PILATES FOR POSTURAL STABILITY IN COMPUTER USERS

BY

LANA STRYDOM

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SUPERVISOR: DR. M L BAARD
CO-SUPERVISOR: MR. P E OLIVIER
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1.1 INTRODUCTION

The impact of computer use is evident in every day life (Harrington, Carter, Birrell and Gompertz, 2000:264). Lind (2002:18) explains that global trends continue to show that the most severe work-related health problems that exist amongst computer users are musculoskeletal disorders. As technology has lead to increases in automation, so it has lead to increases in work-related illnesses.

Although studies have explored the effects of ergonomics (Thibodeau, 1995:322) in static working positions there has been little evidence supporting a solution in overcoming poor occupational postures. Many health practitioners argue that occupationally caused, or aggravated, musculoskeletal disorders are steadily increasing. Thus, even though computers have improved productivity and made work easier for the population in general, they have adverse effects as well. Designing the proper tools or a setup of the work place is of prime importance for the elimination of chronic diseases attributed to sedentary lifestyles.
Regular physical activity had long been regarded as an important component of a healthy lifestyle. This notion has recently been reinforced by scientific evidence linking regular physical activity with a wide array of physical and mental health benefits, synonymous with an improvement in wellness (Pratt, Macera, and Wang, 2000:63). According to Pratt et al. (2000:63) higher direct medical costs associates with physical inactivity.

Further cross-sectional epidemiologic studies and controlled experimental investigations conducted by Okura, Nakata and Tanaka (2003:1131) had demonstrated that physically active adults, in contrast to their sedentary counterparts, tend to develop and maintain higher levels of physical fitness. These studies had not only demonstrated the positive results of physical activity, such as an improvement in blood lipid profile, body composition, glucose tolerance and insulin sensitivity, but had also shown that participation in such activity decreased the risk of developing several chronic hypokinetic diseases, including coronary heart disease (CHD), hypertension, non-insulin dependant diabetes mellitus (type II), osteoporosis, colon cancer, anxiety and depression. In addition, low levels of habitual physical activity and the subsequent low levels of physical fitness were associated with a marked increase in all-cause mortality rates. Okura et al. (2003:1131) confirm that effects of exercise intensity on physical fitness and risk factors for coronary Herat disease.

1.2. PROBLEM CLARIFICATION

The advancement of electronic technology and proliferation of computer use has resulted in a variety of work-related neck, lower back, hand, arm and wrist injuries in computer operators (Evans and Patterson, 2000:35). According to Deyo (1998:49) work disability related to back pain has risen steadily, despite economics being increasingly post-industrial with a reduction in manual labour.

Sedentary occupations lend themselves to computer use which is a constant risk factor for the development of lower back pain (Cartas, Nordin, Frankel, Malgady and Sheikhzadeh, 1993:603; Lengsfeld, Frank, van Deursen and Griss, 2000:665; Videman, Nurminen and Troup, 1990:728). According to Van Vuuren, van Heerden, Becker, Zinzen and Meeusen
lower back problems constitute one of the most challenging medical problems in industrial countries. Lower back pain affects 58 – 84% of all adults at some point in their life and place a significant burden on health services internationally (Goubert, Crombez, De Bourdeaudhuij, 2004:390).

A growing number of studies have also suggested that people with lower back pain may have deficits in postural coordination, such as deficits in the coordination of whole-body voluntary movements (Cacciatore, Horak and Henry, 2005:565). Poor seated posture is often exaggerated by poorly designed workstations that offer little movement for the employee to adjust or adapt him or herself. Occupational postures such as sitting at a desk and standing during lunch breaks have an effect on postural stability. Anderson and Ortengren cited in Kayis and Hoang (1999:255) stated that during sitting, the activity of the back muscles is similar to that during standing, but in supported sitting, as with the elbows resting on the knees, there is no activity in the lumbar back muscles. Following appropriate postural training (both static and dynamic), the patient or employee can take responsibility for the management of pain that results from chronic postural strain and many activities of daily living (Travell and Simmons, 1983:548).

The American College of Sport Medicine (ACSM) advised individuals to engage in aerobic activity for 20-60 minutes, three to five days a week with latest documented research Pate, Pratt, Blair, Haskell, Macera, Buchard, Buchner, Ettinger, Heath, King (1995:402). Prat et al. (1995:403) advising structured physical activity in adults to be performed for an accumulated 30 minutes or more of moderate-intensity physical activity on most, preferably all, days of the week. The same author went on to establish that although the earlier exercise recommendations were based on documented improvements in fitness, they provide most of the disease prevention benefits associated with an increase in physical activity. Majority of these benefits could be gained by performing moderate-intensity physical activities outside of formal conventional exercise programmes that has particular relevance to Pilates intervention.
Decline in flexibility has been associated with a decline in functional ability, therefore aiding to the advancement of hypokinetic disease states, such as chronic low back pain and debilitating associated wellness. Flexibility represents the ability to move a joint through its full range of motion (ROM) and is one of the key principles in the design of a Pilates programme. Dynamic stabilization according to Brukner and Khan (2007:158) refers to the ability to utilize strength and endurance in a functional manner throughout all planes of motion despite changes in the centre of gravity. This component has specific relevance to Pilates exercise programme design for postural awareness education. There is a lack of documented evidence pertaining to the efficacy of functional core strengthening exercises. Randomized controlled trials have been scarcely documented on the efficacy of core such strengthening programmes. Brukner and Khan (2007:1670) state that most studies have been prospective and of uncontrolled case series study design. According to Graf, Guggenbühl and Krueger (1998:81) back disorders and discomfort are major sources of lost work time and worker dissatisfaction.

Work place layout, working postures and working technique has so far been poorly researched. General conclusions have only recently started to influence ergonomics. Studies have focused on work-related lower back disorders which has resulted in work absence among the employed and found it to be common as well as expensive to alleviate. Financial costs, accrued due to reduced productivity, sick leave, work disability, and the use of medical services, related to hand, arm, shoulder, and neck injuries are considerable (Ijmker, Blatter, Van der Beek, Van Mechelen and Bongers, 2006:214). According to Wynne-Jones, Dunn and Main (2006:1) the cost of lower back pain to employers is high, with an estimated £9090 million lost in the United Kingdom in 1998. Researchers, such as Johanning (2000:94); Pope, Goh and Magnusson, (2002:50); Zinzen (2002:41) and Deyo (1998:49), focus on lower back pain and work-related poor postural awareness and control.

Physical exercise has the potential to reduce work-related musculoskeletal stress, both immediately and over a long-term period. Accumulating evidence indicates that physical activity and structured exercise help maintain an independent life by maintaining postural
stability, strength, endurance, bone density and functional ability (Skelton, 2001:33). Physical exercise programmes have been adopted and used successfully in many oriental countries such as China, Japan and Korea (Ylinen, Takala, Nykanen, Hakkinen, Malkia, Pohjolainen, Karppi, Kautiainen and Airaksinen, 2003:2509; Tsauo, Lee, Hsu, Chen and Chen, 2004:254; Takala, Viikari-Juntura and Tynkkynen, 1994:17).

Research has shown that Pilates-based exercise improves torso- or core strength and offers other benefits including spinal and joint mobility, proprioception, balance, and coordination. Cassity (2004:86) reiterates that the use of Pilates as a method of training could enhance biomechanical functioning of the body, balance, co-ordination, postural and spatial awareness, strength and flexibility. Pilates-based exercise is increasing in popularity as a general and clinical exercise training technique. Although Pilates has been practiced for almost a decade, there is a limited amount of sound research on Pilates being used as an intervention method to combat musculoskeletal disorders. Many health care professionals are only recently starting to refer patients to certified Pilates instructors for specialized exercise programmes to address postural awareness and education, as well as rehabilitation purposes.

For the purpose of this study the Biodex Stability System (950-304) was used to measure the postural stability of the participants. The Biodex Stability System challenges a participants’ balance while standing on a movable platform that tilts to a maximum of 20 degrees in different directions. According to The Biodex Service/Operation Manual (2000:1-2) using this unique device, clinicians can assess neuromuscular control by quantifying the ability to maintain dynamic bilateral and unilateral postural stability on a static or unstable surface. The system uses a mechanical system which ranges from level one to level eight, one representing the greatest instability. The Biodex Stability System was shown to be reliable in studies (Hinman, 2000:249 and Aydoğan, Aydoğan, Cakci and Doral, 2006:1).
1.3. PROBLEM STATEMENT

In this study computer users were selected due to the fact that there has been a high incidence of employees and employers who experience discomfort when sitting for prolonged periods of time. Any prolonged posture will lead to static loading of the soft tissues and cause discomfort (Pope et al. 2002:49) Pilates can be used to improve muscular symmetry and in turn aid in the adjustment of musculature imbalances while seated for extended amounts of time. Learning to use the body correctly and working in alignment helps to achieve greater muscular symmetry because postural imbalances are rectified (Kimberly and Katherine Corp, 2002:2).

Given the widespread use of computers, it may be more appropriate now than ever before to consider specific exercises that could be performed at home or at the workstation to relieve musculoskeletal discomfort resulting from sedentary work.

1.4. AIM OF THE STUDY

The purpose of this study was to determine the impact of a Pilates training programme on the postural stability of sedentary adult computer users in the workplace.

1.5. OBJECTIVES OF THE STUDY

In order to address the aim of the study the following objectives prior to and after the eight week Pilates intervention programme, were set and explored; to assess and describe the overall postural indexes, to assess and describe the anterior-posterior postural indexes, to assess and describe the medial-lateral postural indexes.
1.6. METHODOLOGY

This study employed an exploratory, descriptive quasi-experimental approach which uses quantitative data collected through a pre- and posttest statistical analysis completed by computer users in the Nelson Mandela Metropole. The computer users were selected using non-probability convenience sampling. Volunteers were obtained by means of convenience- and snowball sampling in which participants already involved in the study found other participants relevant to the study. The sample included male and female computer users; the age range of the participants was 25 to 59- years. The reason for choosing a wide sample of age ranges was that Pilates can be applied to and benefits can be derived from any age.

An inclusion criterion was that the participants must have been sedentary and been using a computer for at least three years. Mahler, Froelicher, Miller & York (1995:18) cited in Whaley, Armstrong, Brubaker and Otto (2005) clarify that a sedentary lifestyle or physical inactive identified person is one who does not participate in 30 minutes of continuous or intermittent physical activity for a minimum of three days a week.

1.7. LIMITATIONS OF THE STUDY

The first limitation of this study was the small sample size. Teaching Pilates exercises to a large group would have negatively affected the reliability of the study. Due to the complex nature of Pilates’ exercises it is extremely important for the instructor to provide individual attention at all times during the one hour class.

It was not possible to include intermediate or advanced exercises from the Pilates repertoire, which could have influenced the results, as the variety of somatotypes of the participants prohibited progression from a beginner level to a higher level of performance. Due to the diverse nature of computer users in the Nelson Mandela Metropole and the volunteer dependency of the sample, it was not possible to select a more homogenous age range for the participants. The wide range in variance could have diluted the significance of the results obtained.
1.8. **SUMMARY**

The study explored the proposition that sedentary computer users in the workplace could prevent debilitating musculoskeletal problems due to poor working postures by participation in a regular mat-based Pilates intervention programme.

For the purpose of this treatise, literature pertaining to ergonomics and work-related injuries, postural stability and the Pilates method as intervention strategy to train postural stability, will form the core body of evidence as the study furthermore unfolds.
CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Computers and visual display terminals are frequently used by sales personnel, managers, engineers and technical workers. Use of computers and video display terminals in workplaces has increased dramatically during the last two decades (Waikar and Bradshaw, 1995:16). The Occupational Safety and Health Administration, cited in Waikar and Bradshaw (1995:16), confirmed that presently there may be as many as 80 million visual display terminals in the workplace.

In many countries, the widespread use of computers has led to considerable media attention concerning potential adverse health effects (Ijmker et al. 2006:212). The advancement of electronic technology and the proliferation of computer use have resulted in a variety of work-related neck, lower back, hand, arm and wrist injuries in computer operators (Evans and
Patterson, 2000:35). Sudol-Szopińska (2006:263) states that the dynamic growth of new workplaces associated with the introduction of modern technologies has increased the frequency of many health problems over the recent years. Technology has rapidly and profoundly changed the manner in which office work is done and the work settings needed to support it. According to Kaplan and Aronoff (1996:6) technology has also highlighted how the office environment affects occupants’ health and productivity. The phenomenon has raised public consciousness about ergonomics and the study of how humans interact with their physical work environment. Health problems, such as carpal tunnel syndrome, cumulative trauma disorders, and repetitive strain injuries; caused by inadequate design of the workplace environment has decreased originally anticipated levels of office productivity (Attaran and Wargo, 1999:92).

In this technological age the impact of computer use is evident in every day life (Harrington et al. 2000:264). In addition, the financial costs, accrued due to reduced productivity, sick leave, work disability, and the use of medical services, related to hand, arm, shoulder, and neck are considerable (Ijmker et al. 2006:214). According to Budnick, cited in Lucas (2007:2), Verizon, a leading call centre in the United States of America, purchased ergonomic workplace plans in pursuit of controlling absenteeism and turnover. According to Croasmum (2004:1) everything from new tools and equipment to modified schedules are being implemented to keep the rising absenteeism rates at bay in a countries long known for its rigorous work ethic.

The proliferating use of computers in the workplace, to substitute to manual tasks, results in jobs becoming progressively more sedentary. Attaran and Wargo (1990:92) confirm that employees are moving around less as they work. Holding the upper body still in an upright position requires a lot of muscular effort and contributes to what is called a static load. Any prolonged posture will lead to static loading of the soft tissues and cause discomfort (Pope et al. 2002:49). Static working positions and poor postures are both associated with the development of musculoskeletal disorders and discomfort (Graf et al. 1998:81). A study conducted by Marcus, Gerr, Monteilh, Oritz, Gentry, Cohen, Edwards, Ensor and Kleinbaum (2002:236) emphasized that the risk of musculoskeletal pain may be reduced by encouraging specific seated postures. As far as the lumbar spine is concerned, a good posture is one in
which the spine is towards the mid-point of its range of movement and the trunk is unconstrained (i.e. free to move anteriorly and posteriorly), (Karwowski, 2006:469). Selby and Triano (2006:1) confirm that posture is important for sitting in office chairs and at a workstation. The same authors explain that by adopting a user-friendly workstation, which includes proper adjustments of the office chair, computer and desk positioning, functional postures will be prevalent. According to Fujimaki and Mitsuya (2002:17) the advantages of the reclining posture result in reduced seat pan pressure, prolonged sitting posture that can be maintained over time, and reduced fatigue of the upper body.

Pilates can be used to improve muscular symmetry and in turn aid in the adjustment of musculature imbalances while sitting for extended amounts of time. Learning to use the body correctly and working in alignment helps to achieve greater muscular symmetry because your imbalances are rectified (Kimberly and Katherine Corp, 2002:2). Named after its creator, Joseph Pilates, Pilates is a method of exercise that focuses on strengthening the core, which consists of the abdominal and back musculature of the body. According to Giusti (2003:1) Pilates aims to improve flexibility and strength through mat and machine exercises that involve a series of stretches and controlled movements. It is purported to improve postural awareness with a large focus on facilitating movement and re-education, however, there is limited research to support this (Kaesler, Mellifont, Swete Kelly and Taaffe, 2007:1).

Considered one of the fastest growing forms of exercise in the world Joseph Pilates believed his method could improve posture and alignment, while improving strength without bulking (Crews, 2006:58). Pilates-inspired exercise is increasing in popularity as a general and clinical exercise training technique (Kaesler et al, 2007:1). Solie (2007:19) confirms that Pilates is a method of mind-body conditioning that improves body awareness, posture and flexibility. Assuming a bent over posture at your desk for prolonged amounts of time will inevitably affect our posture. Being seated for most of the day places great stress on musculoskeletal structures, particularly the spine, and habitual problems with posture occur because of the constant load on deep supporting muscles (Solie, 2007:19).

Kryzanowska, cited in Davis (2007:103), described Pilates as being a way of life. The use of Joseph Pilates’ principles in life will influence the posture you assume when sitting or walking.
(Davis, 2007:103). Grimes, cited in Davis (2007:103), confirmed that all Pilates exercises, as strange as they may seem, are based on everyday movement.

The following chapters will describe and further explain the relationships between the role of ergonomics, lower back pain, postural difficulties, postural stability and lastly how the Pilates method can possibly play a role in the augmentation, resolution and improvement of these issues.

2.2. ERGONOMICS AND WORK-RELATED INJURIES

In the 21st century individuals spend many hours working on PCs, laptops, and telephones creating the risk for the development of musculoskeletal disorders (Lind, 2002:18). Thibodeau, (1995:322) confirmed that “Desk Jockeys” suffer from aching backs, stiff necks, and poor posture. He continues to illustrate that health care costs of ergonomic injuries are a growing concern to employers. Thibodeau (1995:322) believed that the human body is not designed to be immobile or to perform repetitive movements for hours on end. According to Waikar and Bradshaw (1995:16) working with computers and/or visual display terminals constitutes as sedentary work. This type of work lends itself to constrained postures which impart static loads on the neck, back, shoulders and upper extremities (Waikar and Bradshaw, 1995:16). Sjogaard (1990:1) states that because there is insufficient research on poor posture in the workplace, the result will manifest in the form of a syndrome of pain and injuries.

Literature identifies several disorders as a result of chronic occupational computer usage to indicate symptoms in the neck, shoulders, arms, hands or wrists. Gerr, Marcus & Monteilh (2004:1) report that computer users are at increased risk of upper extremity musculoskeletal disorders. According to the same authors early studies often found elevated rates of musculoskeletal disorders among keyboard users when compared to non-users.

Jonai, Villanueva, Takata, Sotoyama and Saito (2001:219) indicate that not only is there an increase in workload, but also increased pressure to meet deadlines in a technological
market. This could lead to employees spending greater amounts of time engaged in computer usage. Constrained posture and higher neck muscle activities have been reported among users of notebook computers. Cole, Ibrahim, and Shannon (2005:1233) conclude that performing biomechanical/physical tasks, such as organizing the workstation and psychosocial stressors at work are among the causes of work-related cumulative trauma disorders and repetitive strain injury.

According to the Bernard (1997:10) of the National Institute of Occupational Safety and Health (NIOSH) in the United States of America links between computer use and a number of symptoms, including pain in the hand, wrist, arm, neck, shoulders and lower back as well as eye strain and headache, are well established. Delleman and Dul (2002:341) states that injuries of this nature should be viewed as a potential source of strain on health services, morbidity, disability and decreased earnings. Furthermore work-related musculoskeletal complaints and disorders are a major cause of sick leave and disability (Delleman and Dul, 2002:341).

Sudol-Szopińska (2006:263) states that prolonged sitting may lead to numerous general complications such as fatigue or discomfort, but also more specifically diseases of the musculoskeletal system (the spine and upper limbs), deep vein thrombosis, as well as obesity and its health-related consequences. Physical risk factors, such as prolonged sitting and neck flexion have been identified as predictive of neck pain in the study of a mixed population of workers from various industries, health and professional settings (Ariëns, Bongers, Hoogendoorn, Houtman, Van Der Wal and Van Mechelen, 2001:1896). According to Hush, Maher and Refshauge (2006:81) these and other physical factors, such as posture and neck muscle endurance have not been prospectively investigated specifically in office workers.

Global trends show that the most severe work-related health problems that exist amongst computer users are musculoskeletal disorders (Lind, 2002:18). Hadler, cited in Gangopadhyay, Bharadwaj, Das and Ghoshal (2005:2), concurs that musculoskeletal disorders are the most common self-reported work related illness. There is a profound increase of risk factors involving long-time computer usage, as documented by Bishu,
Hallbeck, Riley and Stenz (1991:90). The same authors conclude that sitting for prolonged periods of time, performing repetitive motions and assuming poor postures will result in musculoskeletal disorders. Hadler, cited in Gangopadhyay et al. (2005:2), explains further that these reported work-related injuries generally cause excess stress on muscles, ligaments, tendons, nerves and blood vessels as a result from prolonged sitting.

As technology has lead to increases in automation, so it has lead too increases in work-related illnesses. This is evident by the tremendous rise in cumulative trauma disorders; the fastest growing category of workplace trauma (Rowan and Wright, 1994:7). Graf et al. (1998:81) propose that static working positions and poor postures are both associated with musculoskeletal-disorders and discomfort. Rowan and Wright (1994:7) noted that cumulative trauma disorders, which are musculoskeletal and nervous system injuries, result from repeated exposure to micro-traumas rather than a single traumatic event.

Travers (1992:129) defines cumulative trauma disorders as a class of musculoskeletal disorders of tendons, tendon sheaths, muscles, and related nerves and bones of the hands, wrists, elbows, shoulders, neck, and back that are caused or aggravated by repeated exertions and movements of the body. Sauter, Schleifer, Knutson (991:151), identified risk factors associated with cumulative trauma disorder as, repetition of motion, extremes in joint position, prolonged constrained posture, mechanical pressure points, and vibration. Grant and Brophy (1994:1) specifically mention the impact of certain prolonged, non-neutral positions of the joints that might stretch, compress, or otherwise stress tendons, nerves, or other soft tissue, on the incidence of cumulative trauma disorders in the office. Thibodeau (1995:322) identified the following factors that contribute to cumulative trauma disorders in the office, namely, repetitive work without adequate recovery time; sustained static exertions-prolonged holding of a single posture; forceful exertions, use of excessive strength during any activity; localized contact stresses and pressures on the soft tissues caused by external surfaces (e.g., constant rubbing against a desk edge). Chronic musculoskeletal disorders, associated with repetitive work, are also of increasing concern to industry, employees, workers' compensation insurance carriers, and regulatory agencies (Sjogaard, 1990:1).
According to Carcone and Keir (2006:755) while comfort is an important criterion to the user, there has been little research to relate comfort to biomechanical variables, such as pressure or lower back posture in office seating. Incorrect lumbar spine posture during sitting has been linked to lower back pain (Dolan, Adams and Hutton, 1988:197; Wilder and Pope, 1996:61). However, posture measurements when seated typically require alterations of the backrest and use of cumbersome equipment, both of which are likely to alter natural behavior and sitting posture of the user (Bendix, Poulsen, Klausen and Jensen, 1996:533).

Research on upper limb disorders in adults has shown that functional impairment, pain and discomfort in upper limbs, neck and shoulder increases with frequency and duration of exposure to computer use (Bernard, 1997:1; Evans and Patterson, 2000:35). Lucas (2007:2) describes how desk jobs cause neck and shoulder problems, which could eventually leading to arm and wrist problems. Neck and upper limb symptoms are frequently reported by computer workers (Bernaards, Ariëns and Hildebrandt, 2006:80). Punnett and Bergqvist (1997:2) cautions management to take heed of the increasing financial impact of injuries caused by extended computer usage. Without comfortable workstations employees are forced to continue repetitive movements which eventually lead to upper limb pain and injury.

The available epidemiological evidence suggested that hand, arm, shoulder and neck symptoms are associated with the duration of computer use and, in fact, increase steadily with each hour of computer use per day (Punnett and Bergqvist, 1997:2). It should be noted that previous studies by Homan and Armstrong (2003:48), Heinrich, Blatter and Bongers (2004:1027), Douwes, Blatter and de Kraker (2004:113) and Lassen, Mikkelsen, Kryger and Andersen (2005:122) relied on self reports for the measurement of the duration of computer use. The same authors however explained that the use of self-reports may lead to overestimation of the duration of computer use, which might result in misclassification.

A systematic review of available literature indicate that these associations are evident internationally and across studies in spite of variations in study design, case definition and terminology which pose barriers to direct comparisons between data sets (Harrington et al. 2000:264). Computer screen glare, posture and workspace suitability have all been
associated with headaches and other symptoms (Alexander and Currie, 2004:256). Neck and shoulder pain has been associated with time spent computing, postural deviations and muscle loading (Bernard, 1997). According to Paoli and Merllié (2000:1) over 50 million European workers reported using the computer at least half of their working hours. Recent large-scale surveys showed one-year prevalences of hand, arm, shoulder and neck symptoms ranging from 24 to 44% among office workers (Juul-Kristensen, Sogaard, Stroyer, and Jensen, 2004:390; Jensen, 2003:197; Lassen, Mikkelson, Kryger, Brandt, Overgaard, Thomsen, Vilstrup and Anderson, 2004:521).

The need clearly exists for executives to explore ergonomic risk factors and to address the key areas which continuously result in a poor working posture.

2.3. LOWER-BACK PAIN

Over the past century, there has been an increase in the proportion of seated occupations (van Dieen, de Looze and Hermans, 2001:739). These jobs, although generally less physically demanding, are a risk factor for the development of lower back pain (Cartas et al. 1993:603; Lengsfeld et al. 2000:665; Videman et al. 1990:728). Individuals tend to adopt passive or slumped postures when seated for a prolonged duration (Andersson, Ortengren, Nachemson, Elfstrom and Broma, 1975:105; Adams, Hutton and Stott, 1980:245; Adams and Hutton, 1985:625; Hedman and Fernie, 1997:734). The same authors concluded that prolonged sitting may lead to lower back pain due to deactivation of the erector spinae muscles, thus relying on spinal ligament support, which may lead to injury over time.

Johanning (2000:94) confirms that lower back pain and disability are among the leading causes of occupational injury in industrialized countries. Pope et al. (2002:50) concur that occupational lower back pain is an immense burden for both industry and health care systems. Moreover, lower back pain represents the most common cause of disability in persons under 45 years of age which encompasses a major component of the work force (Bigos et al.1994:0642).
According to Van Vuuren et al. (1991:2) lower back problems constitute one of the most challenging medical problems in industrial countries. The same authors confirmed a high prevalence and cost implication linked to chronic work-related spinal disorders. It is further commonly accepted that 50–80% of the population suffers from idiopathic lower back pain at least once in their lifetime (Zinzen, 2002:41). The role of pain-related fear and its associated avoidance behaviour in the development of chronic musculoskeletal pain has received increased attention (Asmundson, Norton and Norton, 1999:97; Al Obaidi, Nelson, Al Awadhi and Al Shuwaie, 2000:1126; Vlaeyen and Linton, 2000:317 and Swinkels-Meewisse, Roelofs, Verbeek, Oostendorp and Vlaeyen, 2003:371). Although heavy manual labour as an occupational trend has decreased, the prevalence of lower back pain has increased. According to Deyo (1998:49) work disability related to back pain has risen steadily, despite economics being increasingly post-industrial with a reduction in manual labour.

Seventy percent of spinal disorders, involving the lumbar spine, are treated by physiotherapists (Spitzer 1987:51). Occupational exposure to fixed postures and prolonged sitting has become a risk factor to both employee and employer. Pope et al., (2002:56) confirms that there is an increase in symptoms in those with lower back pain who sit for prolonged periods. According to Graf et al. (1998:81) back disorders and discomfort are major sources of lost work time and worker dissatisfaction.

Workers who undergo periods of static or cyclic trunk flexion have an increased risk of lower back pain (Marras, Lavender and Leurgans, 1993:617; Punnet, Fine, Keyserling, Herrin and Chaffin, 1991:337). Biomechanical factors contributing to this risk may include excessive or cumulative spinal loading (Kerr, Frank, Harry, Norman, Wells,, Neumann and Claire, 2001:1069), ligament and disc strain (Dolan, Earley and Adams 1994:1237), and spinal instability (Omino and Hayashi, 1992:693). Active muscular recruitment and reflexes play a major role in both spinal and ligamentous load as well as spinal stability (Gardner-Morse and Stokes, 1998:86; Granata and Marras, 1995:1309).According to Snijders, Hermans, Niesing, Jan Kleinrensink and Pool-Goudzwaard (2007:2) lower back pain is often attributed to intolerable high intradiscal pressure as a result of long-term sitting.
Poor posture can be a cause of back pain and therefore it should be corrected to prevent constant discomfort (Neumark, 1998:D8). Ose (2005:161) substantiates this claim by stating that poor posture can often be the result of high degrees of monotonous work and/or frequent heavy lifting. A growing number of studies have suggested that people with lower back pain may have deficits in postural coordination, such as deficits in the coordination of whole-body voluntary movements (Cacciatore et al. 2005:565).

In particular, anticipatory postural adjustments, which precede voluntary movements to stabilize the body in advance, are abnormally coordinated in people with lower back pain (Hodges and Richardson 1996, 1998 & 1999). People suffering from lower back pain also have deficits in standing and seated balance compared too people without lower back pain and may have deficits in automatic postural coordination (Byl and Sinnott, 1991:328; Meintjies and Frank, 1999:710; Alexander and La Pier, 1998:378; Radebold, Cholewicki, Polzhofer and Greene, 2001:724).

Economic analysis of work-related lower back disorders has focused on work absence among the employed and found it to be common as well as expensive to alleviate (Wynne-Jones et al. 2007:1). According to the same authors the cost of lower back pain to employers is high, with an estimated £9090 million lost in the United Kingdom in 1998. Lower back pain affects 58 to 84% of all adults at some point in their life place a significant burden on health services internationally (Goubert et al. 2004:390).

A major point of concern according to van Vuuren, van Heerden, Becker, Zinzen and Meeusen (2007:2) is that although literature on the epidemiology of lower back pain is accumulating, for the most part studies are restricted to high-income countries, which comprise less than 15% of the world's population. Volinn (1997:1747) agrees that very little is known about the epidemiology of lower back pain in the rest of the world.

Considered from medical, social or economic perspectives, the cost of musculoskeletal injuries experienced in the workplace is substantial, and there is a need to identify the most efficacious interventions for their effective prevention, management and rehabilitation (Boocock, McNair, Larmer, Armstrong, Collier, Simmonds and Garrett 2006:291).
2.4. POSTURE

According to Loots (2004:2) good posture represents the state of balance in an individual at rest and during motion. Ideal posture involves a minimal amount of stress which is conducive to maximal efficiency in the use of the body (Montgomery and Connolly, 2003:186). According to Montgomery and Connolly (2003:186) ideal posture is one that requires minimal muscular activity to maintain and allows for maximum movement efficiency. Posture is also a reflection of the “position” of many systems that are regulated, determined and created through limited functional patterns (Hruska, 2002:1).

There have been many previous attempts in literature to evaluate computer users’ posture, however, only a few have focused on evaluating a physical programme used as an intervention to improve postural control (Emmons and Wilkinson, 2001:77-87; Pope et al. 2002:49-68; Jonai et al. 2001:219-229; Lucas, 2007:1-7). As mentioned before the slumped posture is typical of a computer user. The upper cross posture syndrome, affecting the head, neck and shoulders, is the source of computer user’s complaint of chronic neck and shoulder tightness and pain (Cipriano, 2003:26).

The centre of gravity is a fundamental orientation that must be defined to facilitate analyzing movements (Hyde, 2002:46). Hyde (2002:46) describes the centre of gravity as the point where the body balances on both sides as well as in all planes without the tendency to rotate, fluctuate or fold. To maintain upright stance, the central and peripheral components of the nervous system are constantly interacting to control body alignment and the centre of gravity over the base of support (Alexander and La Pier, 1998:378).

To maintain erect posture and balance, the lumbar erector spinae muscles compensate and extend the spine, resulting in hypertonicity of the lumbar erector spinae and adapting weakening of the opposing abdominal muscles (Cipriano, 2003:27). According to Thompson and Hunt (1984:1) static stability is achieved when the posture of the spine is in equilibrium and also in a state of minimum energy expenditure. Herrington and Davies (2003:52) confirm that the neuromuscular system acts to maintain postural stability and reduce the impact of deleterious loads on the spine.
Muscle recruitment, spinal posture, and external load contribute to the energy expenditure of the musculoskeletal system (Bergmark, 1989:1; Gardner-Morse, Stokes and Laible, 1995:802; Granata and Wilson, 2001:650).

Skelton (2001:34) defined balance as a complex automatic integration of several body systems. According to Cote, Brunet, Gansneder and Shultz (2005:42) peripheral components in balance include the somatosensory, visual, and vestibular systems. The postural control system’s aim is to coordinate and maintain the stability of the multiple degrees of freedom of the body (Chiari and Cappello, 2005:271). According to the same authors this system includes several interacting components, namely the skeletal, muscular, neural and sensory systems. Van Daele, Huyvaert, Hagman, Duquet, van Gheluwe and Vaes (2007:44) confirm that integrated information from these three independent sensory sources is used to maintain postural stability. The reciprocal integration of these sensory systems will be discussed in the next section on postural stability.

2.5. POSTURAL STABILITY

The task of postural control involves controlling the body’s position in space for stability (defined as controlling the centre of body mass relative to the base of support) and orientation (defined as the ability to maintain an appropriate relationship between body segments) and between the body and the environment for a task (Shumway-Cook and Woollacott, 2006:184).

Occupational postures such as sitting at a desk and standing during lunch breaks have an effect on postural stability. Andersson and Ortengren cited in Kayis and Hoang (1999:255) stated that during sitting, the activity of the back muscles is similar to that during standing, but in supported sitting, as with the elbows resting on the knees, there is no activity in the lumbar back muscles. With arms resting on a desk, back muscle activity is substantially decreased (Andersson and Ortengren cited in Kayis and Hoang (1999:255). In the seated individual, the “slumped” posture, or fatigued position, is characterized by a flattened lumbar spine (loss of normal lordosis), an increased kyphosis of the thoracic spine, protracted scapulae, and
usually by a flattened cervical spine with the head forward (Travell and Simons, 1983:548). Furthermore Travell and Simons (1983:548) emphasize that this type of posture leads to multiple muscle and joint problems in the trunk, upper limbs, neck, and head, as well as limited respiratory function.

With high work demands placed on workers, the inclination is to pay less attention to postural stability. Since normal postural stability occurs automatically, without conscious effort, it was assumed that further muscular recruitment was needed to control balance (Shumway-Cook and Woollacott, 2006:184). The same authors however proved that there are significant requirements for postural stability, and that these requirements vary depending on the postural task, on the age of the individual, and on the individual’s balance abilities. Some of these requirements include body alignment (which minimizes the effect of gravitational forces), muscle tone, and postural tone (which keeps the body from collapsing in response to the pull of gravity (Shumway-Cook and Woollacott, 2006:185).

Branton, cited in Hendriks, Spoor, de Jong and Goossens (2006:1611) hypothesized that there is continual need for postural stability while sitting. According to Carcone and Keir (2006:755) while comfort is an important criterion to the user, there has been little research to relate comfort to biomechanical variables, such as pressure or lower back posture in office seating. The maintenance of postural stability in the seated position has not been studied in depth (Shumway-Cook and Woollacott, 2006:186). The same authors confirm that concepts important for standing postural stability will be shown to be equally valid for postural stability during sitting.

Poor seated posture is often exaggerated by poorly designed workstations that offer little movement for the employee to adjust or adapt him or herself. Also, poor body posture and inadequate seat support have been described as co-factors in the pathogenesis of musculoskeletal disorders of the spine (Burdorf, Derksen, Naaktgeboren, van Riel, 1992:263). Ostrom (1981), cited in Waikar and Bradshaw (1995:18), pointed out that “dynamic sitting”, implying a change in posture every five minutes, is important for comfort and promoting good
circulation. Travell and Simons (1983:548) confirms that frequent changes of position are needed to promote health of the muscles and intervertebral discs.

According to Loots (2004:1) postural training in general could therefore be beneficial for both body and mind, and an appreciation of good posture and its resulting efficiency represents the best kind of preventative medicine. The results of Adkin, Carpenter and Frank (2003:2) provide converging evidence in identifying balance as a key modulator of postural control. With this in mind, Salavati, Moghadam, Ebrahimi and Arab (2006:1) affirm that the maintenance of balance is an essential requirement for the performance of daily tasks and sporting activities. In order to maintain postural control, humans continuously use information from somatosensory, visual and vestibular sources, resulting in efferent signals that activate appropriate postural muscles (Gustafson, Noaksson, Kronhed, Moller and Moller 2000:168-172). It is well known that the central nervous system (CNS) preserves stability of the body by generating postural adjustments simultaneously with or just prior to the initiation of voluntary movement (Massion 1992:35). Shumway-Cook and Woollacott (2006:185) confirm that each sense (visual, somatosensory and vestibular systems) provides the CNS with a different kind of information about position and motion of the body thus; each sense provides a different frame of reference for postural stability.

Toussaint, Michies, Faber, Commissaris & van Dieen (1998:85) conclude that the magnitude and timing of these postural adjustments is critical and depends on the physical demands associated with the movement as well as the behavioural context in which the movement is performed. According to Horak & Macpherson (1996:255) postural adjustments, based on the integration of a rich source of sensory information, are matched to the parameters associated with the task and are modified by the context in which the task is performed.

Salavati et al. (2006:1) states that several studies have examined how pathologic conditions, aging and fatigue affect postural stability. The same author emphasizes that muscular fatigue impairs proprioception and postural stability. Neck, mid-back and especially lower back pain often result from an unbalanced posture. As a result of these unbalanced activities, the most used muscles of the chest (the pectoralis group) and the inward rotation of the shoulders tend
to be comparatively over-strong and shortened (Frost, 2002:140). The same author states that their opponents, external rotators consisting of the supraspinatus, infraspinatus, teres minor and subscapularis, tend to be weak and lengthened. According to Rybski (2004:731) the round back, or increased kyphosis in the thoracic spine, results in tight anterior-intercostals (pectoralis major and minor, latissimus dorsi and serratus anterior), stretched and weakened scapulae retractors, and stretched thoracic erector spinae. In order to correct the postural imbalances, specific exercises are needed to strengthen, and thereby shorten the neglected muscles and also to stretch the incorrectly shortened ones (Frost, 2002:141).

Since gravity is a constant force our bodies are designed to respond to it. Balasubramaniam and Wing (2002:531) conclude that forces arising from gravity, external events or our own actions, all tend to disturb the unstable equilibrium that preserves posture. The authors furthermore continue to state that loss of balance automatically activates a neuromuscular reaction Balasubramaniam and Wing (2002:532) affirms that posture should be actively maintained so that joints between body segments are free to move under external forces that could be constant or variable in nature.

Following appropriate postural education (both static and dynamic), the patient/employee can take responsibility for the management of pain that results from chronic postural strain and many activities of daily living (Travell and Simons, 1983:548). The same author makes the profound statement of the more aware we become of poor posture the more likely we will exercise control over it.

### 2.6. PHYSICAL EXERCISE AS AN INTERVENTION FOR BOTH MIND AND BODY

Accumulating evidence indicates that physical activity and structured exercise help maintain an independent life by maintaining postural stability, strength, endurance, bone density and functional ability (Skelton, 2001:33). The benefits of physical activity to the mind and the body have long been acknowledged by health professionals (James and Johnston, 2004:77). According to Long and Flood (1993:109-19) physical activity stimulates muscle relaxation after physical exertion and can distract workers from stressful work aspects. Furthermore, the
same authors state that physical activity may reduce stress through increased self-efficacy and self-esteem. According to Bernaards et al. (2006:81) increasing physical activity might be effective in reducing neck and upper limb symptoms. Physical exercise programmes have been adopted in the workplace and used successfully in many oriental countries such as China, Japan and Korea (Waikar and Bradshaw, 1995:16).

Several other studies have been published on the effectiveness of exercise programmes to reduce pain and disability in patients with neck and shoulder symptoms (Levoska and Keinanen-Kiukaanniemi, 1993; Takala et al. 1994:19; Klemetti, Santavirta, Sarvimaki and Bjorvell, 1997; Gowans, DeHueck, Voss and Richardson, 1999; Taimela, Takala, Asklöf, Seppälä and Parviainen, 2000; Horneij, Hemborg, Jensen and Ekdahl, 2001; Waling, Jarvholm and Sundelin, 2002; Kjellman and Oberg, 2002; Viljanen, Malmivaara, Uitti, Rinne, Palmroos and Laippala, 2002; Tsauo et al. 2004:253; Ylinen et al., 2003:2510; Sjögren, Nissinen, Jarvenpaa, Ojanen, Vanharanta and Malkia, 2005; Chiu, Lam and Hedley, 2005). However, most of these studies show only short-term effects of exercise programmes (Levoska and Keinanen-Kiukaanniemi, 1993; Taimela et al. 2000; Kjellman and Oberg, 2002; Tsauo et al. 2004:254; Sjögren et al. 2005). Lifestyle physical activity interventions that aim to increase physical activity up to at least thirty minutes per day seem to be promising with regard to the maintenance of physical activity (Prochaska, DiClemente and Norcross, 1992:1102).

With specific reference to decreasing lower back pain Kavcic, Grenier and McGill (2004:1254) confirm that postural stability exercises assist the skeletal muscles around the vertebral column to act as load absorbers, thereby stabilizing the spine. Increased strength of trunk flexors and extensors muscles are thought to raise intra-abdominal pressure and to decrease spinal loading (Aspden, 1988:268; Morris, Lucas and Bresler, 1961:3288). This in turn according to Lee, Hoshino, Nakamura, Kariya, Saita and Ito (1999:54) may reduce the occurrence of back problems.
2.7. THE PILATES METHOD AS INTERVENTION STRATEGY TO TRAIN POSTURAL STABILITY

Pilates is a mode of exercise developed by the late Joseph Pilates (Hastings 2001:12). According to Owsley (2005:19) Joseph Pilates was born in Dusseldorf, Germany, in 1880. As a child he suffered from asthma, rickets and rheumatic fever (Shedden and Kravitz, 2006:111). Joseph Pilates was a German expatriate who first made his mark in England during World War I when he developed a series of exercises and innovative equipment to help prisoners of war regain strength and mobility. Following World War I Spanish influenza broke out, not a single prisoner or guard from the prison camp died during the pandemic (Owsley, 2005:19). It was at this time that Joseph Pilates began devising the system of original exercises today known as “mat-work”, or exercises done on the floor.

Joseph Pilates had designed ways for wounded soldiers to rehabilitate muscles in their hospital beds during World War I (Chessher, 1998:44). Joseph Pilates moved to New York set up an exercise studio where he taught professional ballet dancers and refined his teaching method (Giusti, 2003:28).

It is estimated that currently in the USA 25 million people regularly participate in Pilates classes and more than one million do the same in the UK (Is Pilates bad for your Back? 2007:1). The objectives of Pilates exercises programme are to increase muscle strength, endurance, and flexibility together with the maintenance of spinal stability (Shedden and Kravitz, 2006:111). According to Pilates Perfection (2002:1) Pilates exercises simultaneously address the components of flexibility, strength, while emphasizing body symmetry and abdominal control during movement.

According to Solie (2007:19) Pilates is a method of mind-body conditioning, where core exercises are designed to create an awareness of the deep thoracic and abdomino-pelvic muscles and to readjust any musculoskeletal imbalances. Pilates exercises are focused on the stabilizing contractions of the postural muscles (Muscolino and Cipriani, 2004:122). All
movements are performed and coordinated with breathing patterns and accurate body alignment to provide maximum results with minimal repetition. Cassity (2004:86) reiterates that the use of Pilates as a method of training could enhance biomechanical functioning of the body, balance, co-ordination, postural and spatial awareness, strength and flexibility. These improvements in the physical body also have a positive effect on the mental health of the participant (Russell, 2006:1).

Pilates exercises are performed in a neutral spine position. According to Owsley (2005:22) a neutral spine is defined as the point halfway between a posterior pelvic tilt and an anterior pelvic tilt. A neutral spine is biomechanically and functionally correct to maintain good posture (Liemohm and Pariser cited in Owsley, 2005:22).

According to Baker (1999:2) studies have illustrated the specificity of roles of the abdominals between trunk flexion and lumbo-pelvic stabilization. The multifidus and transverse abdominus stabilize the spine through co-contraction (Panjabi, 1992:390-397). Postural muscles, including the anterior and posterior abdominal wall musculature, provide trunk stability, which is crucial to balance and postural stability (Mullhearn and George cited in Johnson, Larsen, Ozawa, Wilson, Kennedy, 2006:1). The abductor and adductor muscles of the hip joint, situated in the femoral triangle, provide optimum stability and mobility to the hip and lumbo-pelvic area when in a balance position (Drake, Vogl, and Mitchell, 2005:502).

Richardson and Jull, cited in Baker (1999:2), confirms that as far as the pelvic stability is concerned, strong abdominal muscles, especially the deep transverse abdominus and the internal and external obliques, allow for the proper positioning of the pelvis and hence, the limbs and spine during tasks such as running and jumping. Crews (2006:59) emphasizes that the contraction of the pelvic floor muscles, along with other synergistic musculature (piriformis, obturator internus, rectus abdominus, internal and external obliques and transverse abdominus), contribute to spinal and pelvic stability. Gardner-Morse and Stokes cited in Shedden and Kravitz (2006:111), support this latter finding of reciprocal interaction between relevant musculature.
According to Loots (2004:1) postural rehabilitation has physical and psychological considerations. This was demonstrated by improvement in posture and increased body awareness, a decrease in the tendency to become fatigued, a decrease in back and neck stiffness and improvement in mental attitudes. Owsley (2005:19) confirms that little evidence exists in the literature with regard to computer users using a Pilates training programme as a method of intervention to enhance postural stability. Kaesler et al. (2007:37) confirm that Pilates as a movement system is purported to improve postural awareness through the facilitation of movement re-education. It is the purpose of the current study to explore and determine the effect of a Pilates intervention on postural stability in computer users.

Foltz-Gray (2003:77) states that an improper posture effects symmetrical movement and is responsible for the inability to move freely. The author continues to argue that postural education including postural awareness should impact upon the accuracy and symmetry of movement performances, such as walking correctly. Bernardo (2007:106) supports literature findings on the effectiveness of the Pilates method in improving flexibility and abdominal- and lumbo-pelvic stability.

Mortensen, Kaiser, Gibb & Allsen (2004:39) explored the effects of a Pilates-based conditioning programme on two-footed vertical jump and single-leg hop in modern dancers. The experimental group (n=13) participated in the daily technique class, as well as a 50-minute Pilates-based conditioning programme three days a week. Results showed that there may be an advantage to using the Pilates-based conditioning programme to improve single-leg hop height in modern dancers. Other relevant studies include Segal, Hein and Basford (2004:1977 – 1981) who used an observational study to evaluate the effect of Pilates on flexibility and body composition and concluded that overall flexibility did improve. Johnson et al., (2006:4) found that Pilates-based exercise improved dynamic standing balance in healthy adults.

Johnson et al., (2006) used Pilates as an intervention method and found that ten Pilates-based exercise sessions, using healthy adults, resulted in a significant change in dynamic balance. Gladwell, Head, Haggar and Beneke (2006:338) evaluated the effect of a
programme of modified Pilates for active individuals with chronic non-specific lower back pain. The experimental group participated in a six week Pilates intervention programme indicating an overall improvement in functional movement.

According to Rydeard (2002:1) a randomized controlled trial, with a pre-test, post-test design (Part I, main study) with a 3, 6 and 12-month postal questionnaire follow-up (Part II) was used. The treatment group participated in a 4-week programme offered by a physiotherapist while the non-treatment group received usual care and no specific treatment intervention. A treatment programme was designed to train trunk stability and neuromuscular performance during movements involving hip extension utilizing Pilates apparatus and a home programme. In the main study the treatment group demonstrated a significant reduction in average pain intensity compared to the non-treatment group.

The principles outlined by Joseph Pilates in his book Return to Live through Contrology are still relevant today (Pilates cited in Owsley 2005:21) and as such provided guidelines for the Pilates intervention programme design and prescription followed by the participants in this study. According to Owsley (2005:21-22) the eight principles which underpin the performance of each of the exercises are; concentration, co-ordination and control, centering and alignment, flow of movement, precision, breathing, relaxation, and stamina.
2.8. SUMMARY

In a technological working world the use of computers is inevitable in everyday life. Static working positions will continue to disrupt the working relationship between employee and employer if an effective programme is not implemented. Absenteeism due to neck pain and low back pain, amongst other complaints, will continue to affect productivity. Physical exercise programmes should be used as a method of controlling and maintaining posture and postural stability. Creating awareness and postural educational programmes should become a primary goal and concern to both an employee and employer. Pilates, developed by the late Joseph Pilates, should be used to contest and control imbalanced postures, incorrect pelvic alignment and asymmetrical body movements.
CHAPTER 3: METHODS AND PROCEDURES

3.1. Introduction

3.2. Research Design

3.3. Research Participants

3.4. Data Collection Methods

3.5. Measuring Instrument

3.6. The Pilates Intervention Programme

3.7. Data Analysis

3.8. Ethical Considerations

3.9. Summary

3.1 INTRODUCTION

The preceding chapters have served to support the reasoning behind the present research study. In chapter 2 an overview of available literature on ergonomics, lower back pain, posture, postural stability and the use of Pilates to achieve good posture and postural stability were given. This was done to provide a foundation for the study.

The present chapter provides an overview and description of the research design and methodology employed in this study. A detailed description of the measuring instrument, the Biodex Stability System, will also be provided. This chapter also gives a clear depiction of how this study was carried out, the way in which participants were chosen and the manner in
which data was collected and analyzed. The ethical considerations taken into account will also be discussed.

3.2. RESEARCH DESIGN

This study employed an exploratory, descriptive quasi-experimental, non-equivalent group approach. This design was used to gather quantitative data, collected through pre- and post tests, for statistical analysis.

Typically, a research process begins with an exploratory study for preliminary identification of possible factors or variables, then moves to a descriptive study to define the salient or key variables, and concludes with a causal study, such as an experiment, to test the variables for strength of association or cause-and-effect relationships (McNabb, 2004:134). The same author explains that exploratory research is conducted for the reason of gathering insight into an issue. Rubin and Rabbie (2001:123) conclude that the exploratory design is typically used when a researcher is examining a new area of interest, or the subject of the study is relatively new and unstudied, or a researcher seeks to test the feasibility of undertaking a more careful study.

According to De Vos (2000:214) the exploratory design explores the nature of the problem, the extent to which the problem is known to the researcher, and the quantity and quality of the information available on the relevant subject will determine the manner, range and depth of the relevant exploratory study. Exploratory research is conducted when a research problem or issue has very few or no earlier relevant studies to which to refer to for information about the issue or the problem (Collis and Hussey, 2003:10). The same authors conclude that this approach to research is usually very open and concentrates on gathering a wide range of data and interpretations.

A quasi-experiment is a design which is similar to a true experiment, but differs in that one or more characteristics of a true experiment are missing (Kerr, Griffiths and Cox, 1996:67). A
design is quasi-experimental if subjects are not randomly assigned to groups but there is still a control or comparison group (Garson, 2007:1). This category of design is most frequently used when it is not feasible for the researcher to use random assignment. A quasi-experimental design is a study which has most of the trappings of an experiment, but which is unable to control potential factors, or perhaps is not guided by an idea of what all the factors are (Kilty, 2002:1). The same author warns that this lack of control sometimes leaves quasi-experiments with dubious outcomes, such as a lack of consistent internal logic and other invalid reasoning.

In situations where it is known that only a small sample size will be available to test the efficacy of an intervention, randomization may not be a viable option (Harris, McGregor, Furuno, Zhu, Peterson and Finkelstein, 2006:16-23). According to Harris et al. (2006:16-23) quasi-experiments are studies that aim to evaluate interventions, but that do not use randomization. Trochim (2006:1) agrees that a quasi-experimental design appears to be like an experimental design, but lacks the key ingredient of random assignment. The same author concludes that there is something compelling about these designs that are easily more frequently implemented in field research than their randomized alternatives.

According to Trochim (2006:1) the non-equivalent group design is probably the most frequently used design. It is structured like a pretest-posttest randomized experiment, but it lacks the key feature of random assignment. In quasi-experimental designs, targets receiving the intervention are compared to a control group of selected, non-randomly assigned targets that do not receive the intervention (Rossi, Lipsey and Freeman, 2004:247).

The quasi-experimental designs have been developed to control as many threats as possible. Since participants are not randomly assigned to groups, one cannot assume that the populations being compared are equivalent in all aspects prior to the treatment, and accordingly internal validity is threatened. Shadish, Cook and Campbell (2002:1) cited in Harris et al. (2006:16-23) outline nine threats to internal validity, namely ambiguous temporal precedence, selection, history, maturation, regression, attrition, testing, instrumentation and interactive effects.
The lack of random assignment of participants is the major weakness of the quasi-experimental study design. Researchers often choose not to randomize the intervention for one or more reasons; namely, ethical considerations, difficulty of randomizing subjects, difficulty to randomize by locations, and small available sample size (Harris et al. 2006:16-23). The use of both a pretest and a comparison group makes it easier to avoid certain threats to validity; however selection may still be biased. According to De Vos et al. (2002:145) the comparison group pretest-posttest design utilized, is the equivalent of the classical experiment, but without random assignment of subjects to the groups. The experimental and comparison groups will undergo a pretest to indicate the extent of their differences (De Vos et al. 2002:146).

Quasi-experiments aim to demonstrate causality between an intervention and an outcome. These designs were developed to provide alternate means for examining causality in situations which were not conducive to experimental control. Similar to randomized trials, quasi-experiments aim to demonstrate causality between an intervention and an outcome (Harris et al. 2006:16-23).

3.3. RESEARCH PARTICIPANTS

The sample of this study included male and female computer users from the Nelson Mandela Metropole undergoing Pilates as an intervention programme to improve postural stability. Forty healthy male and female participants volunteered to participate. The age range of the participants was 25 – 59- years-old. An inclusion criterion was that the participants must have been using a computer for at least three years. The reason for choosing a wide sample age range, is that Pilates can be performed and benefit individuals at any age. It offers a solution to those with restricted mobility, elite athletes, and has been as beneficial for an 11-year-old as it is for an 80-year-old (Isacowitz, 2006: xvi). Furthermore, as the sample population was dependent on convenient or accidental sampling, only volunteers who committed themselves to the study were selected. De Vos et al., (2002:207) defines accidental sampling as including
any case that happens to cross the researcher's path and is relevant to the phenomenon in the sample until the desired number has been obtained.

A sample of twenty participants in both the experimental and control group meant that a total of 40 participants took part in the research study. However three participants in the experimental and the control group respectively did not complete the study, due to time constraints. This meant that the study experienced a 15% drop-out rate. According to the researchers Reid and Smith (1981) and Sarantakos (2000) in De Vos et al. (2002:199), a complete coverage of the total population is seldom possible, and all the members of a population of interest cannot possibly be reached. However, a large sample needs to be drawn as a certain degree of participant mortality and drop-out occurs in any research (De Vos et al. 2002:200). Hence, in concurrence, a study sample was chosen which included individuals aged between 19 and 55 years of age. This was done to ensure a wide range of the population through varying age groups with the intention of determining whether similar effects on the postural sway and lateral sway variables could be perceived throughout the range of participant age groups.

3.3.1. SAMPLING DESIGN AND TECHNIQUE

The participants, computer users, in this particular study were selected using non-probability convenience sampling. According to Gerrish and Lacey (2006:175) non-probability samples consist of people from whom the researcher finds it convenient to collect data (Whitley 2002:394; Polit and Beck, 2004:292), and, by definition, easy to access (Lewis-Beck, Bryman and Liao, 2004:197). Non-probability methods have the advantages of being cost-effective, can be used when the sampling frame is not available, are useful when the population is so widely dispersed that cluster sampling would not be efficient, and are often used in exploratory studies (Gilles, 2002:77). However, a non-probability sample, being unrepresentative of a whole population, may demonstrate bias (Cohen, Manion and Morrison, 2000:99). Gilles (2002:78) agree that the likelihood of bias is high.
Although convenience sampling has the aforementioned weakness, it remains the most common form of sampling in the Social Sciences (Polit and Beck, 2004:292).

Volunteers were also obtained by means of snowball sampling in which participants already involved in the study found other participants relevant to the study. De Vos et al. (2002:336) defines snowball sampling as the collection of data on the few members of the target population that can be located, and then seeks information from these individuals that enables the location of other members of that population. Volunteers were obtained by the placement of an advertisement on the NMMU staff and student e-mail portals. After approval by the Biokinetics and Sports Science Unit (BSSU) of The Nelson Mandela Metropolitan University (NMMU), the participants were contacted either by telephone, email or direct consultation to organize the most suitable times for testing on the Biodex Stability System. Written consent forms (Appendix A) were obtained from each participant prior to the commencement of the assessment.

3.3.2. EXCLUSION CRITERIA

Female participants beyond the first trimester of pregnancy were not included as part of the control or experimental group as performance of the Pilates exercises required participants to be positioned in a supine position and uterine blood supply could have been negatively affected. Individuals younger than 18 years of age, were furthermore excluded from participation, since they require parental or guardian permission before participating in an exercise programme. Furthermore the differentiation between male and female participants was not made as the study numbers were too small.
3.4. DATA COLLECTION METHODS

Formal consent was obtained from the Biokinetics and Sports Science Unit (BSSU) of The Nelson Mandela Metropolitan University (NMMU) in order to conduct the assessment, using the Biodex Stability System. The identified participants were then contacted by the researcher to explain the nature of the research study and to gain verbal consent for their participation. Once the various individuals verbally agreed to participate in the study, they were either given an envelope by hand or electronically which explained in detail all necessary information regarding their participation.

Each participant received a letter of informed consent concerning the nature, purpose and procedure of the study (Appendix B and C). The BSSU assisted with the administration of the assessment at both the pre- and post test phases. The Biokinetics interns were briefed and trained on the purpose and use of the Biodex Stability System as a measuring instrument to assess postural stability, as well as given instructions for the exact procedure to follow in completion of the assessment if the researcher could not be present.

The methods and procedures of testing that guided the assessments, were those used in compliance with The Biodex Stability System Manual (2000). When performing a postural stability test it is important to remember that a participants’ score on the test assesses the deviations from the center, therefore a lower score would be more desirable. The following testing protocol was used to assess the participants: three test repetitions, at the same time, using a two legged stance at stability level of eight, for the duration of twenty seconds each (The Biodex Stability System Manual 2000:8-6). In order to negate the learning effect the first trial has not been used in the statistical analysis. Each participant completed the testing in less than twenty minutes and the corresponding results were instantaneously printed by the Biodex Stability System.

The postural stability test results were then analyzed by a qualified statistician at the Nelson Mandela Metropolitan University. A verbal report, pertaining to the participants’ scores, was
provided by the researcher on request of individual participants, who asked for feedback of their results.

### 3.5. MEASURING INSTRUMENT

The Biodex Stability System (950-304) was used to measure the postural stability of the participants. The Biodex challenges a participants’ balance while standing on a movable platform that tilts to a maximum of twenty degrees in different directions. The system uses a mechanical system which ranges from level one to level twelve, where level one represents the greatest instability. According to the Biodex Stability System Manual (2000:8-6) the test protocol commonly used with the Biodex Stability System is a Dynamic Balance test. The following protocols were used in this study to maintain reliability and validity; namely, a test duration of twenty seconds at a stability level of eight using a two legged stance (Appendix D).

According to The Biodex Stability System Manual (2000:1-2) using this unique device, clinicians can assess neuromuscular control by quantifying the ability to maintain dynamic bilateral and unilateral postural stability on a static or unstable surface. Most of the balance tests performed on the Biodex has been used in clinical settings due to the fact that facilitators require minimal specialized training and instrumentation. To understand more clearly the mechanics and functioning of the Biodex see (Appendix E).

According to Hinman (2000:242) when used in the testing mode, the Biodex system provides an overall stability index (OSI) that represents the variance of the foot platform displacement in degrees, from a level position, in all the ranges of motion during the test. Greater amounts of body movement associated with an unstable posture produce high OI’s; a low OI indicates little body movements and is associated with a more stable posture. Stability indexes (SI’s) are also calculated for the anterior-posterior (AP) and medial-lateral (ML) directions, which represent the variance of platform displacement for motions occurring in the sagittal and frontal planes, respectively. In addition, the Biodex system displays the platform as a series of
concentric circles, or zones, that are divided into 4 quadrants. The percentage that an individual spends in each zone and quadrant is reported along with the SI values.

Reliability and validity are both important factors to take into consideration when conducting research (De Vos et al. 2002:120). Factors that were taken into consideration to ensure reliability and validity in this study include the standardized protocols utilized when using the Biodex Stability System. The Biodex Stability System was used specifically, in testing format, to measure the dependent variable of postural stability.

Reliability of a measure is its degree of consistency. A perfectly reliable measure gives the same result every time and is applied to the same person or thing, barring changes in the variable being measured (Whitley 2002:124). Validity measures the degree of accuracy.

The Biodex Stability System was shown to be reliable in several studies. Hinman (2000:249) claims that the balance measures (SI) produced by the Biodex Stability System appear to be reliable measures of postural stability. Research reported intra-class correlation coefficient (ICC) values of 0.6 (for a stability level of eight) to 0.95 (for a stability level of two) in healthy subjects (Pincivero, Lephart and Henry cited in Salavati et al. 2006:2).

A normative data was developed for bilateral stance with the pre-selected highest stability level of eight. The Biodex Medical Systems is accredited with ISO 9001:2000 and ISO 13485:2003 certified companies.

3.6. THE PILATES INTERVENTION PROGRAMME

A clearly defined Pilates beginner mat based programme was designed based on the eight Pilates principles as discussed in chapter two. Appendix (F) presents the selected exercises performed with control using only eight to twelve repetitions per exercise. The duration of the intervention programme lasted for an eight week period with a frequency of twice weekly at
times suitable to the participants. The Pilates exercise sessions lasted sixty minutes and included a warm-up and cool down phase.

The programme combines flexibility and strengthening exercises that emphasizes body symmetry and abdominal control. Core exercises are designed to create an awareness of the deep torso muscles and to re-pattern any muscular-skeletal imbalances. Attention was particularly focused on accessing and training the core postural muscles that stabilize the body and are essential to providing support for the spine in daily functional activities. All movements are coordinated with breathing patterns and body alignment and precision and accuracy in the quality of the movement performance was essential to provide maximum results.

The mat based Pilates exercise sessions were performed in groups of four participants at a time, to ensure proper supervision and correct performance of the exercises. An internationally qualified and accredited instructor was utilized throughout the duration of the study. Pilates mat based exercises are performed with control using only eight to twelve repetitions per exercise.

### 3.7. DATA ANALYSIS

At the completion of the pre- and post test assessment, the data was recorded on a data sheet in Excel for both the experimental and control groups. Analysis of data was performed utilizing descriptive and inferential statistics through the help of a statistician at the Nelson Mandela Metropolitan University. Descriptive statistics investigates the mean, ranges and standard deviations of a measure to produce more logical, understandable and manageable information.

According to Gravetter and Wallnua (1995:62) the advantage of using the mean is that it can be algebraically manipulated and is also a better estimate of the population mean than other
measures of central tendency. According to Warrack and Keller (1997:106), by far the most popular and useful measure of central location is the arithmetic mean. The mean was used in this study to calculate the average for the dependent variables of overall postural stability indexes, anterior-posterior and medial-lateral stability changes in computer users as measured in the pre- and post tests, respectively. The standard deviation of a set of measurements is the positive square root of the variance of the measurements (Warrack and Keller, 1997:123).

Further investigations utilized inferential statistics to determine the effect of an eight week Pilates training programme on the dependent variables of postural stability as indicated by the changes in OSI, API and MLI indexes of computer users.

Significance of results was computed at a p-value of less the 0.05. Analysis of covariance (ANCOVA) was used in this study. ANCOVA is an extension of ANOVA that typically provides a way of statistically controlling for the effects of continuous or scale variables, but that is not the focal point or independent variables in the study (Leech, Barrett and Morgan, 2005:141). ANCOVA makes all the assumptions of ANOVA as well as those of regression (Dytham, 2003:195). ANCOVA asks the question; if the pre-test scores are held constant, would there be any significant differences between the post test scores for the experimental and control group?
The postural stability test results acquired in this study are shown as an example in Appendix (G) and the following discussion indicates the interpretation of the statistical data, the format of which will be used in the discussion of results in chapter four and five, according to The Biodex Stability System Manual (2000):

1. **Stability Level**: Indicates the stability of the foot platform. When in a “locked” mode, the platform is fully stable. A setting of 12 is the most stable and represents the “released” setting. A setting of one is the least stable foot platform setting. Stability settings of 12 through one allow the foot platform a full 20 degree of deflection from level in any direction. For participant centering prior to testing, the foot platform deflection is limited to less that five degrees.

2. **Overall Stability Index (IS)**: Represents the variance of foot platform displacement in degrees from level, in all motions during a test. A high number is indicative of a lot of movement during a test with static measures; it is the angular excursion of the participant’s centre of gravity.

3. **Anterior-Posterior Stability Index (AP)**: Represents the variance of foot platform displacement in degrees, from level, for motion in the sagittal plane.

4. **Medial-Lateral Stability Index (ML)**: Represents the variance of foot platform displacement in degrees, from level, for motion in the frontal plane.

5. **Standard Deviation**: The amount of variability in the statistical measure. A low standard deviation demonstrates that the range of values from which the mean was calculated were close together.

6. **Percent time in Zone/Quadrant**: These values represent the percentage of test time the participant spends in each Zone/Quadrant during the test.

As indicated in the abovementioned discussion the standard deviation was automatically calculated by the Biodex Stability System.
3.8. ETHICAL CONSIDERATIONS

According to De Vos et al. (2002:75), ethics are defined as a set of widely accepted moral principles that offer rules for and behavioural expectations of the most correct conduct towards experimental subjects and respondents. To ensure that the study followed adequate ethical and moral guidelines, permission and approval for the proposed research was sought from The Human Ethics Committee of the Nelson Mandela Metropolitan University.

The following appendices include relevant information pertaining to ethical considerations of the study:

Appendix A, B and C was given to each participant explaining the rationale for the research, what the information will be used for, as well as the participants’ rights. These were given to the participants in the experimental and control group prior to the commencement of the study.

The researcher explained and clearly defined the Pilates intervention to the participants ensuring that the participants knew exactly what the intervention intended to do. Participants were verbally informed that their involvement in the research study was voluntary and that he/she may withdraw from the research study at any time without being unfairly discriminated against.

All information was treated with confidentiality and only the general conclusions were made public. The participants’ identity with reference to the test results was upheld. Confidentiality was explained and participants were treated with professionalism. On completion of the eight week Pilates programme, the control group was offered the opportunity to participate in the intervention programme, as participation in the Pilates programme could possibly have been the initial reason for voluntary participation in the study.
3.9. SUMMARY

This study employed an exploratory, descriptive, quasi-experimental design with a non-equivalent group approach to evaluate the effect of an eight week Pilates intervention programme on the postural stability of computer users; and to assess the overall stability index, the anterior-posterior, and the medial-lateral stability indexes, prior to and after the implementation of the mat based Pilates programme. A test retest design incorporating an experimental and control group was used, where participants were matched paired based on the scores obtained for the dependent variables, following completion of the initial assessment.

The participants were volunteer computer users selected by means of non-probability convenience and snowball sampling. All participants were sedentary at the onset of the study and regarded as being at a beginner level.

The Biodex Stability System (950-304) was used to measure the dependent variables of postural stability and challenges a participants' balance while standing on a movable platform that tilts to a maximum of twenty degrees in different directions. The system uses a mechanical system which ranges from level one to level eight, where level one represents the greatest instability. Analysis of data was performed utilizing descriptive and inferential statistics.
CHAPTER 4: RESULTS AND DISCUSSION

4.1. Introduction

Pilates can be used to improve muscular symmetry and in turn aid in the adjustment of musculature imbalances while sitting for extended amounts of time. Learning to use the body correctly and working in alignment helps to achieve greater muscular symmetry because imbalances are rectified (Kimberly and Katherine Corporation, 2002:2). The purpose of this study was to determine the impact of a Pilates training programme on the postural stability of computer users in the workplace.

Data was gathered from the participants prior to and after the eight week Pilates intervention programme. This data was furthermore processed and analyzed in order to describe the effect of the intervention programme on the postural stability in computer users.

Analysis of data was performed utilizing descriptive and inferential statistics. According to Warrack and Keller (1997:106) by far the most popular and useful measure of central
tendency is the arithmetic mean. Measures of variability or dispersion of data were analysed and recorded in terms of variances and standard deviations. According to Warrack and Keller (1997:120) variance is one of the two most widely accepted measures of the variability of a set of quantitative data (the other is standard deviation). The same authors confirm that variance and standard deviation are closely related and take into account all the data in a set; and are of fundamental importance in statistical inference.

According to Warrack and Keller (1997:4) inferential statistics is a body of methods used to draw conclusions or inferences about characteristics of populations based on sample data. In order for the statistics to be significant they have to be practical; therefore the experimental group must be different to the control group post intervention. Compensation was made for both the experimental and control groups’ initial performance overall stability index (as the sample was not identical).

As suggested by Gravatter & Wallnau (2005) the indexes were tested at a 95% level of probability (p<0.05). It must be noted that where p-values were reported as 0.000 it does not imply that it is equal to zero, it means that it is less that 0.0005.

In order to address the aim of the study, as in Chapter 1, the following objectives were explored statistically:

- To assess and describe the overall postural indexes,
- To assess and describe the anterior-posterior postural indexes,
- To assess and describe the medial-lateral postural indexes.
4.2. ANTHROPOMETRICAL ANALYSIS

Descriptive statistics investigate the means, ranges and standard deviations of a measure to produce more logical, understandable and manageable information.

According to Gravatter and Wallnau (2005) the advantage of using the mean is that it can be algebraically manipulated and is also a better estimate of the population mean than other measures of central tendency.

The sample in this study included male and female computer users undergoing Pilates as an intervention programme. Forty healthy male and female participants volunteered to participate. The forty participants were divided equally amongst the experimental (Exp) and control (Con) groups.

However three participants in the experimental and the control group respectively did not complete the study, due to time constraints. This meant that the study experienced a 15% drop-out rate.

Descriptive data are exhibited in table 1.

Table 1 below shows that the total number of participants who participated in this study was 34. The mean age of the participants was 39.32 years. The oldest participant tested was 59-years-old, whereas the youngest was 25-years-old. The median age of the sample was 39.5 years the standard deviation was 9.83. The first quartile represented an average age of 31 while the 3rd quartile represented an average age of 46 years. The minimum height of (1.00) refers to 151 – 165cm and the maximum height (2.00) refers to 166+cm tall. The height was used in accordance with the Biodex Stability System Manual.
Table 1: Descriptive Data of the Control and Experimental Group

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Con</th>
<th>Exp</th>
<th>Height</th>
<th>Age (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Mean</td>
<td>39.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>9.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>1.00</td>
<td>2.00</td>
<td>1.00</td>
<td>25.00</td>
</tr>
<tr>
<td>Median</td>
<td>39.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>59.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>3.00</td>
<td>2.00</td>
<td></td>
</tr>
</tbody>
</table>

Key:  Con – Control Group

Exp – Experimental group

Please note that the descriptive data i.e. quartiles, medians and height, were provided by the researcher for the reader to gain for further insight of the sample and not for analytical research.

4.3. OVERALL POSTURAL STABILITY INDEX SCORES PRE- AND POST- THE PILATES PROGRAMME

The Biodex system provides an overall stability index (OI) that represents the variance of the foot platform displacement in degrees, from a level position, in the anterior-posterior (AP) and medial-lateral (ML) directions during the test.

The participants’ overall index, anterior-posterior, and medial-lateral scores were measured by the Biodex system.
Table 2 and 3 showed an overall positive improvement in postural stability; however the mean score obtained for the experimental group of 0.43 is clearly higher than the 0.29 value achieved by the control group.

Table 2: Pre- and Post-Test Postural Stability Indexes of Experimental Group

<table>
<thead>
<tr>
<th>Statistics</th>
<th>OI ae</th>
<th>API ae</th>
<th>MLI ae</th>
<th>OI be</th>
<th>API be</th>
<th>MLI be</th>
<th>OI de</th>
<th>API de</th>
<th>MLI de</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
</tr>
<tr>
<td>Mean</td>
<td>0.99</td>
<td>0.75</td>
<td>0.56</td>
<td>0.56</td>
<td>0.40</td>
<td>0.30</td>
<td>-0.43</td>
<td>-0.35</td>
<td>-0.26</td>
</tr>
<tr>
<td>SD</td>
<td>0.55</td>
<td>0.46</td>
<td>0.30</td>
<td>0.22</td>
<td>0.20</td>
<td>0.14</td>
<td>0.42</td>
<td>0.41</td>
<td>0.26</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.40</td>
<td>0.20</td>
<td>0.20</td>
<td>0.30</td>
<td>0.20</td>
<td>0.10</td>
<td>-1.50</td>
<td>-1.20</td>
<td>-0.90</td>
</tr>
<tr>
<td>Median</td>
<td>0.90</td>
<td>0.60</td>
<td>0.50</td>
<td>0.50</td>
<td>0.40</td>
<td>0.30</td>
<td>-0.30</td>
<td>-0.20</td>
<td>-0.20</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.30</td>
<td>1.70</td>
<td>1.40</td>
<td>1.00</td>
<td>0.90</td>
<td>0.60</td>
<td>-0.10</td>
<td>0.00</td>
<td>-0.10</td>
</tr>
</tbody>
</table>

- a: Pre-Test, b:Post-Test, e:Experimental Group, d:Difference;

Table 3: Pre- and Post-Test Postural Stability Indexes of Control Group

<table>
<thead>
<tr>
<th>Statistics</th>
<th>OI ac</th>
<th>API ac</th>
<th>MLI ac</th>
<th>OI bc</th>
<th>API bc</th>
<th>MLI bc</th>
<th>OI dc</th>
<th>API dc</th>
<th>MLI dc</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
<td>17.00</td>
</tr>
<tr>
<td>Mean</td>
<td>1.25</td>
<td>0.94</td>
<td>0.68</td>
<td>0.96</td>
<td>0.68</td>
<td>0.51</td>
<td>-0.29</td>
<td>-0.25</td>
<td>-0.16</td>
</tr>
<tr>
<td>SD</td>
<td>0.96</td>
<td>0.74</td>
<td>0.49</td>
<td>0.51</td>
<td>0.38</td>
<td>0.29</td>
<td>0.55</td>
<td>0.43</td>
<td>0.30</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.50</td>
<td>0.30</td>
<td>0.20</td>
<td>0.40</td>
<td>0.20</td>
<td>0.10</td>
<td>-2.00</td>
<td>-1.40</td>
<td>-1.20</td>
</tr>
<tr>
<td>Median</td>
<td>0.90</td>
<td>0.70</td>
<td>0.50</td>
<td>0.90</td>
<td>0.70</td>
<td>0.40</td>
<td>-0.10</td>
<td>-0.10</td>
<td>-0.10</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.20</td>
<td>3.10</td>
<td>2.20</td>
<td>2.20</td>
<td>1.70</td>
<td>1.10</td>
<td>0.30</td>
<td>0.20</td>
<td>0.20</td>
</tr>
</tbody>
</table>

- a: Pre-Test, b:Post-Test, c:Control Group, d:Difference

Key:

- OI – Overall Postural Stability Index
- API – Anterior-Posterior Stability Index
- ML – Medial-Lateral Stability Index
- SD – Standard Deviation
The control group experienced an overall improvement in postural stability. The mean overall postural stability score of 0.29 was the largest improvement, followed by the anterior-posterior postural stability mean score improvement of 0.25 and lastly the medial-lateral postural stability mean score improvement of 0.16 after the post-test.

Based on the statistics in table 2 and 3, figure 1 represents the pre- and post test mean scores of the overall postural stability indexes for the experimental (Exp) group and control (Con) group respectively. The following information was derived;

The experimental (Exp) group recorded a pre-test overall postural stability score of 0.99 (OI-ae) and a post-test mean score (OI-be) of 0.56, the control (Con) group recorded a pre-test overall postural stability score of 1.25 (OI-ac) and a post test mean score (OI-bc) of 0.96, the overall postural stability index score of the experimental group improved by 0.43 (OI-de) and the control group (Con) improved by 0.29 (OI-dc) from the pre-test to the post-test.
These scores were furthermore interpreted statistically using ANCOVA. ANCOVA is used when the researcher wants to neutralize the effect of a continuous independent variable in the experiment. If any variables are known to influence the dependent variable being measured, then ANCOVA is ideally suited to remove the bias of these variables (Field, 2005:364).
In this study the following independent variables were compensated for in the overall postural stability indexes summarized in 4.3, the anterior-posterior and medial-lateral postural stability indexes summarized in 4.4.

1. Relationship between the ages of the experimental group pre-test and the control group pre-test (Age),

2. Relationship between experimental group pre-test and the control group pre-test (OI Pre-Test),

3. Relationship between the height of the experimental group pre-test and the control group pre-test (Height),

4. Relationship of the experimental groups’ height pre-test and control groups’ height pre-test (ExpCon*Height).

All of these extraneous variables had pre-test effects but ANCOVA was used to control for them. The p-value measures how much statistical evidence exists, so that it can be weighed in relation to other factors (Warrack and Keller, 1997:346). A p-value less that 0.05 shows that there is a significant statistical difference between the experimental and control group.

Table 4: ANCOVA results for the post-test Overall Postural Stability Index of the Experimental and Control Groups

<table>
<thead>
<tr>
<th>Overall Index (OI)</th>
<th>F</th>
<th>p (d.f.=1, 28)</th>
<th>eta-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.03</td>
<td>0.859</td>
<td>n.a.</td>
</tr>
<tr>
<td>OI Pre-Test</td>
<td>66.91</td>
<td>0.000</td>
<td>0.7</td>
</tr>
<tr>
<td>ExpCon</td>
<td>20.16</td>
<td>0.000</td>
<td>0.42</td>
</tr>
<tr>
<td>Height</td>
<td>2.31</td>
<td>0.139</td>
<td>n.a.</td>
</tr>
<tr>
<td>ExpCon*Height</td>
<td>2.56</td>
<td>0.121</td>
<td>n.a.</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>F = 20.16</td>
<td>p &lt; 0.05</td>
<td>Eta² = .42</td>
</tr>
</tbody>
</table>
ANCOVA revealed that there was a statistically significant difference ($p<0.05$) between the overall stability (OI) post-test scores of the experimental and control groups (ExpCon).

According to Gravatter and Wallnau (2005:233) eta-squared demonstrates the practical significance of the intervention programme. Eta-Squared interpretation used below is represented in the following table and will be used consistently with interpretations:

Table 5: Interpretation of Practical Significance of the Intervention

<table>
<thead>
<tr>
<th>$0.01 &lt; r^2 &lt; 0.09$</th>
<th>Small Effect of Intervention/Small Practical Significance of Treatment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.09 &lt; r^2 &lt; 0.25$</td>
<td>Medium Effect of Intervention/Medium Practical Significance of Treatment.</td>
</tr>
<tr>
<td>$r^2 &gt; 0.25$</td>
<td>Large Effect of Intervention/Large Practical Significance of Treatment.</td>
</tr>
</tbody>
</table>

Eta² analysis results confirmed that the Pilates intervention had a practically significant ($Eta^2 > 0.25$) impact on post-test overall stability experimental scores.

4.4. ANTERIOR-POSTERIOR AND MEDIAL-LATERAL POSTURAL STABILITY SCORES

Participants scores were calculated for the anterior-posterior (AP) and medial-lateral (ML) directions, which represent the variance of platform displacement for motions occurring in the sagittal and frontal planes, respectively.

Based on the statistics in table 2 and 3, figure 2 represents the pre- and post test mean scores of the anterior-posterior indexes for the experimental (Exp) group and control (Con) group respectively. The following information was derived:

(1) The experimental group (Exp) recorded a pre-test anterior-posterior score (API-ae) of 0.75 and post test mean score (API-be) of 0.4,
(2) The control (Con) group recorded a pre-test anterior-posterior score of 0.94 (API-ac) and a post test mean score (API-bc) of 0.68,

(3) The anterior-posterior postural stability index score of the experimental group improved by 0.35 (API-de) and the control group improved by 0.25 (API-dc) from the pre-test to the post-test.
Table 6: ANCOVA results for the post-test Anterior-Posterior Postural Stability Index of the Experimental and Control Groups

<table>
<thead>
<tr>
<th>Anterior-Posterior Index (API)</th>
<th>F</th>
<th>p (d.f.=1, 28)</th>
<th>eta-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0</td>
<td>0.979</td>
<td>n.a.</td>
</tr>
<tr>
<td>API Pre-Test</td>
<td>34.45</td>
<td>0</td>
<td>0.55</td>
</tr>
<tr>
<td>ExpCon</td>
<td>11.18</td>
<td>0.002</td>
<td>0.29</td>
</tr>
<tr>
<td>Height</td>
<td>0.93</td>
<td>0.344</td>
<td>n.a.</td>
</tr>
<tr>
<td>ExpCon*Height</td>
<td>1.4</td>
<td>0.247</td>
<td>n.a.</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>F = 11.18</td>
<td>p &lt; 0.05</td>
<td>Eta² = .29</td>
</tr>
</tbody>
</table>

The significant difference in table 6 highlights the effect of the Pilates intervention in improving the anterior-posterior stability of the participants as measured on the Biodex. Table 6 shows the two groups as being statistically different as \( p = 0.002 \) \((p < 0.05)\). Eta² showed that the Pilates intervention was practically significant as \( \text{Eta}^2 > 0.25 \).

Based on the statistics in table 2 and 3, figure 3 represents the pre- and post test mean scores of the medial-lateral indexes for the experimental (Exp) group and control (Con) group respectively. The following interpretation was deducted:

1. The experimental group recorded a pre-test medial-lateral score (MLI:ae) of 0.56 and post test mean score (MLI:be) of 0.30,

2. The control group recorded a pre-test medial-lateral score of 0.68 (MLI:ac) and a post test mean score (MLI:bc) of 0.51,

3. The medial-lateral postural stability index score of the experimental group improved by 0.26 (MLI-de) and the control group improved by 0.16 (MLI-dc) from the pre-test to the post-test.
Figure 3: Pre- and Post-test Mean Postural Stability Medial-Lateral Scores
Table 7 below shows that there is a statistical significant difference between the two groups $p = 0.002$ ($p < 0.05$). $\eta^2$ showed that the Pilates intervention was practically significant as $\eta^2 > 0.25$.

Table 7: ANCOVA results for the post-test Medial-Lateral Postural Stability Index of the Experimental and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>p (d.f.=1, 28)</th>
<th>eta-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Medial-Lateral Index (MLI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.1</td>
<td>0.750</td>
<td>n.a.</td>
</tr>
<tr>
<td>MLI Pre-Test</td>
<td>25.33</td>
<td>0.000</td>
<td>0.47</td>
</tr>
<tr>
<td>Con</td>
<td>11.83</td>
<td>0.002</td>
<td>0.3</td>
</tr>
<tr>
<td>Height</td>
<td>1.87</td>
<td>0.182</td>
<td>n.a.</td>
</tr>
<tr>
<td>Con*Height</td>
<td>1.57</td>
<td>0.220</td>
<td>n.a.</td>
</tr>
<tr>
<td><strong>ANCOVA</strong></td>
<td>F = 11.83</td>
<td>p &lt; 0.05</td>
<td>$\eta^2 = 0.30$</td>
</tr>
</tbody>
</table>

4.5. MEASURES OF DISPERSION

Measures of dispersion were measured by the Biodex System for each participant. The measures of dispersion were used and analysed as a supplement to the overall, anterior-posterior and medial-lateral scores shown above. A decrease in scores over three consecutive trials measured pre- and post intervention is seen as favourable. An increased displacement from the centre point of the Biodex platform is displayed as a higher score (which is unfavourable).
Figure 4: Pre- and Post-Test Measures of Dispersion
Resulting measures of overall postural stability dispersion scores are shown graphically above in Figure 4. The experimental group recorded a pre-test overall measure of dispersion score of 0.88 (OI:ae) and a post-test measure of dispersion mean score (OI:be) of 0.34. The control group recorded a pre-test overall measure of dispersion score of 0.92 (OI:ac) and a post-test measure of dispersion mean score (OI:bc) of 0.65. The overall measure of dispersion score of the experimental group improved by 0.53 (OI:de) and the control group improved by 0.27 (OI:dc).

Table 8: ANCOVA results for Overall, Anterior-Posterior and Medial-Lateral post-test Measures of Dispersion for the Experimental and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>p (d.f.=1, 28)</th>
<th>eta-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall Index (OI_SD)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>2.68</td>
<td>0.113</td>
<td>n.a.</td>
</tr>
<tr>
<td>OI Pre-Test</td>
<td>15.74</td>
<td>0.000</td>
<td>0.36</td>
</tr>
<tr>
<td>ExpCon</td>
<td>14.98</td>
<td>0.001</td>
<td>0.35</td>
</tr>
<tr>
<td>Height</td>
<td>2.65</td>
<td>0.115</td>
<td>n.a.</td>
</tr>
<tr>
<td>ExpCon*Height</td>
<td>4.27</td>
<td>0.048</td>
<td>0.13</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>F = 14.98</td>
<td>p &lt; 0.05</td>
<td>Eta² = .35</td>
</tr>
<tr>
<td><strong>Anterior-Posterior Index (API_SD)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.22</td>
<td>0.279</td>
<td>n.a.</td>
</tr>
<tr>
<td>API Pre-Test</td>
<td>18.48</td>
<td>0.000</td>
<td>0.40</td>
</tr>
<tr>
<td>ExpCon</td>
<td>14.44</td>
<td>0.001</td>
<td>0.34</td>
</tr>
<tr>
<td>Height</td>
<td>3.33</td>
<td>0.079</td>
<td>0.11</td>
</tr>
<tr>
<td>ExpCon*Height</td>
<td>3.91</td>
<td>0.058</td>
<td>n.a.</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>F = 14.44</td>
<td>p &lt; 0.05</td>
<td>Eta² = .34</td>
</tr>
<tr>
<td><strong>Medial-Lateral Index (MLI_SD)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>4.32</td>
<td>0.047</td>
<td>0.13</td>
</tr>
<tr>
<td>MLI Pre-Test</td>
<td>19.54</td>
<td>0.000</td>
<td>0.41</td>
</tr>
<tr>
<td>ExpCon</td>
<td>15.52</td>
<td>0.000</td>
<td>0.36</td>
</tr>
<tr>
<td>Height</td>
<td>0.83</td>
<td>0.371</td>
<td>n.a.</td>
</tr>
<tr>
<td>ExpCon*Height</td>
<td>2.97</td>
<td>0.096</td>
<td>n.a.</td>
</tr>
<tr>
<td>ANCOVA</td>
<td>F = 15.52</td>
<td>p &lt; 0.05</td>
<td>Eta² = .36</td>
</tr>
</tbody>
</table>
Table 8 above revealed the analysis of covariance ANCOVA as having a statistically significant difference between the two groups \( p = 0.001 \) (\( p < 0.05 \)). It also reveals that the anterior-posterior and medial-lateral both had statistically significant differences of 0.001 and 0.000 respectively. \( \eta^2 \) showed that the Pilates intervention was practically significant as \( \eta^2 > 0.25 \) in all three overall, anterior-posterior and medial-lateral indexes (refer table 2 for interpretation).

Table 9: Pre- and Post-Test Measures of Dispersion of the Experimental Group

<table>
<thead>
<tr>
<th>MD:Statistics</th>
<th>OI-ae</th>
<th>API-ae</th>
<th>MLI-ae</th>
<th>OI-be</th>
<th>API-be</th>
<th>MLI-be</th>
<th>OI-de</th>
<th>API-de</th>
<th>MLI-de</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Mean</td>
<td>0.88</td>
<td>0.81</td>
<td>0.58</td>
<td>0.34</td>
<td>0.32</td>
<td>0.25</td>
<td>-0.53</td>
<td>-0.48</td>
<td>-0.33</td>
</tr>
<tr>
<td>SD</td>
<td>0.76</td>
<td>0.72</td>
<td>0.31</td>
<td>0.18</td>
<td>0.17</td>
<td>0.11</td>
<td>0.7</td>
<td>0.67</td>
<td>0.25</td>
</tr>
<tr>
<td>Minimus</td>
<td>0.19</td>
<td>0.23</td>
<td>0.18</td>
<td>0.12</td>
<td>0.14</td>
<td>0.09</td>
<td>-2.69</td>
<td>-2.55</td>
<td>-0.84</td>
</tr>
<tr>
<td>Median</td>
<td>0.55</td>
<td>0.45</td>
<td>0.49</td>
<td>0.28</td>
<td>0.28</td>
<td>0.24</td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.31</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.12</td>
<td>2.98</td>
<td>1.29</td>
<td>0.74</td>
<td>0.72</td>
<td>0.45</td>
<td>-0.16</td>
<td>-0.09</td>
<td>-0.15</td>
</tr>
</tbody>
</table>

\( \text{a: Pre-Test, b:Post-Test, e:Experimental Group, d:Difference} \)

A score difference of overall stability indexes of the measures of dispersion is shown as 0.53 in the above table 9. The table also shows a score difference of anterior-posterior measures of dispersion as 0.48 and finally a score difference of medial-lateral dispersion of 0.33. The experimental group had more of an anterior-posterior dispersion than a medial-lateral dispersion as indicated by the difference of 0.15 (subtract 0.33 from 0.48).

Table 10: Pre- and Post-Test Measures of Dispersion of the Control Group

<table>
<thead>
<tr>
<th>MD:Statistics</th>
<th>OI-ac</th>
<th>API-ac</th>
<th>MLI-ac</th>
<th>OI-bc</th>
<th>API-bc</th>
<th>MLI-bc</th>
<th>OI-dc</th>
<th>API-dc</th>
<th>MLI-dc</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Mean</td>
<td>0.92</td>
<td>0.88</td>
<td>0.62</td>
<td>0.65</td>
<td>0.6</td>
<td>0.46</td>
<td>-0.27</td>
<td>-0.28</td>
<td>-0.15</td>
</tr>
<tr>
<td>SD</td>
<td>0.72</td>
<td>0.76</td>
<td>0.4</td>
<td>0.44</td>
<td>0.4</td>
<td>0.29</td>
<td>0.48</td>
<td>0.49</td>
<td>0.29</td>
</tr>
<tr>
<td>Minimus</td>
<td>0.32</td>
<td>0.27</td>
<td>0.21</td>
<td>0.15</td>
<td>0.15</td>
<td>0.12</td>
<td>-1.53</td>
<td>-1.67</td>
<td>-0.97</td>
</tr>
<tr>
<td>Median</td>
<td>0.66</td>
<td>0.63</td>
<td>0.44</td>
<td>0.45</td>
<td>0.43</td>
<td>0.34</td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.1</td>
</tr>
<tr>
<td>Maximum</td>
<td>3.12</td>
<td>3.26</td>
<td>1.73</td>
<td>1.59</td>
<td>1.59</td>
<td>1.19</td>
<td>0.49</td>
<td>0.35</td>
<td>0.3</td>
</tr>
</tbody>
</table>

\( \text{a: Pre-Test, b:Post-Test, c:Control Group, d:Difference} \)
A score difference of overall stability indexes of the measures of dispersion is shown as 0.27 in the above table. The table also shows a score difference of anterior-posterior measures of dispersion as 0.28 and finally a score difference of medial-lateral dispersion of 0.15. The control group had more dispersion anterior-posteriorly than medial-laterally as indicated by the difference of 0.13 (subtract 0.15 from 0.28).

4.6. SUMMARY

The aim of the study was to determine the impact of a Pilates training programme on the postural stability of computer users in the workplace. The objectives of the study were used to assess and describe the overall stability, anterior-posterior and medial-lateral indexes pre- and post the eight week mat based Pilates intervention programme.

Statistically the study showed that there was a difference between the pre and post-test of the experimental group, the pre and post-test of the control group, but more importantly there was a statistical and practical difference between the post-tests of both the experimental and control group.

Statistically the mean overall postural stability score of 0.43 indicated the highest improvement, followed by the anterior-posterior postural stability mean score improvement of 0.35, and a 0.26 improvement of the medial-lateral postural stability mean score post the Pilates intervention programme.

ANCOVA concluded that the following relationships did not play a role in the treatment results:

- the ages of the experimental group pre-test and the control group pre-test,
- the experimental group pre-test and the control group pre-test,
- the height of the experimental group pre-test and the control group pre-test,
- the experimental groups’ height pre-test and control groups’ height pre-test.
The Pilates intervention programme proved to be practically significant. The eta-squared results showed that the size of the treatment effect for all three postural stability scores was large (OI: 0.42; API: 0.29; MLI: 0.30). The eta-squared results showed that the size of the treatment affect for all three measures of dispersion scores was large (OI: 0.35; API: 0.34; MLI: 0.36).
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction
5.2. Effects of Pilates on Work-Related Injuries in Computer Users
5.3. Effects of Pilates on Postural Stability
5.4. Conclusions
5.5. Limitations and Recommendations

5.1. INTRODUCTION

Based upon the body of evidence presented in the literature overview in chapter 2, and guided by the research aim relating to the objectives of the study, this chapter now reports on the outcomes of the statistical analyses of the selected dependent variables of overall postural stability, anterior-posterior and medial-lateral stability. These findings highlight the positive effect of the treatment variable, namely, participation in an eight week mat-based Pilates intervention programme for adult sedentary computer end-users. According to Rydeard, Leger & Smith (2006:472) the Pilates method is a movement system that incorporates a conditioning programme that improves muscle control, flexibility, coordination, strength, and muscle tone. The basic principles underlying the performance of Pilates-based exercises are to create postural awareness and postural alignment, to enhance movement integration, to coordinate breathing with exercise performance, and to increase efficiency and flow of movement.
5.2. EFFECTS OF PILATES ON WORK-RELATED INJURIES IN COMPUTER USERS

The principal findings of literature on ergonomics and work-related injuries reiterate that the human body is not designed to be immobile or to perform repetitive movements (Thibodeau, 1995:322). Individuals who work with computers and/or visual display terminals lead a sedentary working lifestyle and this type of work lends itself to constrained postures, which impart static loads on the neck and entire spine, including the lower back, as well as the shoulders and upper extremities (Waikar and Bradshaw, 1995:16). Sjögaard (1990:1) states that because there is insufficient research on poor posture in the workplace, the result will manifest in the recurrent form of a chronic syndrome of pain and musculoskeletal injuries. Literature clearly provides sufficient evidence of the impact of physical activity and structured exercises on the reduction of work-related musculoskeletal stress, as a result of changes in biomechanical loading of the spine, neural mobilisation, enhanced core stability and functional stability (Johanning, 2000:94; Ose, 2005:161; Pope et al. 2002:49; Press cited in Brukner and Khan, 2007:357).

A plethora of evidence in the acquired literature furthermore demonstrates the importance of an effective intervention programme, such as Pilates, to combat the epidemic of musculoskeletal disorders. Epidemiological studies indicated that low back pain was one of the most widely experienced health-related problems in the world as it affected up to 85% of the population at some time of their lives (Simmonds & Dreinsinger in Durstine & Moore, 2003:217; Press cited in Brukner & Khan, 2007:352). Although the authors reported that back pain improved over a three-month period in the vast majority of incidences, nearly 50% presented with at least one recurrent episode. The authors alarmingly reported low back pain to be the most common disability in those under the age of 45 and posed the most expensive health care challenge in those between the ages of 20- to 50- years.

The multidimensional nature of this chronic condition with a tendency to reoccur, contributed to a large portion of work absenteeism, a resultant loss of productivity and ultimately imposing a significant economic burden on health systems as well as inflicting great costs on society at
large (Bull, Pratt, Shepard and Lankenau, 2006:127). Although official figures could not have been accessed in the processing of this dissertation, an estimated cost to the economy of South Africa for chronic low back pain amounted to more than R2 billion in 1999 (Belot, 2005). According to the Belot (2005) the estimated figure grew to R6 billion in 2002.

Active rehabilitative intervention programmes should be included as a problem management approach to address postural-related musculoskeletal disorders of individuals in the workplace. Hubley-Kozey and Vezina (2002:1106) and Hodges (2003:245) stated that exercises to improve trunk stability reduced the intensity of associated pain, alleviated functional disability, and improved back extension strength, mobility and endurance. Considerable evidence exists pertaining to the role that the trunk muscles play in stabilizing the spine, in addition to the essential role played by the transversus abdominis and lumbar multifidus muscles (Hodges, Eriksson, Shirley & Gandevia, 2003:1873; Muscolino & Cipriani, 2004: 18; Press cited in Brukner and Khan, 2007:375).

Spinal stabilization exercises have been well documented in the management of low back pain over the last decade. Pilates as an alternative method of intervention utilizes spinal stabilization exercises as one of the fundamental principles of movement performance and subsequently proved to be effective in combating the epidemic of musculoskeletal disorders due to a sedentary occupation. Mannion, Kaser, Webber, Rhyner, Dvorak & Muntener (2000:273) and Mannion, Muntener, Taimela & Dvorak (2001:772) ascribed weakness in the paraspinal muscles to histo-morphologic and structural changes which occur due to type II muscle fiber atrophy as a result of disuse and deconditioning. Therefore, part of the significance of this study was embedded in utilising Pilates as a method of intervention to address and restore the structural and functional postural related weaknesses and impairments that is an inherent condition in sedentary occupations, such as in end-computer users.
5.3. EFFECTS OF PILATES ON POSTURAL STABILITY

Kendall, McCreary, Provance, Rodgers and Romani (2005:59) define a good posture as a state of muscle and skeletal balance which protects the supporting structures of the body against injury or progressive deformity. Under such conditions the muscles will function more efficiently and the optimum positions are afforded for the thoracic or abdominal regions. According to the authors, thoracic kyphosis is known to alter the shape of the thoracic cage, decrease the anterior-posterior diameter of the thorax, thus reducing the distance between the xiphisternum and pubis, and alter the position of the ribcage so that it surrounds the abdominal cavity.

Postural stability can be assessed through the limits of stability and limits of stability can be defined, under dynamic conditions, as “the maximum displacement of the center of body mass during a feet-in-place response to external postural perturbations that can be controlled without a fall or a step” (Mancini, Rocchi, Horak and Chiari, 2008:450). Control of body segments is needed for the coordination and production of anticipatory adjustments that would counteract the critical perturbations of posture (De Nunzio, Nardone and Schieppati, 2007:258).

Brukner and Khan (2007:163) emphasized the importance of trunk muscle strength, muscle control, muscle endurance and patient education in the performance of Pilates stabilisation exercises. The Pilates exercise intervention programme utilised in this study includes the before mentioned components. Furthermore a core body of evidence explored Pilates as an effective and efficient intervention programme for low back pain. Anderson, Butler and Roach (2006) used a six week randomised control trial to examine whether subjects with chronic low back pain or recurrent low back pain improved on pain and disability measures. The results demonstrated greater improvements with regards to pain and disability in the Pilates groups than in the massage groups. The same authors concluded that the Pilates method therefore improves low back pain and is an effective mode of rehabilitation for persons with low back pain. La Touche, Escalante and Linares (2007) conducted a systematic review to analyse specific articles where the Pilates method was used as treatment for non-specific low back pain.
pain. The studies chosen were clinical trials and randomised control trials. All the studies under investigation supported each other by displaying positive results when using the Pilates method as exercise intervention for persons with low back pain. The studies showed effects, such as improved general function and reduction in pain, when applying the Pilates method.

One of the aims of the study was to determine whether the Pilates intervention would cause any changes in the anterior-posterior and medial-lateral stability scores. The Pilates intervention programme addressed the musculo-skeletal symmetry and range of motion whilst increasing the extensibility of the relevant muscles and connective tissue. Tortora (2005:259) proposed that an additional benefit of the Pilates programme which includes flexibility reduced the effects of gravitational forces acting on the body and improper posture due to incorrect alignment of soft tissues, hence acting to improve and maintain good posture.

The body of evidence confirms that overall postural stability, anterior-posterior postural stability and medial-lateral postural stability improved.

5.4. CONCLUSIONS

The rationale of the study to determine the effects of the Pilates intervention programme on computer users yielded significant positive results in the overall, anterior-posterior and medial-lateral postural stability indexes. The quantitative data analysed in this study has become a very useful tool outlining the relevance of a Pilates exercise programme designed for postural awareness. The steady rise of work disabilities relating to neck and lower back pain continues to burden both the employer and employee. The role of postural education should not be underestimated and maintenance thereof should be incorporated in everyday functioning. This should become the responsibility of both the employer and employee in future postural awareness and pain management.
5.5. LIMITATIONS AND RECOMMENDATIONS

In all studies there are a number of factors that limit the outcome or have an effect on the study’s results. The following limitations could have had an impact on the results obtained in the study.

The relative small sample size based on sedentary volunteer end computer users and more importantly, the restricted use of beginner level mat-based exercises only, without being able to progress to intermediate and advanced level of Pilates exercises, posed to be a challenge for the researcher. Furthermore, having access to more than one Pilates instructor to train a group of four participants at one session should address the problem at hand and therefore increase the reliability and validity of the outcomes of the study. Also diversity of the level of Pilates taught.

Due to the time constraints on behalf of the participants, who had to fit the sessions into their lunch hour break and traveling to the Pilates venue, an eight week intervention period was followed. Ideally, an extended duration of at least 12 weeks of Pilates intervention training should be followed to obtain more specific and reliable results to bridge the gap in documented evidence of the long-term effect of Pilates training on the human body. Longitudinal studies were also lacking in the literature retrieved.

A further limitation was the diverse sample age range which could have influenced the physiological response to the Pilates exercises. An investigation into the age-related physiological responses to Pilates exercises would be an interesting study to pursue.

During this study there was consistent positive feedback from the participants post the intervention programme. A further recommendation for future studies would be the exploration of the research participants’ experience of the Pilates.
To summarize, the suggestions for further research would be as follows:

- To explore and describe the effects of a Pilates intervention programme using a larger sample size,
- To determine the effects of a Pilates intervention programme on homogenous age groups of a specific gender,
- To explore and describe the effects of a 12-week Pilates intervention programme on other selected health-related dependent variables, such as functional core strength, upper and lower body strength, as well as flexibility,
- To determine the effects of using the Pilates reformer as specialized equipment as a Pilates specific training method on aforementioned selected variables, and
- To explore and describe psychosocial outcome measures for those with low back pain being treated with Pilates as a method of intervention.
REFERENCES


Chessher, M. 1998. Pilates: there’s a reason celebrities love it and gyms are scrambling to offer classes; who doesn’t want to look taller and slimmer? *Weight Watchers Magazine*, 31(7):44.


Appendix A: INFORMATION AND INFORMED CONSENT FORM

<table>
<thead>
<tr>
<th>Title of the research project</th>
<th>Pilates for Postural Stability in Computer Users.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal investigator</td>
<td>Lana Strydom</td>
</tr>
<tr>
<td>Address</td>
<td>143 River Road</td>
</tr>
<tr>
<td></td>
<td>Walmer</td>
</tr>
<tr>
<td></td>
<td>Port Elizabeth</td>
</tr>
<tr>
<td></td>
<td>6070</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
</tr>
<tr>
<td>Contact telephone number</td>
<td>722562042</td>
</tr>
</tbody>
</table>

**A. DECLARATION BY OR ON BEHALF OF PARTICIPANT:**

<table>
<thead>
<tr>
<th>I, (the undersigned), ______________________________ (name)</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.D.No._________________________________________________</td>
<td></td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>I, in my capacity as __________________________ (relationship)</th>
</tr>
</thead>
<tbody>
<tr>
<td>of the participant ____________________________ (name)</td>
</tr>
<tr>
<td>I.D. No._________________________________________________</td>
</tr>
<tr>
<td>of ____________________________________________________</td>
</tr>
<tr>
<td>_________________________________________________________ (address)</td>
</tr>
</tbody>
</table>
### A.1. I HEREBY CONFIRM AS FOLLOWS:

<table>
<thead>
<tr>
<th></th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> I, the participant, was invited to participate in the above mentioned research project which is being undertaken by Lana Strydom of the Department of Human Movement Science in the Faculty of Health Science at the NMMU.</td>
<td>-</td>
</tr>
<tr>
<td><strong>2.2. Procedures:</strong> I understand that I will be tested on the Balance Biodex System at the NMMU in June and again in September 2007</td>
<td>-</td>
</tr>
<tr>
<td><strong>2.3. Risks:</strong> N/A</td>
<td>-</td>
</tr>
<tr>
<td><strong>2.4. Possible Benefits:</strong> As a result of my participation in this study I will have my postural stability recorded on the Balance Biodex Balance System at the NMMU.</td>
<td>-</td>
</tr>
<tr>
<td><strong>2.5. Confidentiality:</strong> My identity will not be revealed in any discussion, description or scientific publications by the principle investigators.</td>
<td>-</td>
</tr>
<tr>
<td><strong>2.6. Access to findings:</strong> Any new information/or benefit that develops during the course of the study will be shared as follows: via email or telephone.</td>
<td>-</td>
</tr>
<tr>
<td><strong>2.7 Voluntary participation/refusal/discontinuation:</strong></td>
<td>-</td>
</tr>
<tr>
<td>My participation is voluntary:</td>
<td>Yes [ ] No [ ]</td>
</tr>
<tr>
<td>My decision whether or not to participate will in no way affect my present or future medical care/employment/lifestyle:</td>
<td>Yes [ ] No [ ]</td>
</tr>
</tbody>
</table>
3. The information above was explained to me/the participant by Lana Strydom in English and I am in command of this language and I was given the opportunity to ask questions and all these questions were answered satisfactorily.

4. No pressure was exerted on me to consent to participation and I understand that I may withdraw at any stage without penalisation.

5. Participation in this study will not result in any additional cost to myself.

A.2. I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE ABOVE MENTIONED PROJECT:

Signed/confirmed at ___________________________ (place) on ________________ 2007.

Signature of participant: ________________________________

Signature of witness: ________________________________

Full name of witness: ________________________________
## B. STATEMENT BY INVESTIGATOR:

I, Lana Strydom, [I.D.No. 8308030251085], declares that

I have explained the information in this document to ____________________________ (participant);

He/She was encouraged and given ample time to ask me any questions;

This conversation was conducted in English and Afrikaans where necessary.

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**I have detached Section C and handed it to the participant:**

Signed at _____________ on _________________ 2007

Signature of investigator ______________________________

Signature of witness ______________________________

Full name of witness ______________________________

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## C: IMPORTANT MESSAGE TO PARTICIPANT:

Dear Participant,

Thank-you for your participation in this study. Should, at any time, during the study, an emergency arise as a result of the research, or you require further information with regard to the study,

Kindly contact Lana Strydom at 0722562042.
Appendix B: LETTER TO EACH PARTICIPANT IN THE EXPERIMENTAL GROUP

Dear Participant

You are being asked to participate in a research study. We are going to give you information that will help you understand, its purposes and its aims. It will also explain what you will be asked to do during the study, the risks and the benefits, and your rights as a participant in this research study. If anything is not clear please feel free to ask the researcher to clarify it to you.

You will be asked to give your approval in the form of a written consent that will include your signature, date, and initials to verify that you understand and agree with the conditions pertaining to the research project.

You reserve the right to ask questions concerning the research study at any time. It would be appreciated if you could immediately report to the researcher any problems you may have during the study. Please call the number listed below or simply email the researcher with any further queries or worries.

The Human Resources Ethics Committee (HREC) has approved this research study at the NMM University. The HREC is a group of independent experts whose responsibility is to help and ensure that the right to health and welfare of the participants in research are protected and that the study is carried out in an ethical manner. This research study cannot be conducted without the HREC approval. If you would like to contact the HREC with any further questions please contact the Research Management at (041) 504 4536.

Participation in research is completely voluntary. You are not obliged to take part in research, and if you choose not to participate, your present and/or future medical care will not be affected in any way. You will also not incur a penalty and/or loss of benefits to which you may be otherwise entitled.

If you agree to partake in the research study, you have the right to withdraw at any given time, during the study without penalty or loss of benefits. However, if you do withdraw, you should return for the final discussion in order to terminate the research in an orderly manner.
The nature of the research study that you will be involved in is an experiment with a group of adults. We will measure your postural stability using the Biodex Balance Stability System. Thereafter, an 8 week Pilates training programme will be provided to you, which you will need to comply with throughout the study. Your postural stability will again be evaluated after the Pilates training programme to measure any fluctuations.

The improved posture, after the Pilates training programme, will positively aid in developing a strong muscular system in the stomach area. The Pilates training programme should have a positive effect on your posture while seated at the computer for many hours of each week. In a technological working environment posture will become the essence to better performance levels.

This informed consent has been prepared in accordance with current Medical Research Council guidelines. Please remember that this study can be terminated at any time by the researcher or the HREC that initially approved it.

Please feel free to contact me at any time during this research study!

Yours Faithfully

Lana Strydom

0722562042
Appendix C: LETTER TO EACH PARTICIPANT IN THE CONTROL GROUP

Dear Participant

You are being asked to participate in a research study. We are going to give you information that will help you understand, its purposes and its aims. It will also explain what you will be asked to do during the study, the risks and the benefits, and your rights as a participant in this research study. If anything is not clear please feel free to ask the researcher to clarify it to you.

You will be asked to give your approval in the form of a written consent that will include your signature, date, and initials to verify that you understand and agree with the conditions pertaining to the research project.

You reserve the right to ask questions concerning the research study at any time. It would be appreciated if you could immediately report to the researcher any problems you may have during the study. Please call the number listed below or simply email the researcher with any further queries or worries.

The Human Resources Ethics Committee (HREC) has approved this research study at the NMM University. The HREC is a group of independent experts whose responsibility is to help and ensure that the right to health and welfare of the participants in research are protected and that the study is carried out in an ethical manner. This research study cannot be conducted without the HREC approval. If you would like to contact the HREC with any further questions please contact the Research Management at (041) 504 4536.

Participation in research is completely voluntary. You are not obliged to take part in research, and if you choose not to participate, your present and/or future medical care will not be affected in any way. You will also not incur a penalty and/or loss of benefits to which you may be otherwise entitled.
If you agree to partake in the research study, you have the right to withdraw at any given time, during the study without penalty or loss of benefits. However, if you do withdraw, you should return for the final discussion in order to terminate the research in an orderly manner.

The nature of the research study that you will be involved in is an experiment with a group of adults who make use of computers in their everyday work setting. We will measure your postural stability using the Biodex Balance Stability System, and after an 8 week period we will retest on the same System.

The tests used to measure your postural stability are easy and will not harm you in any way. These tests will provide you with the insight of your postural stability, as well as motivating you towards engaging in a Pilates training programme to improve your everyday work experiences.

This informed consent has been prepared in accordance with current Medical Research Council guidelines. Please remember that this study can be terminated at any time by the researcher or the HREC that initially approved it.

Please feel free to contact me at any time during this research study!

Yours Faithfully

Lana Strydom

0722562042
Appendix D: PROTOCOLS FOR PERFORMING A POSTURAL STABILITY TEST

1. Position the support handles as per patient protocol.
3. At the Main Menu, touch <testing>. The Testing Menu screen should now be displayed.
4. Touch <Postural Stability>. The user Setup Information screen should now be displayed.
5. Touch the <Keypad> icon for the “Name” and enter the participant’s name. Touch <OK> to return to the User Setup Information screen.
6. Touch the <Keypad> icon for “Age” and then enter the patient's age. Touch <OK> to return to the User Setup Information screen.
7. Touch the appropriate <Height> key to highlight the patient height range setting desired. Touch <Next> to advance to the Patient Position screen.
8. Position the patient on the system and explain the test protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
9. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient’s left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Postural Stability Testing screen.
10. At the Postural Stability testing screen, touch <Stance> to scroll through the three stance positions provided: left right or both.
11. Touch <Tracing> to toggle tracing On or OFF as desired.
12. Touch <Clear Tracing> to clear any tracing that remains from previous tests.
13. Touch <More Options> to advance to the Postural Stability Test Options screen if desired. Here the Time Trial Time is set as 20, Test Trials as 3, Rest Countdown as 10, Platform Settings as 8, and toggle the bilateral comparison to “No”. Touch <OK> to confirm your selections and return to the Postural Stability Testing screen.
14. Press <Start> to release the platform (if not static) and activate the Postural Stability Test screen.
15. With the patient ready to begin the test, touch <Collect Data>. The screen will provide a three-second countdown before beginning the first of three test trials. The display screen will show Total Trial Time, Platform Setting and Stance to the left of the grid. Trial Number and score are displayed to the right of the grid.

16. After completing the tests, a “Test Complete” message is displayed. Touch the <Results> to advance to the Postural Stability Test Results screen.

17. At the Postural Stability Test Results screen, Touch <Print> to automatically generate a printed report.
Appendix E: MECHANICS AND FUNCTIONING OF THE BIODEX BALANCE SYSTEM
Appendix F: PILATES INTERVENTION PROGRAMME

Warm up
Breathing
Imprint and Release
Hip Release
Spinal Rotation
CAT stretch
Hip Rolls
Scapula Isolation
Arm Circles
Head Nods
Elevation and Depression of Scapulae

Exercises
Ab Prep
Breast Stroke Prep 1,2,3
Shell Stretch
Hundred
Half Roll Back
Roll Up
One Leg Circle
Spine Twist
Rolling like a Ball
Single Leg Stretch
Obliques
Double Leg Stretch prep
Scissors
Shoulder Bridge Prep
Roll Over Prep
One Leg Kick
Breast Stroke
Shell Stretch
Saw
Neck Pull
Obliques Roll Back
Side Kick
Side Leg Lift Series 1,2,3,4,5
Spine Stretch Forward
Single Leg Extension
Swimming
Shell Stretch
Leg Pull Front
Seal
Side Bend
Push UP
Appendix G: STATISTICAL DATA ON THE BIODEX BALANCE