot license due to a condition?	Yes	No
3.18) Have you had any emotional trauma? (i.e. Divorce)	Yes	No	• If yes to the above question please list condition/s and date		
• If yes to above question please specify:			1)		
3.19) Do you wear a back brace during flying roles?	Yes	No	2)		
• If yes to above question please specify:			3)		
3.20) Do you wear this back brace during non-flying roles	Yes	No	4)		
• If yes to above question please specify:			5)		

3.24) Please list every aircraft ever flown with, from training to current aircraft (i.e. 172 Cessna Skyhawk, Boeing 747-400)	Total time on aircraft logged (Hours)	Flight days per week	Years flying aircraft	Minimum distance for a single flight (hours)	Maximum distance for a single flight (hours)	Currently flying (answer with X)
1)						
2)						
3)						
4)						
5)						
6)						
7)						
8)						
Other (e.g. helicopter, small fixed wing) 1.						
2.						

3.25) Seat description in aircraft flown the most (More than one applicable)	Armrests present	Armrests absent	Armrest inclination present	Adjustable back inclination		Adjustable back inclination absent
	Seat height adjustable	Seat not height adjustable	Low back support	Non Low back support	Sheep skin cover (padded chair)	Unpadded chair
3.26) Cockpit characteristics (May indicate more than 1)	Side stick controller		Yoke controller			
3.27) Please indicate your daily experiences at work (no limit on options)	Comfortable sitting position	Uncomfortable sitting position	Vibration is minimal	Vibration is clearly felt		Landing impact softened through chair
	Pain felt with prolonged sitting	No pain felt with prolonged sitting	Regularly stretch during flight	Seldom stretch during flight		Landing impact clearly felt

Section: D - Characteristics of pain (LBP = Low back pain)



Low back pain history:

Questions 4.1 to 4.4 is applicable to this diagram with regards to shaded area

4.1) Have you ever had low back pain (LBP)?	Yes	No
4.2) At any time during the past 12 months, have you had LBP?	Yes	No
4.3) Did you have any LBP in the last week?	Yes	No
4.4) Do you have any LBP today?	Yes	No

The following questions apply to current and/ or past low back pain.

May fill in both if have low back pain today and in the past

	Current Low Back Pain Episode:											**Past Low Back Pain experienced:**										
4.5) How would you score your LBP? (0 being no pain, 10 being the worst pain)	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10

	Current Low Back Pain Episode		Past Low Back Pain experienced	
4.6) Describe the pain?	Catching pain	Dull ache	Catching pain	Dull ache
	No LBP	Poking	No LBP	Poking
	Sharp	Shooting	Sharp	Shooting
	Stiffness	Other (Specify):	Stiffness	Other (Specify):
	Stabbing		Stabbing	
4.7) Is the location of the LBP one side or both sides?	One side-left	One side -right	One side-left	One side –right
	Both sides	No LBP	Both sides	No LBP
4.8) Do you ever get the feeling of pins and needles in your legs when the LBP presents?	Yes	No	Yes	No
4.9) If indicated yes to the above question, did the sensation spread down your legs to below your knees?	Yes	No	Yes	No
4.10) Do you ever get a numb feeling in your legs and feet when the LBP is presents?	Yes	No	Yes	No
4.11) Is there any symptoms associated with the LBP? (i.e. Weakness, giving way) Please specify if yes.	Yes	No	Yes	No
	(Please specify)		(Please specify)	

The following questions apply to current and/ or past LBP.	May fill in both if have low back pain today and in the past									
	Current Low Back Pain Episode:					**Past Low Back Pain experienced:**				
4.12) Approximately how many days of LBP have you experienced currently and in the past year?							Have not had LBP in the past			
4.13) Is the LBP constant or intermittent?							Have not had LBP in the past			
4.14) Have you ever been absent from work due to your LBP?	Yes	No				Yes	No	Have not had LBP in the past		
• If "yes" how many days in total?										
4.15) I can only sit in my cockpit chair for "X" time before experiencing LBP ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.16) I can only sit in a car seat for "X" time before experiencing LBP ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.17) I can only sit in my favorite armchair for "X" time before experiencing LBP ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.18) Did the LBP make it difficult to perform activities of daily living? (i.e. Tie your shoe laces/ put socks on)	Yes	No				Yes	No	Have not had LBP in the past		
4.19) Did the LBP affect your leisure activities?	Yes	No				Yes	No	Have not had LBP in the past		
4.20) Have you ever needed bed-rest for your LBP?	Yes	No				Yes	No			
4.21) How did your LBP begin?	Gradually over time	Suddenly	Not sure			Gradually over time	Suddenly	Have no LBP		
4.22) Do you have LBP only at work?	Yes	No	Have no LBP			Yes	No	Have no LBP		
4.23) Do you have LBP only at home?	Yes	No	Have no LBP			Yes	No	Have no LBP		
4.24) Does the LBP get better over duty free periods?	Yes	No	Have no LBP			Yes	No	Have no LBP		
4.25) Do you think your LBP is related to your work?	Yes	No				Yes	No			
4.26) Have you ever lost your job due to LBP?	Yes	No				Yes	No			
4.27) What do you think has caused or aggravates your LBP?	Bending	Twisting	Lifting heavy objects	Posture	Other: (Specify)	Bending	Twisting	Lifting heavy objects	Posture	Other: (Specify)
	Sitting	Standing	Overhead movements	Driving	Whole body vibration	Sitting	Standing	Overhead movements	Driving	Whole body vibration

The following questions apply to current and/ or past low back pain.	Current Low Back Pain: (low back pain today)			Past Low Back Pain experienced:		
	May fill in both if have low back pain today and in the past					
4.28) Have you ever experienced an IOD? (Injury on duty)	Yes	No		Yes	No	
4.29) Have you received treatment for the LBP?	Yes	No		Yes	No	
4.30) If "yes" to the previous question please specify what treatment (Multiple applicable)	Surgeon	Pharmacy	Traditional healer	Surgeon	Pharmacy	Traditional Healer
	Biokineticist	Physiotherapy	Homeopath	Biokineticist	Physiotherapy	Homeopath
	Clinic	Chiropractic	Other (Specify)	Clinic	Chiropractic	Other (Specify)
4.31) Did you take any medication for the LBP? (pain killers, muscle relaxants)				Yes	No	
4.32) If yes what medication did you take?				Pain killers	Anti-inflammatory	Rubs
				Patches	Traditional medicine	Don't know
4.33) Did the medication help the pain?				Yes	No	
4.34) What is the total cost you have you spent on treatment for your LBP?						
	Current Low Back Pain: (low back pain today)			Past Low Back Pain experienced:		
4.35) Please can you list those things that you would change in your work area in order to decrease the chances of you getting LBP:	1 2 3 4 5			1 2 3 4 5		

Appendix H

PILOT STUDY
LETTER OF INFORMATION

Dear participant: Thank you for your consideration to partake in this study. Your time and knowledge is much appreciated. All information regarding this study is provided below.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

Brief Introduction and Purpose of the Study: Occupational low back pain (LBP) has been described as a massive burden to both the industry and medicine. There are numerous factors affecting the development of low back pain. These include ergonomics and personal risk factors. This is commonly seen in occupations that require prolonged sitting periods characterised by sitting for more than half of the working time. This may be further complicated by concomitant exposure to physical factors such as whole body vibration (WBV) and/or awkward posture, which lead to the highest increase in risk for developing LBP. Most studies performed on occupational LPB does in fact not meet the required standards of the Bradford-Hill criteria which is a common criteria used in assessment of possible causal factors of LBP. As a result no conclusive evidence exists in terms of the exact cause of low back pain development.

Outline of the Procedures: You will be given this letter of information as well as a brief verbal description of the study. Upon agreeing and signing this document you will be required to complete a questionnaire. A rough estimate of 15 minutes is required to complete the questionnaire. It is expected of you to answer all questions truthfully to the best of your knowledge and raise any questions if complete understanding of a survey question is not understood. No follow-ups are required from you as this is a questionnaire survey.

Inclusion criteria for the pilot study:

- Two Pilots :
  - Pilots registered with SACAA.
  - Pilots over the age of 18 years will be included.
  - Pilots flying aircrafts defined as fixed wing.

Exclusion criteria for the pilot study:

- Anyone unwilling to sign the required documents for the pilot group, indicating that they are voluntarily participating.

Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time should you choose. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. There is no financial expense expected to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

Research-related Injury: The study is a questionnaire survey from which no injury or adverse reaction is expected. Participation is purely voluntary and withdrawal from the study is allowed at any time should you so wish.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

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

____________________ __________ ________ _______________

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

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix I

CONFIDENTIALITY STATEMENT – PILOT STUDY

IMPORTANT NOTICE:

THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE EXPERT GROUP, BEFORE THE EXPERT GROUP MEETING CONVENES.

DECLARATION

1. All information contained in the research documents and any information discussed during the expert group meeting will be kept private and confidential. This is especially binding to any information that may identify any of the participants in the research process.
2. The returned questionnaires will be coded and kept anonymous in the research process.
3. None of the information shall be communicated to any other individual or organization outside of this specific focus group as to the decisions of this focus group.
4. The information from this expert group will be made public in terms of a journal publication, which will in no way identify any participants of this research.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Please print in block letters:

Expert Group Member: ______________________________ Signature: ______________________

Witness Name: ______________________________ Signature: ______________________

Researcher's Name: ______________________________ Signature: ______________________

Supervisor's Name: ______________________________ Signature: ______________________

Appendix J: Pilot evaluation form

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Q1: What is your opinion of the subject matter raised in this questionnaire? (Please mark only 1)

Very interesting information and questions	
Interesting	
Average interest	
Lacks interest	
No interest at all	

Q2: In your opinion, do you think the topic raised in this questionnaire was adequately covered?

Yes
No

Q3: What is your opinion about the covering letter? (Please mark only 1)

Very clearly	
Clear	
Adequate	
Ambiguous	
Completely unclear	

Q4: Did you understand all the instructions before each question? (Please mark only 1)

Instructions were very clearly stated	
Instructions were sufficiently clear	
Adequate instructions	
Confusing instructions	
Instructions of no aid	

Q5: Do you think the questionnaire is too long?

Yes
No

Q6: in your opinion, how did you perceive the wording of the questions? (Please tick the appropriate box)

All the questions were clearly stated	
Most of the questions were clearly stated	
Chiropractic and medical terms too often confusing	
Questionnaire will not be understood by the lay person	
Revise questionnaire as it is completely confusing	

DUT DURBAN UNIVERSITY OF TECHNOLOGY

If you had any trouble answering or any problems with a question/s, please indicate the question number and state how this question can be revised.

Thank you for your time in assisting me with my research project. Your input is greatly appreciated.

Please be reminded that all information regarding the topic discussed is confidential.

Please place an “X” in the relevant box: FINAL QUESTIONNARE

Section A: Demographics

1.1) Age: (at last birthday)		1.2) Height: (meters)		1.3) Weight: (kg)	
1.4) Gender:	Male		Female		
1.5) Race:	Black	Colored	Indian	White	Other:
1.6) Marital Status:	Divorced	Married	Separated	Single	Other:

1.7) Number of dependants	1	2	3	4	5	More than 5
1.8) Highest level of education?	1.High School	2. Matriculated	3.Tertiary	4. Commercial license		5. Airline transport license(ATL)
	8. Other (Specify):					

Section B: Social History

2.1) How would you rate your health, at your last full medical?	Excellent	Good	Fair	Poor

2.2)Do you suffer with any condition in the following systems ↓ : Specify if answer yes

Cardiovascular system	Yes	No	
Neurological system	Yes	No	
Respiratory	Yes	No	
Musculoskeletal	Yes	No	
Endocrine	Yes	No	
Abdominal	Yes	No	
Urinary	Yes	No	
Haematological (Blood)	Yes	No	
Skin	Yes	No	
Immune	Yes	No	
Breast	Yes	No	

2.3) How would you rate your stress levels generally at work?	High	Moderate	Low	None
2.4) How would you rate your stress levels generally at home?	High	Moderate	Low	None
2.5) Have you ever been booked off work for stress?	Yes		No	

Smoking:	2.6.1) What is your smoking status?	Current smoker	Ex-smoker	Non- smoker
	2.6.2) If yes, for current smoker or ex-smoker how many cigarettes do you/ did you smoke? (No of packs p.d.)			
	2.6.3) If yes, for current smoker or ex-smoker. How many years have you, or did you smoke? (Yrs)			
Sleeping habits	2.7.1) On average, how many hours do you sleep within 24 hours?			
	2.7.2) Do you have a routine sleeping pattern?	Yes		No
	2.7.3) What is your predominant sleeping position?	On your side	On your back	On your stomach
	2.7.4) During your roster month, are you required to sleep away from home?	Yes	No	N/A
	2.7.5) If yes, how often in a working week do you sleep away from home? (Percentage)	%		
Exercise:	2.8.1) Do you exercise?	Yes		No
	2.8.2) Do you adhere to a regular exercise routine?	Yes		No
	2.8.3) If no, do you feel it's due to your demands of your job?	Yes		No

Exercise:	2.8.4) If yes, what exercise do you do? Indicate how many times per week?	Aerobics	Cardio gym	Cricket	Golf	Weight training	
		Running	Soccer	Swimming	Rugby	Pilates	Other
Travel	2.9.1) Besides your flying, do you spend more than 3 hours seated per day?	Yes	No				
	2.9.2) If yes, please indicate the type of seat and include average hours (e.g. car seat, x hours)	Seat type	1) Car seat	2) Office chair	3) Lounge chair	4)Massage chair	5) Other
		Hours seated					

Section C: Occupation:					
3.1) What is your current work status?	Captain (Short range)	Captain (Long range)	Co-Pilot (Short range)	Co-pilot(Long range)	Training Captain (Short range)	Training Captain (Long range)
	Instructor (Short range)	Instructor(Long range)	Single Pilot Operation	Multi crew Operation	Other	
3.2) How many years have you been in this occupation (Commercial pilot)?						
3.3) How long have you been working for this current company? (Yrs)						
3.4) Do you partake in any other flying roles outside of current occupation? Specify if Yes	Yes	No	Specify:			
3.5) Have you ever been a charted pilot?	Yes	No				

If yes to the above question, were you ever exposed to any of the following?	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	10.Forward positioned arms
3.6) Does your current occupation involve any of the following for majority of the day? (may indicate multiple options)	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	10.Forward positioned arms
3.7) Outside of work, are you exposed to any of the following.	1. Sitting for long periods	2.Lifting heavy objects	3.Turning your body (twisting)	4.Working at a computer	5.Working with your arms overhead
	6.Bending	7. Stress	8. Turbulence/ whole body vibration	9. Continuous pulling/ pushing	10.Forward positioned arms

3.8) If your job involves lifting of heavy objects, how much weight (kg) on average do you lift?	1-10kg	11-20kg	21-30kg	>31kg
3.9) If your job involves lifting of heavy objects, what is it you are lifting?				
3.10) On average, how many times a day do you repeat the lifting tasks required of you?	0-10times	11-20times	21-30times	Continuous
3.11) How many hours are you seated per day?	Hours			

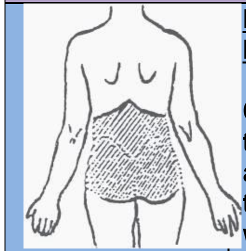
3.12) On average, how many hours do you sit in the cockpit during a duty period?	1-3 hours	3-5 hours	5-7 hours	7-9 hours	>9 hours
3.13) On average how many hours do you sit in the cockpit **weekly**?	5-15 hours	15-25 hours	25-35hours	35-45 hours	>45hours

3.14) Do you have medical aid?	Yes	No	3.21) Have you ever been pregnant?	Yes	No
3.15) Do you have comprehensive medical aid?	Yes	No	• If yes to above question please specify how many times:		
3.16) Have you had any surgery?	Yes	No	3.22) Did you experience any complications whilst being pregnant?	Yes	No
• If yes to above question please specify:			• If yes to above question please specify what complication and during which pregnancy:		
3.17) Have you had any trauma? (i.e. Falls, MVA, Fractures)	Yes	No			
• If yes to above question please specify:			3.23) Have you ever temporarily lost your pilot license due to a condition?	Yes	No
3.18) Have you had any emotional trauma? (i.e. Divorce)	Yes	No	• If yes to the above question please list condition/s and date		
• If yes to above question please specify:			1)		
3.19) Do you wear a back brace during flying roles?	Yes	No	2)		
• If yes to above question please specify:			3)		
3.20) Do you wear this back brace during non-flying roles	Yes	No	4)		
• If yes to above question please specify:			5)		

3.24) Please list every aircraft ever flown with, from training to current aircraft (i.e. 172 Cessna Skyhawk, Boeing 747-400)	Total time on aircraft logged (Hours)	Flight days per week	Years flying aircraft	Minimum distance for a single flight (hours)	Maximum distance for a single flight (hours)	Currently flying (answer with X)
1)						
2)						
3)						
4)						
5)						
6)						
7)						
8)						
Other (e.g. helicopter, small fixed wing) 1.						
2.						

3.25) Seat description in aircraft flown the most (More than one applicable)	Armrests present	Armrests absent	Armrest inclination present	Adjustable back inclination		Adjustable back inclination absent
	Seat height adjustable	Seat not height adjustable	Low back support	Non Low back support	Sheep skin cover (padded chair)	Unpadded chair
3.26) Cockpit characteristics (May indicate more than 1)	Side stick controller		Yoke controller			
3.27) Please indicate your daily experiences at work (no limit on options)	Comfortable sitting position	Uncomfortable sitting position	Vibration is minimal	Vibration is clearly felt		Landing impact softened through chair
	Pain felt with prolonged sitting	No pain felt with prolonged sitting	Regularly stretch during flight	Seldom stretch during flight		Landing impact clearly felt

Section: D - Characteristics of pain (LBP = Low back pain)



Low back pain history:

Questions 4.1 to 4.4 is applicable to this diagram with regards to shaded area

4.1) Have you ever had low back pain (LBP)?	Yes	No
4.2) At any time during the past 12 months, have you had LBP?	Yes	No
4.3) Did you have any LBP in the last week?	Yes	No
4.4) Do you have any LBP today?	Yes	No

The following questions apply to current and/ or past low back pain.

May fill in both if have low back pain today and in the past

	Current Low Back Pain Episode:		Past Low Back Pain experienced:	
4.5) How would you score your LBP? (0 being no pain, 10 being the worst pain)	0 1 2 3 4 5 6 7 8 9 10		0 1 2 3 4 5 6 7 8 9 10	
4.6) Describe the pain?	Catching pain	Dull ache	Catching pain	Dull ache
	No LBP	Poking	No LBP	Poking
	Sharp	Shooting	Sharp	Shooting
	Stiffness	Other (Specify):	Stiffness	Other (Specify):
	Stabbing		Stabbing	
4.7) Is the location of the LBP one side or both sides?	One side-left	One side -right	One side-left	One side –right
	Both sides	No LBP	Both sides	No LBP
4.8) Do you ever get the feeling of pins and needles in your legs when the LBP presents?	Yes	No	Yes	No
4.9) If indicated yes to the above question, did the sensation spread down your legs to below your knees?	Yes	No	Yes	No
4.10) Do you ever get a numb feeling in your legs and feet when the LBP is presents?	Yes	No	Yes	No
4.11) Is there any symptoms associated with the LBP? (i.e. Weakness, giving way) Please specify if yes.	Yes	No	Yes	No
	(Please specify)		(Please specify)	

The following questions apply to current and/ or past LBP.	**May fill in both if have low back pain today and in the past**									
	<u>Current Low Back Pain Episode:</u>					**<u>Past Low Back Pain experienced:</u>**				
4.12) Approximately how many days of LBP have you experienced currently and in the past year?								Have not had LBP in the past		
4.13) Is the LBP constant or intermittent?								Have not had LBP in the past		
4.14) Have you ever been absent from work due to your LBP?	Yes	No				Yes	No	Have not had LBP in the past		
• If "yes" how many days in total?										
4.15) I can only sit in my cockpit chair for "X" time before experiencing LBP ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.16) I can only sit in a car seat for "X" time before experiencing LBP ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.17) I can only sit in my favorite armchair for "X" time before experiencing LBP ….	10 mins	30 mins	60 mins			10 mins	30 mins	60 mins		
	180 mins	360 mins	As long as I like			180 mins	360 mins	As long as I like		
4.18) Did the LBP make it difficult to perform activities of daily living? (i.e. Tie your shoe laces/ put socks on)	Yes	No				Yes	No	Have not had LBP in the past		
4.19) Did the LBP affect your leisure activities?	Yes	No				Yes	No	Have not had LBP in the past		
4.20) Have you ever needed bed-rest for your LBP?	Yes	No				Yes	No			
4.21) How did your LBP begin?	Gradually over time	Suddenly	Not sure			Gradually over time	Suddenly	Have no LBP		
4.22) Do you have LBP only at work?	Yes	No	Have no LBP			Yes	No	Have no LBP		
4.23) Do you have LBP only at home?	Yes	No	Have no LBP			Yes	No	Have no LBP		
4.24) Does the LBP get better over duty free periods?	Yes	No	Have no LBP			Yes	No	Have no LBP		
4.25) Do you think your LBP is related to your work?	Yes	No				Yes	No			
4.26) Have you ever lost your job due to LBP?	Yes	No				Yes	No			
4.27) What do you think has caused or aggravates your LBP?	Bending	Twisting	Lifting heavy objects	Posture	Other: (Specify)	Bending	Twisting	Lifting heavy objects	Posture	Other: (Specify)
	Sitting	Standing	Overhead movements	Driving	Whole body vibration	Sitting	Standing	Overhead movements	Driving	Whole body vibration

The following questions apply to current and/ or past low back pain.	**Current Low Back Pain:** (low back pain today)			**Past Low Back Pain experienced:**		
	May fill in both if have low back pain today and in the past					
4.28) Have you ever experienced an IOD? (Injury on duty)	Yes	No		Yes	No	
4.29) Have you received treatment for the LBP?	Yes	No		Yes	No	
4.30) If "yes" to the previous question please specify what treatment (Multiple applicable)	Surgeon	Pharmacy	Traditional healer	Surgeon	Pharmacy	Traditional Healer
	Biokineticist	Physiotherapy	Homeopath	Biokineticist	Physiotherapy	Homeopath
	Clinic	Chiropractic	Other (Specify)	Clinic	Chiropractic	Other (Specify)
4.31) Did you take any medication for the LBP? (pain killers, muscle relaxants)				Yes	No	
4.32) If yes what medication did you take?				Pain killers	Anti-inflammatory	Rubs
				Patches	Traditional medicine	Don't know
4.33) Did the medication help the pain?				Yes	No	
4.34) What is the total cost you have you spent on treatment for your LBP?						
	Current Low Back Pain: (low back pain today)			**Past Low Back Pain experienced:**		
4.35) Please can you list those things that you would change in your work area in order to decrease the chances of you getting LBP:	1 2 3 4 5			1 2 3 4 5		

Appendix L

MAIN STUDY
LETTER OF INFORMATION

Dear participant: Thank you for your consideration to partake in this study. Your time and knowledge is much appreciated. All information regarding this study is provided below.

Title of the Research Study: An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Researcher: Berno Stander (B.Sc Genetics)

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic)

Brief Introduction and Purpose of the Study: Occupational low back pain (LBP) has been described as a massive burden to both the industry and medicine. There are numerous factors affecting the development of low back pain. These include ergonomics and personal risk factors. This is commonly seen in occupations that require prolonged sitting periods characterised by sitting for more than half of the working time. This may be further complicated by concomitant exposure to physical factors such as whole body vibration (WBV) and/or awkward posture, which lead to the highest increase in risk for developing LBP. Most studies performed on occupational LPB does in fact not meet the required standards of the Bradford-Hill criteria which is a common criteria used in assessment of possible causal factors of LBP. As a result no conclusive evidence exists in terms of the exact cause of low back pain development.

Outline of the Procedures: You will be given this letter of information as well as a brief verbal description of the study. Upon agreeing and signing this document you will be required to complete a questionnaire. A rough estimate of 15 minutes is required to complete the questionnaire. It is expected of you to answer all questions truthfully to the best of your knowledge and raise any questions if complete understanding of a survey question is not understood. No follow-ups are required from you as this is a questionnaire survey.

Inclusion criteria: - participants:

- Pilots registered with SACAA.
- Pilots over the age of 18years will be included.
- Pilots flying aircrafts defined as fixed wing.
- Short, medium and long haul pilots.
- The questionnaires will all be retained for data collection. Any missing data will be noted as such and recorded / analysed as such.

Exclusion criteria: - participants:

- Expert group participants.
- Commercial pilots at Virginia Airport.
- Any persons moonlighting for other travel companies

Risks or Discomforts to the Participant: Not applicable

Benefits: The expected outcome of the study is a comprehensive dissertation and a possible publication of the study. Positive finding of the hypothesis will be made available to the SACAA in the aim of educating pilots and carriers of commercial services, ultimately making changes to risk factors, including seating ergonomics, with the aid of Chiropractic knowledge.

Reason/s why the Participant May Be Withdrawn from the Study: Participation of the study is purely voluntary and withdrawal from the study is allowed at any time should you choose. Information provided may be withdrawn from the study if found that the inclusion/exclusion criteria were not met and/or information was not provided sufficiently to meet the required standard of a completed questionnaire.

Remuneration: Not applicable

Costs of the Study: The questionnaires provided will be funded by the researcher with the expected cost of the study calculated to be R9215.84. You will not undergo any financial expense to partake in the study.

Confidentiality: All data obtained from the survey will be kept confidential. The completed questionnaires will be placed in a sealed box on which no personal details will be placed as to ensure complete confidentiality. The completed questionnaires will be kept safe until all data has been captured after which it will be locked in the department of Chiropractic and Somatology. Access to the documents includes only the researcher and supervisor of the research.

Research-related Injury: The study is questionnaire survey from which no injury or adverse reaction is expected. Participation is purely voluntary and withdrawal from the study is allowed at any time if you so wish.

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

Supervisor: Dr Grant Matkovich (M.Tech Chiropractic) Tel: 031 201 8204

Researcher: Berno Stander (B.Sc Genetics) Tel: 031 303 7316

Institutional Research Ethics administrator Tel: 031 373 2900.

Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
CONSENT

Statement of Agreement to Participate in the Research Study:

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

____________________ __________ _________ __________________

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

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

_________________ __________ ___________________

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

Appendix M

CONFIDENTIALITY STATEMENT – MAIN STUDY

IMPORTANT NOTICE:

THIS FORM IS TO BE READ AND FILLED IN BY EVERY MEMBER PARTICIPATING IN THE RESEACRH STUDY, BEFORE THE STUDY CONVENES.

DECLARATION

1. All information contained in the research documents and any information discussed during the study will be kept private and confidential. This is especially binding to any information that may identify any of the participants in the research process.
2. The returned questionnaires will be coded and kept anonymous in the research process.
3. None of the information shall be communicated to any other individual or organization outside of this specific study as to the decisions of the expert group.
4. The information from this research study will be made public in terms of a journal publication, which will in no way identify any participants of this research.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Please print in block letters:

Research participant: ____________________________ Signature: ____________________

Witness Name: ____________________________ Signature: _____________________

Researcher's Name: ____________________________ Signature: ____________________

Supervisor's Name: ____________________________ Signature: _____________________

Appendix N

Post expert group correction:

ADDENDUM TO RESPONSE TO INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)

To: **The Institutional Research Ethics Committee (IREC)**

From: **Mr B J Stander**

Date: 17 March 2013

Title of Study:

An investigation into the prevalence and risk factors of occupational low back pain amongst commercial pilots registered with the South African Civil Aviation Authority.

Dear IREC,

Thank you for reviewing my proposal. I would like to bring your attention to the following changes that were requested by the Expert Group.

Pre-expert group questionnaire

Heading: Please indicate a cross to mark off your answer
Section A: Demographics
1.1) Age (in years)
1.5) Race: White, Coloured, Indian, Black, Other
1.6) Marital Status: Single, Married, Divorced/ Separated other
1.7) Number of children:
1.8) Highest level of education: No formal education, Primary school, High school, Matriculated, Tertiary, NQF, N2/N3,other(Specify)
Section B: Social History
2.1) How would you rate your health, at the moment?
2.2) How would you rate your stress levels generally?

Post Expert Group Changes

Heading: Please place an X in the relevant box to indicate your answer
Section A: Demographics
1.1) Age (at last birthday)
1.5) Race: To be placed alphabetical in columns
1.6) Break up Divorced and Separated to own box and place alphabetically
1.7) Number of dependants:
1.8) Highest level of education: Matriculated, Tertiary, Commercial Licence, Airline Transport License. Other (Specify)
Section B: Social History
2.1) How would you rate your health, at your last full medical?
2.3) How would you rate your stress levels generally at work
Insert follow up question: 2.4) How would you rate your stress generally at home?

2.3) Are you currently taking any medication for stress?
2.4.2) If yes for current smoker or ex-smoker how many cigarettes do you/ did you smoke
2.4.3) If yes for current smoker or ex-smoker how many years have you/ did you smoke?
2.5.1) On average how many hours do you sleep per night?
2.5.4) During your work week, are you required to sleep in hotels?
2.5.5) If yes, how often in a working week do you sleep in a hotel
2.6.4) If yes, what exercise do you do? Indicate how many times per week?
2.7.1) In addition to your flying, do you spend more than 3 hours seated per day?
2.7.3) If yes, please indicate the type of seat?
Section C: Occupation
3.1) What is your current work status?
3.2) How many months/ years have you been in this occupation (Commercial pilot)?
3.3) How long have you been working for this current company?
3.4) Does your occupation involve any of the following for the majority of the day (may indicate more than one)
3.8) How many hours are you seated per day
3.13) Do you suffer with any condition in the following systems: Specify if answer yes
3.14) Have you had any surgery? If yes to the above question please specify
3.15) Have you had any back surgery?
3.16) Have you had any trauma?
3.17) Have you had any back trauma?
3.18) Have you had any lower limb trauma?
3.19) No question 3.19 created
3.20) Do you wear anything that supports your back? (Back brace, taping)?
3.21) Have you ever been pregnant?
3.22) Please answer for each aircraft type (5 options given to select from), column 3 – duration-(total flying time per aircraft per day)
3.23) Seat description (More than one applicable)
3.24) Cockpit characteristics (May indicate more than 1)

2.5) Have you ever been booked of for stress? (Yes or no question)
2.6.2) Add brackets with Number of packs per day i.e. (No of packs p.d)
2.6.3) Add brackets with abbreviation of years i.e. (Yrs)
2.7.1) On average how many hours do you sleep within 24 hours
2.7.4) During your roster month, are you required to sleep away from home?
2.7.5) If yes, how often in a working week do you sleep away from home as a percentage?
2.8.2) Allow space for indicating the amount of training per week.
2.9.1) Besides your flying, do you spend more than 3 hours seated per day? (Include avg)
2.9.3) Combine **2.7.3 to 2.7.1** as a table
Section C: Occupation
3.1) Include instructor, single pilot- and multi crew operation. Use upper case throughout.
3.2) Remove months from sentence
3.4) Add: Do you partake in any other flying roles outside of current occupation? (Specify)
3.6) Two nr 9's to select, corrected to include nr 10. Add questions: **3.5)** Have you ever been a charted pilot before?**3.7)** Outside of work, are you exposed to any of the following?
3.11) Take out 5 options and allow own amount of hours
3.23) Have you ever lost your pilot license temporarily due to a condition? If yes please list and date.
3.16) Have you had any surgery? If yes to the above question please specify and date.
3.15) Remove question
3.17) Have you had any trauma (i.e.MVA, falls, fractures)
3.18) Have you had any emotional trauma? (i.e. divorce)
3.18) Remove question
3.19) Do you wear a back brace during flying?
3.20) Do you wear this back brace during non-flying roles?
3.21) Question expanded – how many times have you been pregnant. **3.22)**Was there any complication with any, if yes please specify
3.24) Remove option and allow for own examples to be written. Remove column 2 (Indicate which aircraft flown with), change column 3 (total time on aircraft (hours))
3.25) Seat description in aircraft flown the most (More than one applicable)
3.26) Remove all options. Only leave options- Side stick controller and yoke controller

3.25) Please indicate your daily experiences at work (No limit on options)
Section D – Characteristics of pain
Indicate questions 4.1 to 4.4 are related to diagram with regards to shaded are on figure
4.6) Describe the pain? (9 options given)
4.9) If indicated yes to the above question, did the pain spread down your legs to below your knees?
4.10) Do you ever get a numb feeling in your legs and feet when the low back pain present?
4.11) Any other signs and symptoms you experience when you have the low back pain (Associated changes)
4.13) How many hours does the low back pain last
4.14) Did the low back pain last more than a day?
4.17) I can sit in my airplane chair for "X" time before experiencing low back pain...
4.20) Did the low back pain make it difficult to tie your shoe laces or put socks on?
4.27) Does the low back pain get better over the weekends?
4.29) Have you ever lost your job due to low back pain?
4.30) What do you think is the cause of your low back pain?
4.31) Have you ever injured your low back at work?
4.32) Doe you feel your work activities aggravate the low back pain
4.33) Have you ever received treatment for the low back pain?
4.34) If yes to the previous question, please specify what treatment
4.35) Are you taking any medication for the low back pain? (pain killers, muscle relaxants)
4.36) If yes what medication are you taking?
4.37) Does the medication help the pain?
4.38) How much money have you spent on treatment for your low back pain?
4.39) In conclusion, please can you list those things that you would change in your work area in order to decrease the chances of you getting low back pain

3.27) Remove following option – Satisfied with cockpit setup and Unsatisfied with cockpit setup
Section D – Characteristics of pain
Indicate questions 4.1 to 4.4 are related to diagram with regards to shaded are on figure
4.6) Add specify in brackets for **o**ption stated as other i.e. Other (Specify)
4.9) If indicated yes to the above question, did the sensation spread down your legs to below your knees?
4.10) Do you ever get a numb feeling in your legs and feet when the low back pain **is** present?
4.11) Is there any sensory changes associate with the low back pain i.e. pins and needles, weakness.
4.13) Is the low back pain constant or intermittent.
4.14) Remove question
4.17) Remove question
4.18) Combine 4.20 and 4. 21: Did the low back pain affect your daily activities i.e. tie shoe laces, put shoes on
4.24) Does the low back pain get better during duty free periods?
4.26) Remove question
4.27) What do you think aggravates or has caused your low back pain?
4.28) Have you ever experienced an IOD (Injury on duty)
4.32) Remove question
4.29) Have you received treatment for the low back pain?
4.30) Replace public- and private hospital with surgeon, biokineticist, homeopath.
4.31) Question only applicable at past low back pain column. Remove Current column
4.32) Question only applicable at past low back pain column. Remove Current column
4.33) Did the medication help the pain?
4.34) Total cost you have spent on treatment for your low back pain?
4.35) Use abbreviation for low back pain throughout i.e. LBP

Please note that as some questions have been amended, removed or added the numbering has changed as to correspond with the numbering on the post-expert group questionnaire.