AN EVALUATION OF THE EFFECT OF A COMPUTER-RELATED PARTICIPATORY ERGONOMICS INTERVENTION PROGRAMME ON ADOLESCENTS IN A SCHOOL ENVIRONMENT: A RANDOMISED CONTROLLED TRIAL

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DECLARATION

I, Ingrid Vanessa Sellschop, declare that this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signature of the Candidate

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PUBLICATIONS AND PRESENTATIONS ARISING FROM THIS STUDY

RESEARCH PUBLICATIONS

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PRESENTATIONS AT CONGRESSES:

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3. Pain South Africa Congress – Durban 2013.Platform presentation:
   Sellschop, I., Myezwa, H., Mudzi, W., Mbambo-Kekana, N. The effect of a computer-related ergonomics intervention on pain, pain catastrophising and posture in adolescents in a school environment.

ABSTRACT

Computer use is increasing among children and thus the potential for related musculoskeletal pain and postural changes is increasing concomitantly. From an early age children are spending more time in front of computers and television, which encourages a static and passive lifestyle. The cumulative effect of this technology-induced, sedentary lifestyle leads to improper posture as well as pain, repetitive strain injury and dysfunctional movement patterns that can potentially carry into adult life. For this reason, there is a need for designing, implementing and assessing the effectiveness of a participatory ergonomics intervention programme in a school environment in South Africa.

This study consisted of two phases: the main objective of phase one comprised a cross-sectional study to determine the prevalence of musculoskeletal pain and pain catastrophising in grade eight learners working on computers in a school environment; and to determine the body areas most commonly affected by pain among learners routinely exposed to computers; and to measure the observed posture of adolescents working on computers in a school environment; and to establish the attitude of the teachers and principals towards ergonomics in schools. Phase two was a randomised control trial, with the objective to determine the effect of a participatory computer-related ergonomics intervention programme on grade eight learners in terms of the effect on musculoskeletal pain while working on a computer, pain catastrophising, and postural change and ergonomic behaviour.

Sample Selection:

a) **School sample**

Private independent schools were selected to participate in the study because they have principally similar socio-economic ecologies. The particular populations of learners selected for this study were exposed more frequently and with higher intensity to computer use, both at home and at school than is currently the case in less privileged socio-economic environments. Two schools were chosen using randomised cluster sampling from a population of 27 independent co-educational secondary schools in the greater Johannesburg region (Appendix D).

b) **Learner Sample**

The learner sample included all grade eight learners from all three classes at the two randomly selected private schools in the greater Johannesburg region who were invited to participate in the study (n=127). Consecutive sampling was done according to specific inclusion and exclusion criteria.

c) **Teacher and Principal sample**

A convenience sample (n=18) of teachers and principals who responded to the questionnaire was used in this study.

Procedure:

Phase one: A self-report questionnaire was used to obtain demographic data and to measure pain. Pain catastrophising levels were measured with a pain catastrophising scale for children (PCS-C) and observed posture was measured using the Rapid Upper Limb Assessment tool (RULA). The ergonomics of the computer laboratories of the two schools was assessed using the Computer Workstation Design Assessment form (CWDA). The attitude of the teachers and principals of the schools were measured using a self-report questionnaire.

Phase two: A single blind randomized control trial was conducted (pre and post intervention assessment). School A and school B were randomly allocated to either a control group or an intervention group. Allocation into groups was done using concealed allocation with assessor blinding and therefore, the researcher and the research assistant were blinded to group allocation as well as to the delivery of the ergonomic intervention programme to the participants so as to limit assessment bias. The study was conducted over a period of six months. The intervention and control groups were assessed at baseline prior to the intervention and then at three months and six months post-intervention.

The control group and the intervention group were required to answer a validated Computer Usage Questionnaire (CUQ) (Smith, 2007) and the Pain catastrophising questionnaire (PCS-C) (Vervoort et al., 2008) at baseline and at three and six month intervals post-intervention. All the participants underwent biometric measurements of person height, weight, school bag weight and postural analysis using the RULA (Rapid Upper Limb Assessment) (McAtamney and Corlett, 1993) method of observation. The learners from the control and intervention group had their postures assessed with RULA while they were using a computer at school during a computer lesson at baseline, three months and six months.

The computer-related ergonomic intervention programme was developed with reference to the literature from the few intervention studies that have been done (Ismail et al., 2010; Robbins et al., 2009; Heyman and Dekel, 2009) and it was evaluated by four educators, eight learners and an expert in the field of ergonomics during the pilot study and modified accordingly. The intervention was delivered by a physiotherapy lecturer who was trained in the delivery of the intervention programme.

The intervention group received a 45 minute participative intervention programme comprising an educational ergonomic component on posture and workstation set-up and a component of stretches for the neck, shoulders and lower back. This was in the format of a visual power point presentation with planned activities for the participants.

A poster demonstrating correct workstation set-up and a variety of stretches was put in the computer classroom of the intervention group. Thereafter, each learner participant was given a sticker to place on their computer screen at home and at school. This sticker, in the form of a red dot, acted as a reminder to the learner participants to adjust their posture and to do their stretches during the time that they spent on the computer. A free web-based link was given to each participant to download onto their home computer to reinforce the reminder of doing stretches and taking regular short breaks from computer use when at home.

All participants were given a short multiple choice questionnaire test immediately after the intervention to test their comprehension and understanding of the ergonomic concepts that they had been taught during the intervention programme.

The control group participants were not exposed to any ergonomic intervention programme as they were in a different school.

At three months and six months post-intervention, the research assistant repeated all the biometric measurements of the learners with regards to height, weight and school bag weight. In addition, the researcher repeated the RULA analysis of the learners' posture and all the learners who had agreed to participate in the study answered the same questionnaires that they had answered in phase one of the study. The same venue at each school was used at each measurement interval to ensure consistency of environment for accurate measurement purposes.

The RULA (postural assessment) measurements were conducted during the week after the biometric measurements and questionnaires were completed. RULA measurements were conducted by the researcher during the Information technology and design lesson in the computer laboratory of each school. RULA measurements were done by observing each learner for one minute while they worked on a computer during their computer lesson. The computer lesson was 45 minutes in length and the observation process started 10 minutes after the start of the computer lesson. The learners were observed from the dominant hand side and from a side-view during the RULA measurement process.

Results:

Results showed a high prevalence of musculoskeletal pain (77%) in the adolescents in a school environment. A prevalence of rate of 34% was found for learners experiencing musculoskeletal pain while working on computers and a significant percentage (31.4%) of the learners were observed to be in a category 4 action level. In phase two of this study, there was a significant difference ($p<0.05$) in the prevalence rate of musculoskeletal pain relating to computer use between the control (25.8%) and the intervention (42.6%) groups at baseline. After six months, there was no significant difference ($p<0.52$) between the control and intervention groups which may be due to the positive effect of the intervention. However, the withinin group analysis of the prevalence rate of musculoskeletal pain while working on a computer in the intervention group had reduced significantly ($p<0.000$) from 42.6% to 18% over a period of six months, compared to the control group which only had a small reduction in symptoms from 25.8% to 24.2% ($p<0.39$). This suggests that the computer-related ergonomic intervention programme had a positive clinical effect on musculoskeletal pain in learners in the intervention group, but no statistically significant effect was found in the between group analysis over a period of six months.

The results indicated that more than one body area was affected by pain in some of the learners. In the intervention group 21.5% of the learners experienced musculoskeletal symptoms in their right shoulder, 18.6% in their lower back, 16.8% in their left shoulder, 9.3% in their neck and 9.3% in their upper-mid back area. Pain catastrophising scores for the total sample of learners (Mean=25.12, SD = 8.1) were measured using the PCS-C survey. A PCS score of 30 refers to the 75 percentile and is clinically relevant in terms of predicting the risk for developing chronic pain. A large portion of learners (73.2%) scored below the clinically significant 75th percentile (a score >30) and 26.8% scored above a score of 30, indicating that this percentage of learners had clinically significant catastrophising scores.

The average PCS score of both the control and intervention groups decreased over a period of six months and within each group there was a significant decrease in the total PCS score from baseline over a period of six months (p<0.00). In order to determine if the intervention programme had an effect on pain catastrophising in learners, pain catastrophising for the two groups was tested using the statistical test, repeated measures of analysis of variance (ANOVA) to show between group changes. The findings showed that over a period of time, between baseline and three months, there was a significant change in pain catastrophising between the control group and intervention group (p<0.001), however, there was no significant change in pain catastrophising between the two groups at six months (p<0.68), which indicates that the intervention had a positive effect on pain catastrophising in the learner intervention group.

The within group changes were significant (p<0.001) for both groups for pain catastrophising between baseline and six months. This similarity of findings of within group changes between the two groups means one cannot determine if these changes were because of the intervention or because of the Hawthorne effect (an observational bias which occurs when human subjects change their behaviour because they think that they are being observed during an experiment) (Gale, 2004) from the researcher's presence.

None of the learners from this study adopted a posture to qualify for action level 1 (AL 1) in either the control or intervention groups. The majority of learners from both groups (40.9% control and 42.6% intervention) were found to be in AL 2 and Al 4 (36.4% for the control and 26.2% for the intervention group). A large percentage of learners from the schools in this study were found to sit in awkward postural positions that could put them at risk of developing musculoskeletal pain. In this current study there was a significant improvement in the number of learners in the intervention group who shifted from AL 4 to AL 2 and AL 3. At six months post-intervention, there were no learners in AL 4 and the number of learners in AL 3 had reduced from 26.2% at baseline to 14.8% (p<0.001) at six months. The control group RULA scores worsened over the period of six months. Although the learners were still not in an "acceptable" range of postural positions, there was a significant improvement on the pre-intervention stage compared with the post-intervention stage, possibly because of the Hawthorne effect.

In terms of determining risk factors for developing musculoskeletal pain during computer use, the results showed that only the learners at baseline who worked for more than or equal to 2.5 hours per week on a computer were more at risk for developing pain (OR 2.7, $p=0.02$) compared to those who worked for less than 2.5 hours per week on a computer. Furthermore, only the learners with pain catastrophising scores ≥30 at three months were found to be at risk for developing musculoskeletal pain (OR 3.34,$p<0.001$).

The set -up of the computer workstation environment in both the control and intervention schools were found to be inadequate. There were non-standardised and non-adjustable desks and chairs in both schools' computer laboratories and the workspace area of the desk in the intervention school laboratory was compromised. The monitors in both schools were non-adjustable in terms of their height and angle of inclination. With regards to the knowledge of ergonomics amongst teachers from the study, only 13% of the teachers (n=18) had undergone training in ergonomics skills and none of the teachers were satisfied with their knowledge relating to computer-related ergonomics. Finally, the computer-related ergonomics programme in terms of its content was found to be valid and feasible for the South African context.

Conclusion:

This study showed that an ergonomic intervention programme can be effective in reducing the impact of the poor posture in adolescents using computers in schools.

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LIST OF ABBREVIATIONS

AL	– Action Level
ANOVA	– Analysis of Variance
BMI	– Body Mass Index
BRULA	– Baseline Rapid Upper Limb Assessment
CCEI	– Computerised Classroom Environment Inventory
CONSORT	– Consolidated Standards of Reporting Trial
CUQ	– Computer Usage Questionnaire
CWDA	– Computer Workstation Design Assessment
HREC	– Human Research Ethics Committee
IASP	– International Association of the Study of Pain
ICC	– Intraclass Correlation Coefficient
ICDL	– International Computer Drivers Licence
ICT	– Information and Communication Technology
IT	– Information Technology
MCQ	– Multiple Choice Questionnaire
MSP	– Musculoskeletal Pain
NCTE	– National Computer Training Evaluation
PCS	– Pain Catastrophising Scale
PCS-C	– Pain Catastrophising Scale-Children
PE	– Participatory Ergonomics
PEDRO	– Physiotherapy Evidence Database
POE	– Postural Observational Examination
PPAM	– Passive Physiological Accessory Movement
RCT	– Randomised Control Trial
RULA	– Rapid Upper Limb Assessment
SD	– Standard Deviation
SPSS	– Statistical Software Package for Social Sciences
TPCS-C	– Total Pain Catastrophising Scale/score for Children
UNESCO	– United Nations Educational, Scientific and Cultural Organisation
VDU	– Visual Display Unit
VNPS	– Visual Numerical Pain Scale
WMSD	– Work-related Musculoskeletal Disorders

CHAPTER 1

1. INTRODUCTION

1.1 BACKGROUND AND NEED

The use of computer/Information technology by children in a variety of forms such as laptops, desktops and iPads is growing rapidly. Children are using computers for education, leisure pursuits and communication, in both school and home environments (Pollock and Straker, 2003). Worldwide, there is an increase in the use of information and communication technology (ICT) in school education (Pollock and Straker, 2003; Harris et al., 2005). A study done in the United States in 2000, found that 89.6% (n=655) of children aged between six and 17 years, had access to a computer with 20% accessing it at home and 80% at school (Newberger, 2001).

Policy development on ICT education in South Africa dates back to 1995 when education policy and decision makers proceeded to counter the digital divide by initiating programmes for digital inclusion resulting in the adoption of the e-Education White paper in 2004 (Isaacs, 2007). A report by Isaacs (2007) showed that in the Gauteng province of South Africa, 94.5% of 1 897 schools had computers while 78.8% of these schools were using computers for teaching and learning.

Nationally, out of 25 582 schools, 50.9% of schools have access to computers while 22.6% are using computers for teaching and learning (Isaacs, 2007). Computer access in schools may have implications in terms of learners' predisposition to developing musculoskeletal pain in the future.

Musculoskeletal problems reported by school children using computers have often been linked to poor posture (Robbins et al., 2009). Furthermore, recent research on the ergonomics of computer use by children has investigated the potential effects of computer use on a child's health and productivity (Pollock and Straker, 2003). The findings suggest that children using computers may be at risk of developing problems related to the musculoskeletal system (Straker et al., 2000; Heyman et al., 2001; Harris et al., 2005).

While the use of technology will improve a learner’s educational pathways, it also introduces the possibility of exposing young people to poor postural habits and repetitive strain injuries resulting in musculoskeletal pain. Current literature on children shows that a number of causal mechanisms relating to overuse have been outlined as affecting the posture of adolescents and causing neck and back pain, namely: carrying heavy schoolbags; poorly-designed school furniture and a poor fit of furniture to body size; poor muscle strength and motor control; poor and sustained sitting postures when using computers (LeResche et al., 2005).

The prevalence of pain and musculoskeletal pain syndromes in adolescent students relating to lower back pain and upper limb pain is reported to be 40%, (Zapata et al., 2006). As the use of computers increases, there is a concomitant increase in the prevalence of musculoskeletal pain (MSP) among older children and adolescents (Harris et al., 2005; Straker et al., 2000). Back pain and headaches are increasingly common among adolescents, affecting 20% to 50% of the teenage population in developed countries (Jordaan, 2005). Many adults with persistent pain report that their pain condition first occurred during adolescence (Ghandour et al., 2004; LeResche et al., 2005).

Persistent and recurrent pain in adolescence can lead to chronic pain, disability and emotional distress (Sullivan et al., 2001). It has been shown that pain catastrophising is one of the most robust predictors of heightened pain, disability and emotional distress (Sullivan et al., 1995, 2001). A high pain catastrophiser may report a higher level of pain intensity and may not respond to an intervention in the same way as a low pain catastrophiser therefore impacting on the effect of the intervention (Sullivan et al., 2001). Therefore, for the purposes of this study, the psychosocial risk factor of pain catastrophising was measured to assess if pain catastrophising could be influenced, or have any influence on the effect of an ergonomic intervention in a school environment.

Within Africa, prevalence rates of lower-back pain among adolescents are reported to be on the increase (Louw et al., 2007). A study conducted in the Western Cape, South Africa, assessed computer-related musculoskeletal pain and found that the prevalence of musculoskeletal pain among the sample of learners was 74% (Smith et al., 2007).

Participatory ergonomics (PE) are described by Hignett (2001) as: “a concept involving the use of participative techniques and various forms of participation in the workplace”. Wilson (1991) defined participation in ergonomics as: “the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals” (Wilson, 1991, Hignet et al., 2005). Kourinka, (1997) defined participatory ergonomics as “practical ergonomics with participation of the necessary actors in problem solving” and a recent study by Jacobs and Runge (2007) reported that participatory ergonomics training involved students in the planning, developing and implementation of ergonomic solutions in their use of notebook computers in the classroom (Kourink, 1997, Jacobs and Runge, 2007). In the context of this present study,the use of the phrase”participatory ergonomics program” refers to the participative nature of the intervention due to the fact that learners were encouraged to participate in problem solving strategies related to the correct use of schoolbags, computer workstation adjustments and role modelling through out the implementation of the interactive visual ergonomic presentation.

Ergonomic intervention studies in a school environment have a positive outcome by increasing children’s awareness of body mechanics, movement and posture (Heyman and Dekel, 2001; Shinn et al., 2002). Shinn et al. (2002) concluded that there is a need for preventative education on computer use for school-aged children and Williams and Jacob, (2002), further support the concept of educating students in ergonomics by employing strategies that involve active participation by the students themselves.

There is growing evidence that other aspects of back pain prevention in children, such as adapting school furniture to students’ needs are important. Equally important is training in relevant ergonomic subjects. Long-term prevention programmes should form part of the school curricula. Merely adapting school furniture has, on its own, proved to be neither viable nor sustainable for preventing back pain in adolescence (Linton et al., 1994; Milanese and Grimmer, 2004). It is therefore important to assess posture and ergonomic behaviour of adolescents in a school environment so that an effective ergonomic intervention programme can be designed and implemented at a sustainable level and reduce unnecessary health-related costs in the longer term.

1.2 PROBLEM STATEMENT

Computer use is increasing among children and thus the potential for related musculoskeletal pain and changing postural habits is increasing concomitantly. From an early age children are spending more time in front of computers and television, which encourages a static, sedentary and largely passive lifestyle. The cumulative effect of this technology-induced, inactive lifestyle leads to improper posture as well as pain, repetitive strain injury and dysfunctional movement patterns that can potentially carry over into adult life and adds to the burden of disease in any population. Currently, there is no evidence of ergonomic intervention studies that have been done in South Africa or in Africa in general and thus there is a gap in the knowledge of how an ergonomic intervention programme will affect adolescent students in the South African context in terms of musculoskeletal pain and posture.

In addition, the knowledge gained from this randomised controlled longitudinal study will add value to the international body of knowledge by highlighting areas of the longitudinal effect of the ergonomic intervention on posture of adolescents working on computers in a school environment; and whether the psychological determinant of pain catastrophising amongst learners has an effect on the outcome of the intervention programme.

1.3 RESEARCH QUESTION

What effect will a participatory computer-related ergonomics intervention programme in a school environment have on musculoskeletal pain, postural changes and ergonomic behaviour experienced by adolescents?

1.4 AIM

This study aimed to determine the effect of a participatory ergonomics intervention programme addressing musculoskeletal pain, postural changes and ergonomic behaviour in adolescents in a school environment.

1.4.1 Research Objectives

This study had two phases:

Phase one was primarily concerned with determining the prevalence of musculoskeletal pain and associated risk factors among adolescents in a school environment. The main objectives were:

a) **Musculoskeletal pain**

- To determine the body areas most commonly affected by pain among adolescents routinely exposed to computers at school and in a home environment.

- To determine the prevalence of pain catastrophising in adolescents in a school environment.

- To determine the risk factors for developing musculoskeletal pain during computer use by adolescents.

b) **Posture**

- To establish postural changes that occur in adolescents while using a computer during a computer lesson.

c) **Ergonomics of the school environment**

- To evaluate the ergonomic set-up of workstations in a school computer laboratory using a Computer Workstation Design Assessment (CWDA) tool.

- To establish the attitudes and knowledge of teachers and principals in respect of ergonomics in the school environment.

- To assess the feasibility and content validity of a computer-related ergonomics intervention programme developed for grade eight learners in a South African school environment.

Phase two of this study focused primarily on the assessment of the effect of a participatory computer-related ergonomics intervention programme in a school environment on musculoskeletal pain, posture and ergonomic behaviour experienced by adolescents. The main objective was:

- To determine the effect of an intervention programme on musculoskeletal pain, pain catastrophising and posture in adolescents working on a computer in a school environment.

1.5 RELEVANCE OF THE STUDY

The regular use of computers and the potentially debilitating effects of this on adult life warrant the need for designing, implementing and assessing the effectiveness of a participatory ergonomics intervention programme in a South African school environment. Musculoskeletal pain affects productivity and can, in the longer term, result in a socio-economic burden of health problems related to poor ergonomic behaviour.

An ergonomic intervention is relatively simple and inexpensive to implement and thus can be an integral part of life skills within a school curriculum. Introducing and assessing the effect of such an intervention on adolescents within the South African context will create a foundation for establishing a knowledge base of teaching life skills to learners in South African schools that can benefit their future health related to their musculoskeletal system. This study will be of value in terms of encouraging educationalists and stakeholders in the education environment to take cognisance of the fact that although the youth are vulnerable and predisposed to developing musculoskeletal pain related to computer use, there are interventions that may be economically viable and effective. This further endorses the need for this study and emphasises the significance of such a study for all stakeholders involved in the education and health of learners in South Africa. Furthermore, this was a longitudinal study and it was therefore unique in terms of assessing the effect of an intervention programme over a prolonged period of time.

In chapter two, this dissertation presents a detailed review of the literature relating to the study. A description of the development of the ergonomic intervention programme is included in chapter three while the study design, methodology and the key learning points from the pilot study are included in chapter four. The results of the main study are presented in chapter five, and a detailed discussion of these results is given in chapter six. Finally, chapter seven presents the main findings and conclusions that emerged from this study.

CHAPTER 2

2. LITERATURE REVIEW

SECTION A: LITERATURE REVIEW ON PAIN AND ERGONOMICS

2.1 INTRODUCTION

The intention of this literature review was to provide an understanding of the different interrelated areas when considering the predisposition and consequently the effect that poor ergonomics has on children in a school environment. This literature review presents the current evidence relating to ergonomic interventions, both broadly and more specifically in children, and their effects on musculoskeletal pain and posture. Recent studies pertaining to ergonomic interventions, their design and implementation and subsequently their outcomes, with special emphasis on children in a school environment are also reviewed in this chapter.

The history of the various pain theories, causal mechanisms and the numerous risk factors associated with musculoskeletal pain in children are identified and reviewed in detail, particularly with regard to ways of modifying these risk factors through ergonomic intervention programmes. The psychological phenomenon of pain catastrophising is reviewed in relation to its impact on the experience of pain, and consequently the effect that it can have on the outcome of an ergonomic intervention programme.

Measurement instruments that are effective in evaluating the outcome of ergonomic intervention programmes are discussed, as well as school-based ergonomic intervention studies that have been implemented in the past. Publications dating from 1992 to 2014 were sourced for this literature review from electronic data bases such as PubMed, Science Direct, Elsevier and the Physiotherapy Database of Evidence (PEDro), the Cochrane database collection and Research gate. All these databases were accessed through the library of the University of the Witwatersrand and the keywords used were: musculoskeletal pain, pain, pain catastrophising, children, adolescents, school, school health programs, spinal health in schools, education, teachers, ergonomics, ergonomic interventions, computer work-station, healthy computing habits, information technology, posture, postural measurements and postural observation.

2.2 ERGONOMICS AND ERGONOMIC INTERVENTION APPROACHES

Ergonomics has been defined by the International Ergonomics Association as a scientific discipline concerned with the understanding of interactions among humans and other elements of a system (Jacobs et al., 2008). Chapanis (1991) was one of the first ergonomists to use the terms “ergonomics” and “human factors” interchangeably, and described this arena as a body of knowledge concerned about human abilities, human limitations and other human characteristics that are relevant to design.

Since the early 1990s, there has been an increase in the number of studies examining the effectiveness of ergonomic interventions to prevent musculoskeletal disorders. The fact that work-related musculoskeletal disorders (WMSDs) are as a result of a multifactorial number of risk factors spanning the individual, the interpersonal, the physical environment and the organisational environment has created a challenge in terms of the types of study designs used for examining the effectiveness of these interventions (Bédard et al., 1997). The reason for this is that it is often not possible to implement a randomised control trial in the work environment owing to the cost and time involved as well as the ethics surrounding the issue of not giving intervention benefits to all employees. Karsh et al. (2001) conducted a critical analysis of the efficacy of workplace ergonomic interventions to control musculoskeletal disorders and found that only 32% (n=32/101) used experimental or quasi-experimental designs. Furthermore, they found that 84% of the 101 studies analysed found some positive results, but the majority had mixed results (Bédard et al., 1997).

This critical analysis was further supported by Norman and Wells (1998) in their chapter on an overview of ergonomic interventions pertaining to reducing work-related musculoskeletal disorders. They made reference to three types of ergonomic interventions, namely:

i. Engineering interventions – where the aim of the intervention is to reduce exposure to biomechanical risk factors through modification of the machinery or the workstation design;

ii. Administrative interventions – where the primary aim is to reduce time of exposure to biomechanical and psychosocial risk factors; and

iii. Behavioural interventions, where the primary aim is to reduce the effects of risk factors by training, using correct techniques or improving the capacity of the worker.

Chambers et al. (2002) found in their review, that engineering changes were usually recommended as a first approach, followed by administrative changes and lastly behavioural and personal protection approaches. Interestingly, they found there to be a lack of supporting evidence for engineering and administrative ergonomic intervention approaches compared to the assessment of behavioural and personal intervention approaches. The reason for this was that they found more robust experimental designs were used in the behavioural intervention approaches (Chambers et al., 2002).

Smith (1997) proposed that "employee participation" was an essential aspect to reducing stress and resistance to change when implementing technology. He advocated that "participatory ergonomics" should be a primary consideration when implementing an ergonomics intervention in the workplace (Smith, 1997). Thus, the participatory ergonomics approach is an intervention that involves the participation of the necessary stakeholders, at all levels, in the problem-solving process. This ergonomic approach has in the past few years gained more support because it takes into account behaviour responses that change with the implementation of ergonomic interventions. It has been found to have a positive sustainable effect on outcomes relating to prevention and reduction of musculoskeletal disorders in the workplace (Smith et al., 1997, Straker et al., 2003) However, Norman and Wells (1998) noted that scientific evidence when assessed for effect of interventions in the 1990's relating to studies on participatory ergonomics, it was weak and most of the studies were qualitative.

A more recent systematic review by Van Eerda et al. (2010) on the evidence of the process and implementation of participatory ergonomics interventions in the workplace found that out of 190 studies, 52 met content and quality criteria. Furthermore, although they found that there were a variety of ways of implementing participatory ergonomic (PE) programmes, PE interventions tended to focus on physical and work process changes and reported positive outcomes. The authors noted that resources, programme support, ergonomic training, organisational training and communication were the most common facilitators or barriers to successful PE interventions (Hunfeld et al., 2001).

Literature pertaining to the implementation of participatory ergonomics intervention programmes in a school environment is lacking. For this reason, the evidence of past and more recent school based ergonomic interventions in the literature was further explored. The gaps in the implementation process of ergonomic interventions in a school environment as well as areas that could be improved upon in further studies were also reviewed.

2.2.1 School-Based Ergonomic Interventions

Tables 2.1a (1992-2004), 2.1b (2006-2009) and 2.1c (2010-2014) below show a broad overview of the available school-based ergonomic intervention studies and review papers found. The tables summarise the type of intervention used, sample sizes and the key outcome indicators.

Table 2.1a: a Review of School-Based Ergonomic Interventions/Review Papers (1992- 2004)

Article	Author	Year	Type of School Intervention	Research design/sample size	Outcome indicators/ Key results/Level of evidence
Body basics: A cognitive approach to body mechanics training in elementary school back pain prevention programs.	Schwartz, R and Jacobs, K.	1992	School-based biomechanical back educational program	A prospective controlled study: Convenience sample: n=19 students Grade 6 (11-12yrs)	Positive long- term learning but no statistically significant difference between control and intervention groups. Poor level of evidence as small sample size.
The effects of ergonomically designed school furniture on pupils' attitudes, symptoms and behaviour	Linton, S.J. et al.	1994	Ergonomic furniture intervention	A prospective controlled study with a random selection of participants to each group :"traditional furniture vs Ergo-furniture" . n=46 students(10yrs)	Musculoskeletal symptoms and comfort improved in the intervention group. No statistical difference in sitting posture between "traditional" and "ergo" furniture. Poor evidence as sample size was small.
A comparative study of 3 different kinds of school furniture	Aagaard, J. and Storr-Paulsen, A.	1995	Ergonomic furniture intervention	A prospective controlled study with random selection of participants into 3 different groups. n=144 secondary school students (16-18yrs old)	Perception of ergonomics and postural comfort improved with a tilted desk design. Statistically significant difference in postural comfort was found for tilted desks (0-20 degrees). Good evidence and good quality methodology as researchers noted that confounders were eliminated prior to study.

Article	**Author**	**Year**	**Type of School Intervention**	**Research design/sample size**	**Outcome indicators/ Key results/Level of evidence**
Effect of work-station design on sitting posture in young children	Marschall, M. et al.	1995	Workstation design intervention	Quasi-Experimental study design. N=10 (4.7yrs) Traditional vs ergonomic workstation	No statistically significant change in muscular activity with ergonomically designed furniture. Sitting posture was significantly more comfortable. Small sample size but good evidence relating to measurement of muscular activity at ergonomically adjusted workstations.
Health promoting schools and health promotion in schools: 2 systematic reviews	Lister-sharp et al.	1999	Educational intervention Review	Review	Health in schoolchildren
Computer environments for children: a review of design issues.	Barrero, M. and Hedge, D.	2000	Review of design of computer environments	Review	Design of furniture in schools
Computer ergonomics for teachers and students	Williams, I. et al.	2000	Conference proceedings on ergonomics in schools	Report	Ergonomics in schools
Efficacy of body mechanics education on posture while computing in middle school children	Rowe, G. and Jacobs, K.	2002	Educational intervention	Prospective controlled study design with n= 19 learners (11.6 yrs) Pilot study using a convenience sample. control (n=7) and 2 x intervention groups (n=6 and n=7)	No statistical difference in pre-post test scores for learners' knowledge of healthy computing. Poor evidence as sample size was small and only a 12 minute educational intervention was used. High risk for bias due to sampling method.
A health approach to classroom computers: preventing a generation of students from developing repetitive strain injuries.	Bradely Royster, L.	2002	A review for the North Carolina court of law	Review of guidelines for repetitive strain injuries amongst children and ergonomics in schools	Ergonomics Repetitive strain injuries

Article	Author	Year	Type of School Intervention	Research design/sample size	Outcome indicators/ Key results/Level of evidence
Delivering the power of computers to children without harming their health.	Straker, l. and Pollock, C.	2003	Guidelines of ergonomics for children and implementation	Report	Ergonomic guidelines for children using ICT
Sitting habits in elementary school children: a traditional versus a “moving school”.	Cardon, G. et al.	2004	Observational/postural education school intervention	Quasi experimental – n= 22 “moving school” group, n=25 in traditional school group	Posture (POE) improved significantly in the intervention “moving school group” Self reported neck/back pain did not differ significantly between study groups. Narrow sample selection so low level of evidence but good quality measurement tools were used for postural measurement.

Table 2.1b: Review of School-Based Ergonomic Interventions/Review Papers (2006- 2009)

Article	Author	Year	Type of School Intervention	Research design/sample size	Outcome indicators/Key results/Level of evidence
The effect of a two-year multifactorial back education program in elementary school children	Geldof, E. et al.	2006	Back education/postural dynamism intervention	Quasi-experimental pre-post - test design Intervention (n=193), Control (n-172) 9-11yrs	Knowledge about posture was found to be significantly increased following the intervention. There was no significant change in postural behaviour (PEO-portable ergonomic observation method), Fear-avoidance beliefs, and self-reported pain found between the intervention and control groups was not significantly different. Low level of evidence for effect of intervention on postural change and pain reported but good level of evidence for increased knowledge post intervention.
School-Based Interventions for Spinal Pain A Systematic Review	Steele, E.J. et al.	2006	Review	Review	School-based interventions
Ergonomics for children: an educational program for elementary school	Heyman, H. et al.	2008	Educational ergonomic program	Cohort design Elementary schools in Israel	Ergonomics, movement and posture program implementation by physical education teachers was found to have a positive impact on the students' knowledge and postural behavior. Poor quality study methodologically and no precise measurement tools used, although good level of evidence of increase in spinal care knowledge post ergonomic program.
Do ergonomically designed school workstations decrease	Saarni, L. et al.	2008	Workstation design intervention	Prospective controlled study design with a follow-up over	Musculoskeletal symptoms related to postural positions using

Article	Author	Year	Type of School Intervention	Research design/sample size	Outcome indicators/Key results/Level of evidence
musculoskeletal symptoms in children? A 26-month prospective follow-up study.				26 months. Control and intervention group. n=84 reduced to n= 43 children (12-14yrs) over 26 months	adjusted workstations did not show any significant change in pain intensity over time. Good quality study in terms of the controlled study design and standardized measurement tools and consistency of data analysis over the 26 month period. Low level of evidence for the effect of workstation design on childrens' pain intensity levels and a small sample size.
Computer-related posture and discomfort in middle school students.	Jacobs, K. et al.	2009	Educational intervention(20-30mins program)	Descriptive longitudinal study over 3yrs.n= 376 (12-13yrs) Year2: n=243 learners, Year3:n=152 learners	Students' workstations at home were found to be adjusted appropriately to reduce postural strain over the 3 year study period. A mouse pad with reminders printed on it was used as a form of reinforcement. There was a significant decrease in musculoskeletal pain amongst participants over the 3 year study period. Good quality descriptive study and good level of evidence that ergonomic education can facilitate a behavior change amongst students. Sample size and differences in baseline pain data between control and intervention groups suggest caution with the results from this study. Limitations were noted by the researchers regarding small sample size and baseline differences.

Article	Author	Year	Type of School Intervention	Research design/sample size	Outcome indicators/Key results/Level of evidence
Encouraging good posture in school children using computers	Robbins, M. et al.	2009	Postural educational school intervention	A prospective blinded RCT. N=71 children(7-12yrs) Control(n=34) Intervention(n=37)	Prevalence and rating of musculoskeletal symptoms reduced significantly in the intervention group following on screen “pop-up” reminders 1 week post intervention. Good quality study with random allocation of participants into a control and intervention group. Limitations regarding sample size and time constraints are discussed. Good level of evidence for benefits of educating children on ergonomic guidelines with reinforcements.
Ergonomics and computer use: Increasing the awareness of rural secondary school students	Sawyer, J. et al.	2011	Educational intervention	Quai-experimental design Grade 10 students in rural secondary school (n=21)	Survey approach-Evaluation of design of programme and understanding of principles of ergonomics. There was a significant difference in spinal care knowledge and ergonomic principles post the educational intervention. Poor quality study as small sample size. Fair level of evidence for enahancing ergonomic knowledge amongst students.

Table 2.1c: Review of School-Based Ergonomic Interventions/Review Papers (2010- 2014)

Article	Author	Year	Type of School Intervention	Research design/sample size	Outcome indicators
Computer-related posture and discomfort in primary school children: The effects of a school-based ergonomic intervention	Dockrell, S. et al.	2010	Educational intervention	Pre-post-test study design. N=23 children (9-10years)	RULA(posture) scores and intensity of self-reported musculoskeletal pain did show significant improvement post intervention. The intervention had a positive impact on the children's ability to adjust their workstations correctly post-intervention. Small sample size so poor generalisiability to a broader population but good quality study design and measurement tools were tested for reliability. Good level of evidence for effects of an ergonomic intervention on posture in a school environment.
Evaluation of two ergonomics intervention programs in reducing ergonomic risk factors of musculoskeletal disorder among school children	Ismail, S. A. et al	2010	Educational and ergonomically designed classroom furniture type intervention	A prospective controlled intervention study 2 intervention groups and 1 control group. n=229 children (8-12yrs)	RULA scores (posture) were found to be significantly improved in the group that received ergonomic education and ergonomic furniture. Good level of evidence of the impact an ergonomic educational program can have on students as well as increase students' knowledge of ergonomics. Good quality study with a large sample and a control group. No assessor blinding so potential for bias.

Evidence-based guidelines for the wise use of computers by children: Physical development guidelines	Straker, L. et al	2010	Educational guidelines	Guidelines	Computing guidelines summary
Ergonomics and computer use: Increasing the awareness of rural secondary school students	Sawyer, J. et al.	2011	Educational intervention	Quai-experimental design. N=36 Grade 10 students in rural secondary school	A survey approach was used to test students' understanding of principles of ergonomics. The Harvard one minute test was used and found an increase in ergonomic knowledge was attained by students. Poor quality study but fair level of evidence for increased ergonomic knowledge amongst students post ergonomic intervention.
The long-term effectiveness of a back care education program in elementary school children	Dolphen, M et al.	2011	Educational back care programme (1hr for 6 weeks)	Pre-post-test study design, Longitudinal 8 yr follow up. Control n=98, Intervention n=96 (9-11 yrs)	Spinal care knowledge improved significantly post intervention and was sustained over the 8 year period. Spinal care behavior, self-efficacy, fear-avoidance beliefs and prevalence of self-reported neck/back pain did not show any significant change from pre-test to post intervention after 8 year follow up. High quality study, specifying limitations and confounders were accounted for. Good level of evidence for further research of the effect of ergonomic interventions on spinal care behavior and psychological determinants.

Poor sitting posture and a heavy schoolbag as contributors to musculoskeletal pain in children: an ergonomic school education intervention programme	Syazwan, et al.	2011	Educational ergonomic intervention programme (30 minute)	Quasi-experimental time series design (9-11yr olds) Convienence sampling. Control-n=75 Intervention= n=78	Spinal care knowledge, posture(RULA) and schoolbag weight improved significantly following the ergonomic intervention. Neck pain was significantly reduced in the intervention group post intervention. Good level of evidence for implementing and measuring the effect of an ergonomic intervention on spinal care knowledge, postural improvement and change in behaviuor relating to schoolbag weight. Good quality study using standardized measurement tools and a large sample size.
Effects of ergonomics on school teachers	Shuai, J et al.	2014	Educational ergonomics intervention (8 weeks)	Longitudinal study (1year) with pre-post-test study design. n=353 teachers, 4 schools	Awareness, behaviour and attitudes to ergonomics in schools was found to be significantly increased post intervention. Good level of evidence for educating students and teachers on ergonomic guidelines.

The information in this table provides a summary of the evidence regarding the following: between 1992 and 2008, there were numerous studies on furniture and workstation design interventions in schools and between 2008 and 2012 there have been more educational ergonomic interventions in schools investigating the effects of teaching learners about ergonomics to reduce the risk of awkward sitting posture and sedentary behaviour when using computers. As mentioned before, 70% of the interventions reviewed were of the pre-post-test design and only a small percentage was randomised controlled studies. Intervention studies conducted since 2010 using RULA to measure the effect of the intervention on posture appear to be more reliable and consistent in their outcomes. Key findings in these studies from 2010 - 2014 have found the educational ergonomic interventions to have a positive effect on changing the posture of learners while working on computers in a school environment and indirectly an effect on reducing musculoskeletal pain amongst learners. In addition, teaching ergonomics to school teachers has shown a favourable outcome on their knowledge, attitudes and behaviour regarding ergonomics in the school environment.

Limitations reported on from intervention studies in schools relate predominantly to a lack of adequate sample sizes that are representative of the relevant populations as a whole, and the challenges involved in implementing controlled longitudinal studies due to a lack of funding, manpower and the impracticalities involved with the scheduling of the studies within the school timetable. In support of this focus on educational ergonomic interventions in schools, there have been many reports and review papers relating to ergonomics in schools and their benefits for children, as well as published guidelines for encouraging health computing habits among learners.

A more recent longitudinal study by Shuai et al. (2014) in China investigated the effect of an educational intervention programme on teachers in four different schools, and found that the 8 week ergonomics program had a sustained effect of creating awareness and change in attitude and behaviour of teachers towards implementing ergonomics in schools (Shuai et al., 2014). However, with the continuing rise in musculoskeletal pain in children using computers, more high quality longitudinal randomised controlled studies are needed to help support the process of incorporating ergonomics education into the school curriculum (Bennett, 2000; Straker and Pollock, 2005; Straker et al., 2006).

The evidence for school-based ergonomic interventions in the literature is illustrated in a systematic review done by Steele et al. (2006) on school-based spinal health interventions. The authors found that school-based health interventions may be effective in increasing spinal health knowledge and reducing the prevalence of spinal pain. However, inconclusive results were obtained on the effect on spinal care behaviours. From this systematic review none of the interventions described targeted the range of modifiable risk factors for spinal pain in children and adolescents such as poor posture, prolonged awkward sitting positions and carrying heavy schoolbags that had been identified in previous epidemiological studies.

In terms of the delivery of the intervention programme, they found that five out of the twelve studies used a didactic approach, which is not congruent with current “best practice” approaches to health promotion in the school setting, as described by Lister-Sharp et al. (1999) in their review paper on promoting schools and health promotion in schools. Donald et al. (2010) recommended that intervention programmes based on social learning theory that take into consideration the effect of social influences, are most effective and this reinforces key theories and concepts considered in the steps to develop the intervention programme such as learning theory, theories and concepts underlying the development and application of the programme, and behaviour modification. These recommendations by Donald et al. (2010) strengthen the effect of outcome of the intervention program on behaviour modification and are further supported by Lister-Sharp et al. (1999).

A review of the literature on the way in which ergonomic interventions have been implemented in schools over the past decade dates back to 1992, when Schwartz and Jacobs (1992) reported the effects of their study on teaching body biomechanics to a 144 elementary school children as part of a back pain prevention programme. They found that the educational programme increased the knowledge of the learners’ post-intervention. However, the between group analysis of the two intervention groups did not show a significant difference in knowledge scores post-intervention (Schwartz and Jacobs, 1992). From 1992-2002, the majority of published studies focussed on ergonomic furniture and computer workstation design interventions to improve learners’ posture and reduce the prevalence of musculoskeletal pain amongst learners. Key findings based on furniture and workstation design indicated that adjustable chairs, desks and computer workstations to suit the anthropometric needs of learners can influence the risk factor for developing musculoskeletal pain, however, education about ergonomics and preventive exercises are an essential component to ensure the effect and sustainability of ergonomic intervention programs in schools (Aagaard and Storr-Paulsen, 1995; Linton et al., 1994).

Shinn et al. (2002) published a study on the effectiveness of an ergonomic intervention in the classroom. Their aim was to determine if an in-service programme on proper body mechanics and ergonomics for computer workstation usage can increase a student's knowledge in these areas. They used a quasi-experimental design and a convenience sample of 114 sixth grade students enrolled in a word-processing class at a New York Middle school. The in-service programme consisted of a 30 minutes lecture and demonstration on computer ergonomics and the importance of proper stretching techniques and rest periods. Hand-outs were also provided to the students. A non-standardized demographic and ergonomic pre and post questionnaire was used to measure the effect of the intervention and an environmental checklist was used to assess the percentage of ergonomically correct computer workstations. The results of the pre and post test scores, taken before and immediately after the ergonomic intervention, indicated that learning had taken place and that ergonomic education is one way to help students reduce their risks of developing musculoskeletal injury in the classroom environment (Shinn et al., 2002).

Shinn et al.'s (2002) study provided a platform for continuing ergonomic research in the area of children and computer use, however, the methodological rigour did not have an adequate audit trail as no mention was made of how the in-service programme was developed or if the authors had identified certain risk factors in the sample of participants prior to developing and implementing the ergonomic intervention programme. In addition, a convenience sample of 114 grade six students were used which fell short on representivity. Saarni et al. (2009) conducted a controlled intervention over a period of 26 months, to investigate the effects of ergonomically designed workstations on school children's' musculoskeletal symptoms as compared to conventional workstations. However, there were design issues in terms of a small sample size owing to a high dropout rate in the 26 month study. The studies by Shinn et al. (2002) and Saarni et al. (2009) showed contrasting results in that the pre and post-test study yielded a favourable outcome of increasing student's knowledge of ergonomics, following the ergonomic intervention programme whereas the controlled intervention did not report any changes in musculoskeletal symptoms following an intervention for workstation design.

When looking at ergonomic intervention studies, it is important to note if risk factors were identified in the target population prior to the development of the intervention programme; how the sample was chosen; if there was collaboration with the stakeholders and the target population prior to implementation of the intervention; and what reinforcing agents were used to ensure that the intervention was sustainable (Jacobs et al., 2008). The issue of measuring the effect of the intervention is also of concern, as measuring the effect immediately after the intervention can be short sighted as this does not indicate if the effect of the intervention will be sustainable in the long term (Dolphens et al., 2011).

More recent school-based ergonomic intervention studies between 2009 and 2011, have all made use of an educational ergonomic programme approach with applied ergonomic principles, stretches, posture education and a demonstration included, thus following the principles and concepts of the learning theory and behaviour modification. In all these studies, the presence and severity of musculoskeletal pain was measured at the start and end of the intervention. Dockrell et al. (2010a) and Ismail et al. (2010) both used the Rapid Upper Limb measurement (RULA) tool, to measure posture during computer use. Ergonomic interventions that educate students about posture and applied ergonomic principles and stretch exercises make a significant difference to the prevalence of musculoskeletal pain (Dockrell et al., 2010a; Heyman and Dekel, 2009; Robbins et al., 2009; Sawyer and Penman, 2011).

One of the two randomized controlled studies on biomechanical related spinal care programmes implemented in schools, conducted by Dolphen et al. (2011) proved to be a valuable longitudinal study in demonstrating that over a period of eight years, the effect of the spinal back care programmes is not necessarly sustained in terms of changing the behaviour of adolescents into adulthood. This study included an adequate sample of 16 schools that were randomly selcted to participate in the study, with 198 participants selected in the intervention group and 155 participants selected in the control group at baseline and consistent measurements were done at 1 week, 1year and 8 years post-education back care intervention. The authors of the study were the first to measure psychological determinants, such as fear-avoidance beliefs and self-efficacy, which can Influence change in behaviour. Unfortunately, the measurement tools used were not standardised questionnaires, although test-rest reliability was accounted for and thus the interpretation of the results relating to fear-avoidance beliefs and self-effeicacy need to be carefully considered. The response rate after 8 years was 53.4% so the authors do caution the interpretation of the results in terms of the effect of the back care intervention programme on postural behaviour and prevalence of musculoskeletal pain. The reason this study is of importance, is that it highlights areas of consideration when designing and implementing an ergonomic intervention programme in terms of psychological determinants that could affect the effectiveness of the intervention programme.

A second randomised control study, on investigating the effects of a postural education intervention programme in schools, conducted by Robbins et al. (2009), used a small sample size of 71 children aged between 11-12 years of age, with n=37 intervention group and n=34 in the control group. Both groups received postural education, however, the intervention group received “pop-up postural warnings” to act as reinforcements. The prevalence and severity of musculoskeltal pain were the main outcome measures and a standardised visual analogue scale was used to measure pain. The results of the study reported that the overall incidence of musculoskeletal problems in the intervention group showed a greater trend towards reduction, falling significantly ($p<0.0001$) from 32.4% to 5.4% compared with the control group, which fell insignificantly from 29.4% to 20.59% ($p>0.150$). Although the study was a blinded RCT with a small sample size, and a short duration of time between pre and post intervention measurements, it provides good evidence for incorporating “ergonomic reminders” when designing an ergonomic intervention programme in schools.

All studies cited in this literature review were conducted in different geographical areas indicating that the importance of ergonomics in the school environment is a worldwide concern (Ireland, the United States, Malaysia, Israel and Australia). At present, there have been no longitudinal ergonomic intervention studies done in Africa or South Africa and there is certainly evidence in the literature that indicates that computer use in children in African countries, in particular South Africa, is on the increase (Smith et al., 2007).

Initially, an increase in computer use in Australian schools was not accompanied by any consideration of ergonomics (Anna and Newhouse, 2003) and this was similar to findings reported by Bennette (2000) in the United States and the United Kingdom, pertaining to micro-ergonomics issues such as the mismatch between classroom furniture and anthropometric requirements of children using computers. However, countries like New Zealand, Ireland and Australia appear to be at the forefront of implementing proactive ergonomic interventions in the school environment (Bennett, 2000).

In light of the evidence from the literature on the different ergonomic intervention designs relating specifically to increasing childrens' knowledge of spinal care and good ergonomic practice, the researcher implemented a RCT taking into consideration the underlying principles and concepts of learning, as well as consideration of the environment, stakeholders and motivation of the learners, to maximize the quality of the ergonomic intervention. There is growing evidence that other aspects relating to back-pain prevention in children, such as adapting school furniture to students' needs are important (Barrero, 2002). However, equally important is training in ergonomic subjects and long-term prevention programmes as part of the school curricula (Dockrell et al., 2010a; Ismail et al., 2010). It is therefore important to assess posture and ergonomic behaviour of adolescents in a school environment so that an effective ergonomic intervention programme can be designed and implemented at a sustainable level and reduce unnecessary costs in the long term.

Heyman and Dekel (2001) and Shinn et al. (2002) conducted ergonomic intervention studies in a school environment with the positive outcome of increasing children's awareness of body mechanics, movement and posture. The interventions were not measured for effectiveness in the longer term as pre and post-assessments were done immediately at the time of the intervention. An educational in-service programme showed statistically significant differences in the results of pre and post scores ($p<0.0001$) following the intervention (Shinn et al., 2002). Furthermore, the study concluded that there is a need for preventative education on computer use for children of school-going age.

Straker et al. (2010) reviewed the evidence for ergonomic guidelines on computing among children and developed detailed guidelines specifically advising children on ergonomically correct computer use. These guidelines include encouraging a mix of sedentary and whole-body movement tasks. They encourage postures that do not engage in excessive neck and trunk flexion for prolonged periods of time during computing tasks through workstation, chair, desk, display and input-device selection and adjustment. They also address special issues on laptop computer use and carriage, computing skills and responding to discomfort (Straker et al., 2010).

In summary, the key findings from reviewing the literature on the implementation and effectiveness of ergonomic intervention programmes in school environments indicate that there is good evidence with regard to the education of children/learners involving applied ergonomic principles, correct postural positions encouraging a mix of sedentary positions and whole-body tasks, regular stretching of the upper limbs, neck and lower back during computer use and correct workstation set-up are essential components for a successful ergonomic intervention.

There appears to be a gap in the literature pertaining to longitudinal RCTs of ergonomic interventions in schools and the effect they have on key outcomes such as posture and musculoskeletal pain. There is some evidence from the research pertaining to pre-post test designs, pre-post test deisgns with control groups and only two (Robbins et al., 2009, Dolphen et al., 2011) of the eighteen (12%) intervention studies reviewed on ergonomic interventions in schools were randomised control trials. Therefore, there is a lack of rigorous designs and evaluation methods and cause and effect can only be intimated from these three RCT studies. The majority of the studies (70%) reviewed were quasi-experimental and only three prospective longitudinal studies by Saarni et al. (2008), Jacobs et al. (2009) and Dolphen et al. (2011) had been conducted at the time of this review. In spite of these limitations in study designs the major outcomes have contributed to identifying risk factors in schools and as well as possible soultions to reducing their effect on the learner population.

Musculoskeletal pain has been identified as one of the leading causes of chronic and recurrent pain in childhood and adolescence and the prevalence rate ranges from 2% to 36% (Zapata et al., 2006). Studies have shown that the lifetime prevalence rate for lower back pain in children almost doubles between the ages of 12 and 15 years of age, to reach 39% to 71%, continuing to increase into the late teen years. Thus primary prevention of the first episode of low back pain has become a focus of many researchers (Newburger, 2001; Zapata et al., 2006; Perry et al., 2010; Jones et al., 2004). It is necessary to review the current literature pertaining to musculoskeletal pain in children as it is one of the main objectives that will be assessed when considering preventive intervention programmes in the school environment.

2.3 MUSCULOSKELETAL PAIN

Musculoskeletal pain as defined by the International Association for the Study of Pain (IASP) (2009) refers to a number of symptoms that can include local symptoms of pain or widespread and persistent pain; tenderness; peripheral nerve irritation; weakness; and limited motion and stiffness. It is a known consequence of repetitive strain, overuse and work-related musculoskeletal disorders, which can cause pain in bones, joints, muscles and surrounding structures (Marchand, 2012).

Pain is defined by IASP as, “an unpleasant sensory and emotional experience with actual or potential tissue damage” (Marchand, 2012). Adolescents are more prone to developing musculoskeletal pain because of rapid growth spurts at this time of their development (Harris et al., 2005). Children can experience many different types of acute, chronic or recurrent pain depending on the duration of the pain. Pain that is of relatively short duration with regard to hours, days or a few weeks and characterised by a sudden onset and with demonstrable aetiology of some form of noxious or tissue-damaging stimulation is classified as acute pain (Marchand, 2012). In contrast, chronic pain is often defined as any prolonged pain that lasts for three months or longer and which is experienced in the absence of any well-defined organic aetiology (Kashikar-Zuck et al., 2001; Marchand, 2012). The understanding of potential risk factors and their influence on musculoskeletal outcomes is becoming clearer as illustrated in recent studies (Harris et al., 2010; Straker et al., 2011).

Recent findings among studies of school children are that two-thirds of them reported having pain at least once a month, one-third at least once a week, and 6% reported experiencing pain every day (Petersen et al., 2006). One half of the children that reported pain indicated that they had multiple pain symptoms. Although the majority of children experience short-lived pain, there is growing concern of a significant increase in the prevalence of chronic and recurrent pain in children and adolescents (Petersen et al., 2006). Pain in children and adolescents can become a burden for parents and families. It also impacts negatively on their social and learning environment (Hunfeld et al., 2001; Sullivan et al., 2001).

In relation to causal mechanisms and musculoskeletal pain in children, the historical context of the different pain theories needs to be reviewed. The aetiology of musculoskeletal outcomes associated with information and communication technology (ICT) and the associated risk should be considered.

2.3.1 The Historical Context of Pain

Current research suggests that throughout the course of history, numerous approaches and theories about pain have been developed. For the purpose of this study, it is important to consider the different approaches to pain and the theories about pain and its treatment so that one can understand the different therapeutic approaches that are available today. A review of the literature on pain reveals that researchers have identified two parallel developments relating to understanding pain mechanisms namely; one that represents scientific knowledge based on neurophysiological mechanisms and the second that addresses the development of treatments based on clinical experience, without necessarily understanding what is happening physiologically (Marchand, 2012).

Many pain treatments are based on the theory that pain is caused by linear mechanisms which dates back to Descartes' theory that pain follows a specific pathway and that the physiological causality of pain is driven by internal mechanisms within the individual rather than by external mechanisms (Marchand, 2012). Marchand (2012) reports that this particular view relates to the specificity theory in which Descartes believed that the pain system is a direct pathway linking the skin to the brain.

However, the specificity theory of the 19th Century which proposes that information passes from the periphery to the higher centers and back into motor command without any alteration cannot explain the issue of chronic pain and the fact that repeated application of a stimulus in the same region changes the subject's perception of the stimulus (Marchand, 2012). Thus the process of somatosensory perception is more complex and the pattern theory of pain was formulated in response to this finding. This theory suggests that factors other than the stimulation site are responsible for the various somasthetic perceptions and that the intensity, frequency and simultaneous application of stimuli are important considerations. This concept is well supported by the literature (Harreby et al., 1999a; Prista et al., 2004; Marchand, 2012) and underlies the role of spinal modulation of afferent impulses and helps us to understand better the role of temporal and spatial summation in pain perception. It also contributes to the mechanisms associated with chronic pain and is an important consideration when researching the prevalence of chronic and recurrent pain among adolescents.

Following on from the pattern theory of pain formulated in 1884 (Wedderkopp et al., 2001), the later pain theories such as the gate control theory by Melzack and Wall (1965) proposed a model based on anatomical and physiological data, which explains the different types of pain as well as the mechanisms underlying the modulation or adaptation of somatosensory afferents. According to this model, information coming into the afferent fibres is adjusted by both peripheral and descending modulatory mechanisms (Melzack and Wall, 1965). This concept of descending inhibitory mechanisms is supported by a more recent pain theory of body schema, called the Neuromatrix, also developed by Melzack (1990), which accounts for the involvement of several brain structures in the perception and modulation of pain. Melzack developed this neuromatrix theory from his observations of patients that had phantom limb pain following amputation of a limb, which suggests that body image representation is of central origin and does not depend on afferent input to experience pain. He concluded that the neuromatrix includes several brain structures, not only the parietal lobe of the cortex which emphasizes that other factors such as perception, motivation and consciousness all play a role in the perception of pain (Brattberg, 2004).

With the rapid evolution of research and new knowledge about pain integration, expression and perception, various researchers have conducted studies on the impact of the neurophysiology of the emotional dimension of pain. Damasio (2005) emphasises the importance of the affective component in cognitive fields such as learning and decision making (Damasio, 2005). The perception of pain is equally influenced by the emotional or affective component. This emotional component of pain involves the integration of the autonomic, somatic and motor responses in relation to the meaning that we give to pain and the context in which it occurs. The relevance of understanding this emotional dimension of pain and the various brain cortices involved is essential to the design and implementation of intervention programmes for helping to prevent or manage pain. Thus, the different concepts underlying pain theories have evolved from a linear causality to a more circular model (Marchand, 2012). The more recent *gate control* theory, the *descending inhibitory systems* theory, the *neuromatrix* theory as well as studies of the affective component influencing pain all support the fact that pain results from a multitude of interactions and exchanges of information from both the periphery and internally in several areas of the nervous system. In light of this circular pain model, it is essential to consider a multidimensional approach to designing and implementing interventions for people with acute, chronic or recurrent pain (Marchand, 2012). Therefore, consideration of the known risk factors was reviewed in the literature. Models of the relationships between user correlates, computer exposure and musculoskeletal pain are related elements that will be discussed in more detail below.

2.3.2 **Risk Factors and Causal Mechanisms for Developing Musculoskeletal Pain**

Results from epidemiological studies have contributed to the evidence of mechanisms relating to the effect and risk when examining the relationship between risk factors and musculoskeletal disorders in the adult population (Harris et al., 2005). Bernard (1997) developed a model for evaluating evidence of the effect of mechanisms relating to workplace risk factors and musculoskeletal disorders. Their reviews of epidemiological studies found that the evidence for associations between musculoskeletal disorders and risk factors ranged from “strong correlations” to “no correlations”. Specific risk factors such as repetition, force, posture and vibration were shown to have strong correlations with musculoskeletal disorders. In particular they found that prolonged static posturing of the neck/shoulder complex during certain tasks was strongly associated with musculoskeletal disorders of the neck (Bernard, 1997).

A review of the literature relating to studies finding a mismatch between anthropometric measurements of learners and the dimensions of school furniture (Oates, 1998; Laeser et al., 1998; Barrero and Hedge, 2002; Harris and Straker, 2000; Straker et al., 2002; Smith et al., 2007; Straker et al., 2009) as well as heavy schoolbags (Sheir-Neiss et al., 2003; Parcells et al., 1999; Mackie and Legg, 2007) increasing the risk of learners developing musculoskeletal discomfort shows that these risk factors are an important consideration when planning an ergonomic intervention study. The effect of the schoolbag weight can act as a confounding variable and it must be examined as part of a needs assessment prior to the implementation of an intervention (Sheir-Neiss et al., 2003; Parcells et al., 1999; Mackie and Legg, 2007). For example, Ismail et al. (2010) assessed schoolbag weight prior to an ergonomic intervention. They found that carrying a heavy schoolbag in addition to the effect of posture at a computer impacted on musculoskeletal pain. Ismail et al (2010) used a large sample (n=229) and learners ranged between eight and 11 years of age. A limitation of this study, despite that it was conducted over a period of four months, was that not all the learners were measured with the RULA tool and there was no description of how the RULA assessment was carried out, which is important for internal validity and consistency (Ismail et al., 2010).

In addition to these risk factors, lack of physical education in the school curricula, sports participation or the lack there of, and sedentary transport to schools and psychological risk factors (stress, pain catastrophising,anxiety) have also been implicated in the cause of musculoskeletal pain in children (Jordaan et al., 2005, Whitifield et al., 2005, Dunn et al., 2011) . For the purposes of this study, the literature review is focussed on discussing the evidence available relating specifically to computer use, exposure, frequency and location, and the psychological risk factor of pain catastrophising. It is beyond the scope of this review to discuss specifically other physical risk factors in detail.

Most risk factors relating to computer use and identified in the literature as resulting in musculoskeletal pain have been defined by studies in adult populations and their work environments rather than in child-based populations. These risk factors include both intrinsic and extrinsic factors. Intrinsic factors include individual factors such as age, gender, anthropometry, genetics, psycho-sociology, cognition and physiology. Extrinsic factors include physical environment workstation set-up, type of computer use and biomechanical factors such as posture, movement, force and vibration as well as task demands and organizational dynamics (Kumar, 2001; Kuorinka et al., 1987; Mathiassen, 1993; Asundi et al., 2010).

In terms of children's use of information technology (IT) and computers, numerous studies have shown that such use is different from that of adults in a work environment (Straker et al., 2002; Harris et al., 2005; Gillespie, 2006; Breen et al., 2007). Although there are many similarities between risk factors associated with musculoskeletal pain and children's use of computers, there are differences in respect of their anthropometry, their behaviour and their interaction with their environment (Straker, 2006). This has implications for causal relationships between IT use and musculoskeletal disorders in children. Research supporting this theory has mainly been conducted on the ergonomics of computer use by children and the impact that this has on a child's health, both physically and psychologically, as well as on their productivity (Pollock and Straker, 2003). In addition, several studies have shown that children exposed to the use of computers may be at risk of developing musculoskeletal pain (Bennett, 2000; Gillespie, 2006; Jacobs and Baker, 2002; Breen et al., 2007; Kelly et al., 2009).

2.3.2.1 **Computer exposure**

Numerous studies have identified computer exposure as a risk factor among children and adults for the development of musculoskeletal pain (Alexander et al., 2004; Hakala, 2006; Dockrell et al., 2007, 2010a; Kelly et al., 2009; Harris et al., 2005, 2010a). Various models have been developed that attempt to represent the relationship between exposure to risk factors while using a computer and the precipitation of musculoskeletal pain. The multivariate interaction theory of musculoskeletal injury precipitation by Kumar (2001) demonstrates the way in which inherent characteristics of an individual's musculoskeletal system interact with hazards and stresses related to biomechanical factors. It also addresses an individual's biological responses mechanism, including pain behaviour (see Figure 2.1 below). Thus, the multivariate nature of exposure to risk factors and the influence of an individual's physical and psychosocial aspects are taken into consideration, whereas, the exposure-*effect* model by Mathiassen (1993) looks at exposure variables and illustrates the importance of time and how time is associated with injury precipitation.

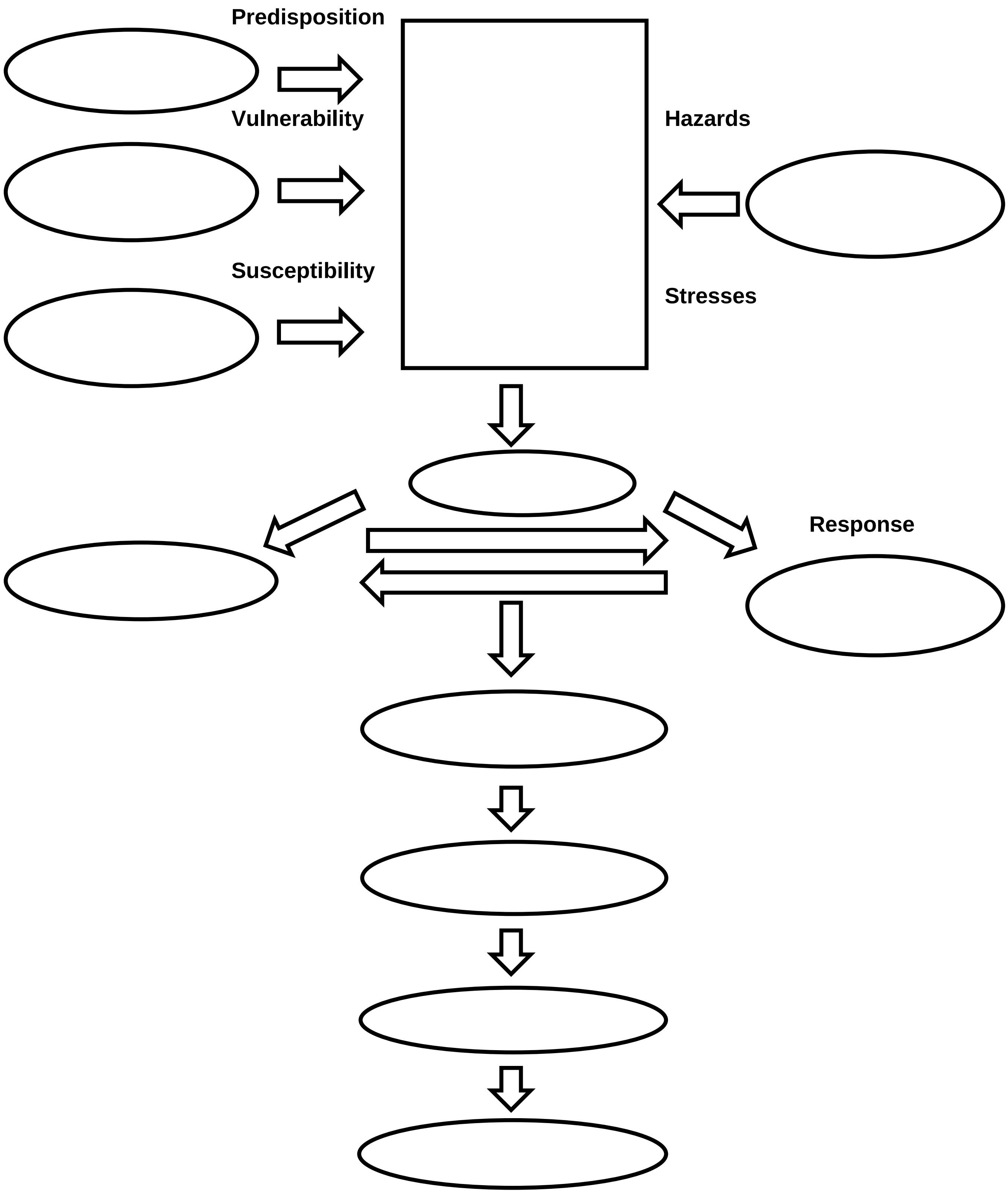

Figure 2.1: Multivariate Intervention Theory of Musculoskeletal Injury Precipitation (Kumar, 2001)

Figure 2.2 illustrates the Exposure – Effect Model developed by Mathiassen (1993) which shows how the acute injury response can become chronic with repeated exposures.

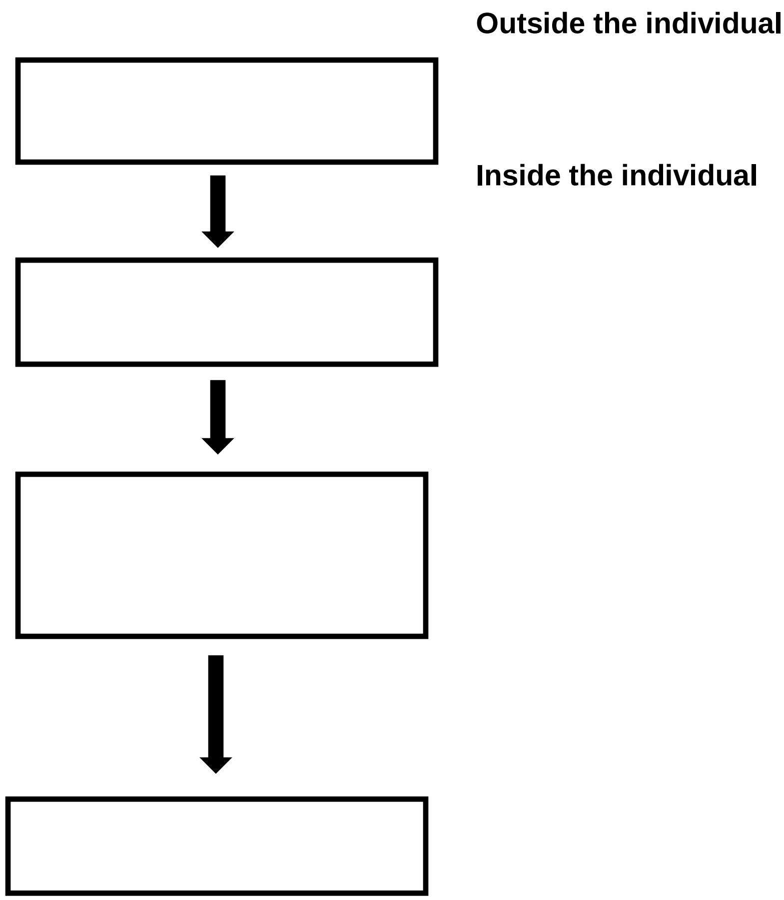

Figure: 2.2: The Exposure-Effect Model (Mathiassen, 1993)

Compared to the first model, the exposure-effect model demonstrates that initially injury responses are acute but continued exposures can lead to chronicity (Kumar, 2001; Mathiassen, 1993). The multivariate interaction theory and the exposure-effect models are based on adults preforming work-related tasks in a work environment. Harris et al. (2005) clearly states that the above model is limited in its application to children using IT as it does not take into consideration factors impacting on the individual such as computer exposure, the environment at home and at school, and psychological determinants. Harris et al. (2005) presented a framework for a model addressing IT use by children related to musculoskeletal problems. They recommended that a useful model would incorporate factors on the individual user, the environment and outcomes.

Subsequent to this proposal, Harris et al. (2010b) published results of a cross-sectional study investigating children’s use of computers at home and at school as well as the development and testing of a multivariate model that would assist in exploring the relationship between children’s use of computers and their risk of developing computer-related musculoskeletal pain. The study involved a large sample of convenience (n=1351) students (792 boys and 559 girls) recruited from primary and secondary schools in Australia. Convenience sampling within stratified groups was done to ensure that the sample represented a cross-section of socio-economic groups, gender and a broad range of school grade levels. As a consequence, the results from this study are more easily extrapolated to apply to a broader population.

The researchers, (Harris et al., 2010b) found different relationships between children’s computer exposure patterns at school and at home and developed and tested two models of exposure. One model was for school computer exposure and the other was for home computer exposure. They concluded from their study that the child-specific model tested revealed a direct relationship between children’s computer exposure and musculoskeletal outcomes for both school and home-computer use. The evidence obtained from their study provided more specific information on relationships between potential risk factors for children’s computer-related musculoskeletal pain, including the direct and indirect effects of potential risk factors for exposure and musculoskeletal pain than previous adult-based models had done (Harris et al., 2010b). However one limitation of the study is that only a small percentage (10%) was on home computer use and this may have skewed the results as the groups compared were not equally representative.

Figure 2.3 below represents the Modified child-specific model formulated by Harris et al. (2010). It shows the unique characteristics of children such as the environments in which they use computers; socioeconomic status, gender, age, musculoskeletal pain and psychological factors can all have an impact on the causal mechanisms underlying musculoskeletal injuries related to computer use.

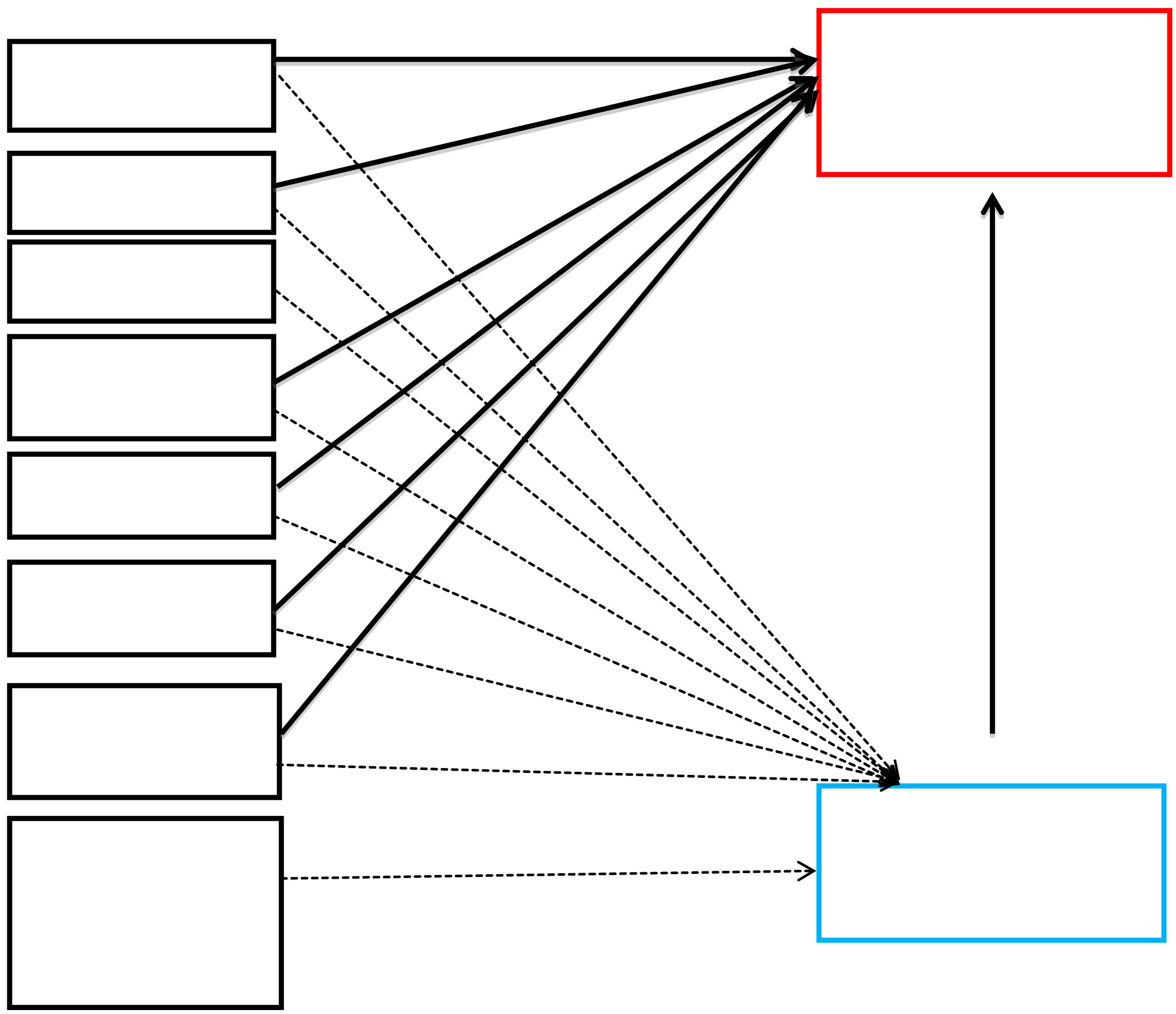

Figure: 2.3: The Modified Child-Specific Model (Harris et al., 2010b)

The child-specific model cited above (Figure 2.3), has shown that children's unique characteristics are an important consideration in understanding the causal mechanisms involved with exposure to computers. Age, gender, musculoskeletal pain, computer exposure, TV exposure and psychological factors were found to have direct and indirect effects on computer-related outcomes. The child-specific models have similarities to the ecological model of musculoskeletal disorders in visual display terminal work (Sauter and Swanson, 2005). Sauter and Swanson's (2005) model demonstrates the relationships between external environmental factors including psychosocial and biomechanical influences based on work-related computer exposure and musculoskeletal outcomes and is therefore unlike any of the models discussed above. Harris et al. (2010b) included computer exposure in their work tasks as well as engaging similar user variables such as psychological and individual factors, work organisation and somatic complaints as part of their child-specific models.

2.3.2.2 **Psychosocial risk factor : Pain catastrophising**

There is evidence in the literature of an association between psychological factors such as stress, depression and anxiety and musculoskeletal pain (Burke, 2002; Jacobs and Baker, 2002; Cho et al., 2003; Tremblay and Sullivan, 2007; Astfalck et al., 2010; Brink et al., 2009; Prins et al., 2008; Smith et al., 2007). Zandvliet and Straker (2001) investigated the relationship between psychosocial and physical risk factors in the classroom. Their findings revealed a complex relationship between computer workstation factors and psychosocial factors such as task orientation, stress and pain catastrophising (Zandvliet and Straker, 2001). In particular, over the last decade, the multidimensional construct of pain catastrophising, has received considerable attention in both adults and adolescents. Research suggests that catastrophising is an important risk factor for developing chronic pain and disability. It contributes to heightened anxiety and depression (Garnefski et al., 2002; Crombez et al., 2003; Vervoort et al., 2008; Tremblay and Sullivan, 2007).

Paediatricians, rheumatologists and orthopeadic manual therapists, review a large number of children with a wide variety of musculoskeletal pains (Melleson and Clinch., 2003; Clinch and Eccleston., 2009). Many of these children have recurrent and persisitent pain which becomes a chronic experience. This experience of chronic pain has been shown to have an impact on the individual in terms of their ability to interact socially as well affecting their ability to learn and concerntrate. The family of the child with chronic pain is also affected in terms of psychological stress, family disruption and financial stress (Palemo., 2000;Crombez et al., 2003; Tremblay and Sullivan., 2007; Vervoort et al., 2008). The extensive research data on the prevalence of musculoskeletal pain in children and the potential for acute, recurrent or persistent pain to become chronic (Sullivan 1995; Crombez et al., 2003, Brattberg, 2004) which can lead to disbility, supports the need to assess the prevalence and effect of the psychosocial risk factor such as pain catatstrophising in children in a school environment.

To date there have been no ergonomic interventions that have measured pain catastrophising as part of the risk factors that could impact on the effect of the intervention. To improve the detection of risks for developing chronic pain and disability, as well as the prevention and treatment among children and adolescents with pain, it is important to understand the function of pain catastrophising and how it leads to heightened anxiety and distress (Vervoort et al., 2008). Pain catastrophising is an important risk factor for developing chronic pain and disability in adults, children and adolescents (Fairbank et al., 1984; Vikat et al., 2008; Ehrmann Feldman et al., 2002).

Pain catastrophising is a multidimensional construct comprising elements of rumination ("I can't stop thinking about how much it hurts"), magnification ("I worry that something serious may happen"), and helplessness ("There is nothing I can do to reduce the intensity of the pain") (Sullivan et al., 1995). Sullivan et al. (1995) proposed the Communal Coping Model to address the different interpersonal functions of pain catastrophising. He suggested that individuals with high levels of pain catastrophising may use exaggerated negative thought patterns in their expression of pain to solicit empathy and support from other individuals (Sullivan et al., 1995). This study on theoretical perspectives on catastrophising and pain such as magnification and rumination may be related to primary appraisal processes of which individuals may focus on and exaggerate the threat value of a painful stimulus. Helplessness, however, may be related to secondary appraisal processes in which individuals negatively evaluate their ability to deal effectively with painful stimuli (Sullivan et al., 2001; Ehrmann Feldman et al., 2001).

Individuals with insecure attachment may use maladaptive coping strategies such as catastrophising and pain behaviours to gain empathy and support from family or other close relatives or friends (Ciechanowski et al., 2001). In the context of pain, Ciechanowski et al. (2001) proposed two main hypotheses to explain how attachment styles might influence the probability of experiencing a high level of pain catastrophising. Sullivan (2001) suggested, by way of the Communal Coping model, which stipulates that interpersonal variables and social context are central determinants of the relation between pain catastrophising and pain outcomes, that adolescents with a preoccupied attachment style would show a high level of pain catastrophising, pain behaviours and emotional distress to obtain more support from family and friends (Feldman et al., 2002;

Molcho et al., 2007). A more recent study by Tsui et al. (2012) refined the Communal Coping Model in examining the interpersonal communication dimension of the communal coping model of catastrophising. They used a sample of 49 chronic pain patients and 19 healthcare providers. They suggest that alleviation of catastrophic thinking may facilitate more effective interpersonal communication between the patient and the healthcare provider (Ghandour et al., 2004). This is considered significant if an interaction between the healthcare provider delivering an intervention to adolescents who may be experiencing chronic pain in a school environment is taken into account as high pain catastrophising may impact on the outcome of the effect of the ergonomic intervention programme (Feldman et al., 2002; Sullivan et al., 2001; Ghandour et al., 2004).

2.3.3 Prevalence and Incidence of Musculoskeletal Pain in Children

The prevalence of musculoskeletal pain refers to the number of cases of reported musculoskeletal pain in a population at a given time (Armstrong and Reilly., 2002).

Studies conducted between 1996 and 2011, with samples sizes ranging from small to large (n = 40 to n = 1483) and that determined the prevalence of musculoskeletal pain among children, were reviewed. The prevalence of musculoskeletal pain syndromes in adolescents from the reviewed studies ranged between 40% and 63.5%. Pain in the upper limbs was reported by between 50% to 73% of adolescents while lower-back pain was reported by between 23% and 50% of adolescents (Straker et al., 2002; Straker et al., 2011b; Burton et al., 1996; Harris et al., 2005; Zapata et al., 2006; Jones et al., 2004; Balague et al., 1999). Longitudinal studies have shown that there is a rapid increase in back pain early on in adolescence between the ages of 12 to 16 years of age (Salminen, 1984; Harreby et al., 1999b; Williams, 2002). Furthermore, Burton et al., (1996) found that the annual incidence of lower-back pain in children between the ages of 11 and 15 almost doubled and that around the age of 20, the incidence rate would level off and tended to remain fairly constant into the 40s (Burton et al., 1996). The increased prevalence of pain in children is an important consideration in that many adults with persistent pain report that their pain condition first occurred during adolescence (Leresche et al., 2005).

Gerr et al. (2002) conducted the first prospective study to establish the working posture of computer use in adults in North America. They used a large sample (n= 632) of participants who were required to work >15 hours on a computer per week and were followed for three years. Work postures and work-station dimensions were measured with medical and psychosocial risk factors such as anxiety and depression being assessed. They found that 46% of neck/shoulder pain and 32% of hand/arm pain occurred during the first month of follow up. More than 50% of computer users reported musculoskeletal pain during their first year of computer use. This study sets the scene for the potential issues that are faced by children exposed to increasing durations of time spent at computers both in the home and school environment (Gerr et al., 1996; Gerr et al., 2002).

In contrast to the numerous prevalence studies on musculoskeletal pain that have been done in the United States, Europe and the Scandinavian regions, only 27 prevalence studies have been done in Africa of which 37% were done in South Africa and 26% in Nigeria, despite the fact that prevalence rates of lower-back pain have been reported to be on the increase (Louw et al., 2007). With specific interest in the prevalence of musculoskeletal pain in adolescents, Jordaan et al. (2005) conducted an extensive epidemiological study in the northern Gauteng region of South Africa and found that lower-back pain in adolescents had a life-time prevalence of 53%, a one-year prevalence of 50% and a point prevalence of 15% among South African adolescents (Jordaan et al., 2005).

A systematic review by Louw et al. in 2007, on the prevalence of lower-back pain and risk factors for lower-back pain among the African population, reported that the prevalence of lower-back pain among this population may be comparable with that reported by research conducted in developed countries. In the study by Louw et al. (2007), the most common population groups studied by African researchers were found to be “workers” and “school scholars”. The results of their review showed a definite concern regarding the prevalence of lower-back pain among adolescents, which Louw et al. (2007) reported may result from the widespread introduction of information technology into the school curriculum (Louw et al., 2007).

The era of advancing information technology in South African schools saw the establishment of computer laboratories in a large percentage of schools by 2013 (Isaacs, 2007). This led Smith et al. (2007) to conduct a large prevalence study on computer-related musculoskeletal pain among learners in the Western Cape Metropolitan region South Africa. Prior to conducting this study, Smith et al. (2007) conducted a rigorous, systematic review of the prevalence of computer-related musculoskeletal pain among children and adolescents at a global level. The research found that out of 12 articles that were retained for the analysis, only one (Burke and Peper, 2002) acknowledged that the sample was a convenience sample, while the potential for recall and measurement bias was high in the studies (Burke and Peper, 2002; Zapata et al., 2006; Ramos et al., 2005b; Jacobs and Baker, 2002; Harris and Straker, 2000; Harreby et al., 1999b; Royster and Yearot, 1999; Jones and Orr, 1998).

Smith et al. (2007) conducted a descriptive study using a large sample (n=1063) of adolescents between 14 and 18 years of age. The study found a prevalence rate of 74% (n=1073) for computer-related musculoskeletal pain among adolescent school learners (mean age 16.3) in the Western Cape. They also established that girls were at greater risk of developing musculoskeletal pain than boys, which corresponds with results from international learner samples (Zapata et al., 2006; Hakala, 2006; Alexander and Currie, 2004). Prevalence rates for musculoskeletal pain studies reviewed by Smith et al. (2007) ranged from 27% to 60% for general musculoskeletal pain. A mean prevalence for neck/shoulder pain was 31.2% and for lower-back pain varied greatly between 7.5% and 65% (Smith et al., 2007). Increasing prevalence rates of musculoskeletal pain in adolescents using computers as reported by Smith et al., (2007) is consistent with international prevalence studies, (Harris et al., 2005; Straker, 2006; Jacobs and Baker, 2002).

Gillespie (2006) looked at aspects of computer use such as frequency, duration and location. She found that home-computer use and electronic-game use contributed to upper extremity or neck symptoms of pain or discomfort among adolescents more significantly than school computer use did. A large sample size of 476 adolescents between the ages of 12 and 18 was used in this cross-sectional study. She found that home computer use accounted for 93% of computer use among this sample (Gillespie, 2006). The odds ratios showed that girls (OR=1.9, p<0.015) were more likely to experience neck and upper extremity pain than boys. These results are similar to a more recent study by Straker et al., (2011), who found there to be a higher one-month prevalence of neck and shoulder pain among females (34.7%; OR=2.61, 95% CI 1.70-

4.00) when compared with males (23.1%) and computer use was found to increase this risk among the sample of female adolescents. The sample in this study was of a large size (n = 1483) and the adolescents used were from a follow-up cohort of the 14-year Raine study (Hands et al., 2011). The results are perhaps more reflective of the relationship between gender and the prevalence of computer-related musculoskeletal pain in adolescents than those from the smaller samples used in the Prins et al. (2008) and Kelly et al. (2009) studies.

In contrast, Prins et al. (2008) found no difference in computer exposure between learners at school, who developed upper quadrant musculoskeletal pain and those learners who remained asymptomatic. However, Prins et al. (2008) found there was a significant association between upper-quadrant musculoskeletal pain and computer use at school. Although the learner sample was small, this study is valuable in that the learners were followed up over a period of six months. The study found that learners (n=27) developed upper-quadrant musculoskeletal pain after being exposed to prolonged sitting positions while using computers. She concluded from her study of 104 learners that extreme cervical angles (<34.75 degrees or >43.95 degrees; OR 2.6; 95% CI: 1.0-6.7) and a combination of extreme cervical and thoracic angles (<63.1 degree or >71.1 degree; OR 2.19; 95% CI: 1.0-5.6) and poor posture, rather than the frequency or duration of computer exposure, predisposed learners to develop upper-quadrant musculoskeletal pain. Furthermore, the results from her study showed that boys are at greater risk of developing upper-quadrant musculoskeletal pain than girls (OR=1.94; 95% CI: 0.9-4.9), which is in contrast to the results from the Raine study (Hands et al., 2011) reported above.

However, a similar study by Kelly et al. (2009), using a small sample of 40 learners (n=24 female, n=16 male) from four Irish secondary schools (no sample size calculation was reported) and an experimental study design, found that learners experienced body discomfort and pain after computer class. This result is supported by similar findings from a study by Jacobs et al. (2002) done with sixth-grade learners in a school environment. Unfortunately, no gender differences with regard to the prevalence of musculoskeletal pain and computer use were noted in these smaller samples. There would seem to be conflicting views about whether or not this population group qualifies for the development of related ergonomic intervention programmes because of the duration and frequency of its exposure to computers, or if a predisposition to poor postural positions justifies the introduction of such programmes as the results from Prins et al.'s study (2008) showed that computer exposure had no effect on the learners compared to the extreme postural angles observed in the group of learners. However, both computer exposure and poor postural positions when using a computer have been identified in the literature as significant risk factors that need to be addressed by an ergonomic intervention programme (Harris et al., 2005; Straker, 2006; Straker et al., 2011a; Smith, 2007; Dockrell et al., 2010a).

In summary, the prevalence of musculoskeletal pain amongst children and adolescents ranges from 40-76%. and this continued high prevalence of musculoskeletal pain has been a cause of concern and is widely researched. Causal mechanisms that have been identified in the literature pertain to work postures, in particular prolonged awkward sitting postures at computer workstations, the amount, frequency and location of computer exposure in a school and home environment. In addition to these risk factors, physical risk factors such as carrying heavy schoolbag loads, participation in sporting activities, lack of physical education in the school curriculum and a sedentary mode of transport, have also been implicated in causing musculoskeletal pain in children (Whitifield et al., 2005, El-Metwally et al., 2007, Dunn et al., 2011).

The evidence found in the literature pertaining to risk factors of both the physical and psychosocial domain is strong and in particular there is more rigorous research being produced in terms of significant cross-sectional correlations being reported between childhood musculoskeletal pain and a number of potential risk factors. These include biological or structural factors (Kjaer et al., 2005; Harris et al., 2005; 2010), anthropometric factors (Oates, 1998; Laeser et al., 1998; Barrero and Hedge, 2002; Straker et al., 2009), psychological (Burke, 2002; Jacobs and Baker, 2002; Cho et al., 2003) and lifestyle factors (Balague et al., 1988; Troussier et al., 1994). The literature supports the need to educate children and adolescents on the risk factors and preventive strategies relating to poor ergonomics and computer exposure in the school and home environment.

With specific reference to this study, the literature reveals that there are various factors that need to be considered when looking at computer exposure among children (Harris et al., 2005; Gillespie, 2006). Important factors including access, location, and frequency, duration of computer use and workstation design will be reviewed. These factors are important when designing and assessing the effect of a computer-related ergonomic intervention programme in a school environment (Dockrell et al., 2010b; Harris et al., 2010b; Straker et al., 2010).

2.3.3.1 **Access to computer use**

A review of the literature yielded many studies that looked at access to a variety of computer use in the form of laptop and desk-top computers as a factor in pain development. Many of these studies revealed that there are differences in access based on a number of factors such as socioeconomic status, gender and geographical location (Hestbaek et al., 2006, Wilson et al., 2003, Jacobs et al., 2006). An example of a study where social stratification has been shown to influence the "digital divide" among population groups is demonstrated by the results from the Wilson et al. study (2003). Wilson et al. (2003) conducted an extensive, general-population survey (n=1004) in North Carolina with a 52% (n=522) response rate. The data were weighted to ensure an accurate geographic distribution across the state of North Carolina. Results obtained by way of bivariate logistic regression analysis showed that black, rural, and female respondents were less likely to have access to home computer use than white, urban, male respondents. In addition, they found that higher income-earning households and better educated respondents were more likely to have access to computers and the internet. They concluded that the racially-based digital divide is the strongest variable influencing access to computers, but this could not be explained by social and economic variables (Wilson et al., 2003). These findings are similar to those by Hestbaek (2006), Jacobs et al. (2006) and Isaacs (2007) in that access to computers was determined by race and geographical urban versus rural locations.

Socio-economic status has been shown to influence accessibility to computers among children both at school and at home. Becker (2000) obtained information from original analyses of data gathered in a national survey of more than 4 000 teachers across California in 1998. He reported that more than 75% of the students had access to computers at school while teachers at lower-income schools reported weekly computer use that was higher than that of teachers at higher-income schools. The data suggest that the reason for this discrepancy was that students at the lower-income schools used a computer more frequently for repetitive practice when compared with the higher-income students using computers for more sophisticated cognitive applications (Becker, 2000). The study found similar results when compared with the study by Wilson et al. (2003) in that there were only subtle differences which were between low income and high income children's access to home computers. The author concluded that schools would have to play a critical role in ensuring equal opportunity for lower-income classes to access the benefits of the more powerful applications of computer technology (Becker, 2000).

For many children in South Africa, school provides the only access to computers. According to a report by Isaacs (2007), some provinces have provided ICT-integration programmes in their schools. The highest percentage of computers in schools is found in the Western Cape and Gauteng provinces where 97% and 94.5% of schools respectively in these two provinces have computers. However, unlike the results of some studies conducted in the United States, children from lower income areas in South Africa tend to have less exposure to computers than children from higher income areas because broad-band connectivity is limited in many of the rural areas. This is compounded by the fact that many public schools cannot afford connectivity (Isaacs, 2007).

There is conflicting literature on whether the socio-economic divide influences accessibility to computers for children attending school (Becker, 2000). However, most of the published information indicates that young people from higher income-earning groups are more likely to have increased access to computers (Wilson et al., 2003). Children from higher income groups usually attend schools with more reliable computer equipment and have teachers with better computer teaching skills (Bleakley et al., 2004; Wilson et al., 2003; Isaacs, 2007; Smith et al., 2007).

2.3.3.2 **Types of computer use in different environments**

Children in this digital era are exposed to a range of different environments and different types of computer use, as well as different types of IT (Wilson et al., 2003). The majority of studies that have explored the different environments that expose children to computers and IT have focused on the school and home environment. Jacobs et al., (2002) used a sample of convenience (n=152) of 6th grade students from an American middle school and found that most of the students had three computers at home but generally did not have furniture designed for computer use. Although the sample used was not representative of the American population, the results did indicate that there was a weak correlation between the number of hours spent using a computer at home and musculoskeletal discomfort (r=0.19, p=0.05) (Jacobs and Baker, 2002).

Previous studies have shown mixed results in respect to use of computers and location namely at school compared with computer use at home. Some studies like those by Olds et al. (2004) and Smith et al. (2007) indicate a higher proportion of school computer use among learners. In particular, the Smith study found that the socio-economic status of the learners influenced this difference in location of computer use. However, the majority of international studies show that total exposure is greater at home, with an increased frequency, duration and mean weekly hours of computer use across higher grades and genders (Harris et al., 2005; Gillespie, 2006; Straker et al., 2006; Harris et al., 2010). Harris et al. (2005) investigated young people's computer exposure patterns at home and school, as well as factors like age, gender and types of IT used. The sample used in this study was large (n=1351), comprising schoolchildren from primary and secondary schools, a mixed-gender base and a broad socio-economic range.

In a later study done by Harris et al. (2010a), older students were reported to have the highest frequency of use of a particular type of technology. However, when they do use technology they spend longer periods using a particular device such as a computer or cell-phone. In view of their study, Harris et al. (2010a) recommended that there is a need to examine a range of exposure variables such as computer use, cell phone use and gaming when investigating relationships between home and school computer use and other IT devices (Harris et al., 2010a).

It can be concluded that Harris et al.'s (2010a) study conducted a detailed exposure analysis that identified exposure patterns vary when the home location is compared with the school location in a context of gender and age (Harris et al., 2010a). Both laptops and desktop computers were used at school, with 24.5% (n=324.5) of learners using both laptops and desktops. Seventy four point two percent (n=999.7) used only desktops and 1.3% (n=135.1) used only laptops. The academic grade of the pupils affected the frequency of all computer activities and the frequency increased in the higher grades.

However, the exception was the grade 6 participants who were using learning programmes and registered the highest frequency of use. A large percentage (98.9%; n=1337) of learners indicated that they were using computers at home. The most common location of computer use at home was the living-room or study (53.7%) and (26.3%) reported using their bedroom or study area for this purpose. Desktop use was reported by 82.5 % (n=1121) of the learners while 33.8% (n= 459) of learners reported using a laptop.

In view of the fact that computer exposure differs among different genders, it is important to note that gender differences have been found in many studies focusing on computer exposure among children (Harris et al., 2005; Straker et al., 2009b; Harris et al., 2010b; Kelly et al., 2009). In particular, studies have shown that boys have a greater frequency and duration of computer use with exposure to gaming, multimedia and use of the internet (Gillespie, 2006; Harris et al., 2010a). A cross-sectional study by Harris et al. (2010b) found significant differences between age and gender associated with their school and home computer use. Their sample was selected across different grade levels and ensured that the analysis by gender and grade level did not bias the results. In contrast to the above study, a review of studies relating to computer use amongst children by Subrahmanyam et al. (2000) found that the gap between the genders in the use of home computers was already diminishing as girls were beginning to spend as much time using the internet as the boys.

In summary, the cited literature shows that young people's exposure to computers and IT is influenced by the environment in which they are used as well as the children's age and gender (Gillespie., 2002; Harris et al., 2010a). Furthermore, computer exposure is also influenced by their use of other forms of IT (Gillespie, 2006). The increase in the use of laptops and more recently iPADs, will also influence the location and exposure of young people to IT. Research on the effects of iPAD use is lacking, but there is sufficient evidence from research on laptop use among children to suggest that increased neck flexion and limited range of neck movement will be similar in effect to that of using an iPAD (Ramos et al., 2005b; Straker, 2006; Asundi et al., 2010). Computer location and type of IT are essential components when examining the effects of computer exposure on young people. However, the frequency and duration of IT use is also an important factor.

2.3.3.3 **Frequency of computer use**

Research has shown that an increase in the time spent on a computer is significantly associated with increased reporting of musculoskeletal pain (Katz, 2006; Straker et al., 2010; Harreby et al., 1999b; Hakala, 2006). The majority of current literature reviewed used hours per day of computer activity to assess computer exposure of participants (Zapata et al., 2006; Hakala, 2006; Ramos et al., 2005b; Burke, 2002; Jacobs and Baker, 2002). An extensive epidemiological study by Hakala et al. (2006), conducted in Finland found that two hours and more than five hours spent at the computer was a risk factor for developing neck/shoulder pain and lower-back pain. Katz et al. (2006) surveyed a large sample of 1 601 senior college students and found that increasing time spent at a computer was significantly associated with increased reporting of musculoskeletal pain ($p<0.0101$) (Katz, 2006). Students who spent more than 20 hours a week using the computer were found to be 40% more likely to experience symptoms of pain (OR=1.4, 95% CI=1.1 to 1.9). Zapata et al. (2006), using logistic regression analysis, found that computer use in excess of four times a week was a predictive risk factor for developing pain (OR= 1.98 (1.17 to 3.21)).

The above studies used large study samples and used rigorous statistical analysis to obtain their results and are therefore a good reflection of quality studies on the impact of hours of computer use on musculoskeletal pain in children. A study conducted in South Africa recently, sought to establish the number of hours spent by learners using a computer and the impact on learners revealed similar results (Smith et al., 2007).

Smith et al.’s (2007) study was conducted in a school environment using a large sample group of learners (n=695) between 14 and 18 years of age. Two groups of learners were identified: a computer group and a non-computer group. The computer group who took computer studies as a subject, spent an average of 1.5 hours a week using the school computer, compared with 1.37 hours a week by the non-computer study group. Overall, the computer group had almost twice as much weekly computer exposure as the non-computer group. The researchers found that weekly computer exposure of more than seven hours was predictive for developing musculoskeletal pain among this study sample. An increase in the number of hours of computer exposure per week was also shown to be associated with an increase in the number of body areas that were affected, but it was not found to be predictive of multiple body areas of pain. Gender differences were found between the total number of hours spent on the computer, both at school and at home – with boys spending a total average of 12.35 hours a week and girls 9.24 a total average of hours a week – on the computer. In addition, through logistic regression analysis, odds ratios showed that school computer use longitudinally for more than three years was a predictive risk factor for developing musculoskeletal pain (OR=2.04, 95% CI= 1.12-3.76) (Smith et al., 2007).

The above study examined a similar duration of computer exposure to international learner samples of weekly computer exposure undertaken by Hakala, 2006; Burke, 2002; Harreby et al., 1999b and Harris and Straker, 2000. Based on the available evidence of extensive research on computer exposure and its effects on the musculoskeletal system, current studies recommend that children should limit the use of IT for learning to two hours a day (Straker et al., 2010b).

Straker et al. (2010b) based his recommendation of two hours of computer use for learning, on the impact of school computer use in the context of a poor workstation set-up (Straker et al., 2010b). Usually, computer lessons at school are 45 minutes long. However, the computer laboratories where learners spend this time, are not necessarily designed or equipped to encourage the children to adopt good working postures (Straker et al., 2010b).

2.3.3.4 Computer workstation design and the implications for sitting postures in children

A review of the literature showed that identifying a causal relationship between risk factors and the development of musculoskeletal pain associated with computer use has been challenging (Harris et al., 2005). Nevertheless, workstation design and posture have been classed as two of the most common potential risk factors and therefore they have been investigated thoroughly by researchers. Numerous epidemiological studies have shown that the most common site of musculoskeletal pain in adults is the lower back, while adolescents experience neck/shoulder pain and tension headaches (Zapata et al., 2006; Straker, 2006; Kelly et al., 2009). There is growing evidence that other aspects relating to back pain prevention in children, such as adapting computer workstations to meet the students’ needs, are important (Laeser et al., 1998a; Oates et al., 1998; Straker et al., 2002, 2008, 2009). So too is training in relevant ergonomic subjects and long-term prevention programmes as part of the school curriculum (Jacobs 2002, 2006; Heyman and Dekel, 2009).

Linton et al. (1994) and Milanese and Grimmer (2004) have shown that merely adapting school furniture has, on its own, proved to be neither viable nor sustainable for preventing back pain in adolescents as one needs to include postural education. To get better results in the prevention of musculoskeletal pain, it is important to assess posture in relation to computer use, workstation design and the ergonomic behaviour of adolescents in a school environment. Following an assessment of these components, the literature supports an effective ergonomic intervention programme to be designed with the inclusion of an educational component comprising aspects of applying ergonomic principles, the correct use of stretch exercises and 'pause' breaks when using a computer, as well as teaching learners about the importance of being active in between computer use. In addition, the intervention programme needs to be cost-effective and sustainable in the long term (Dockrell et al., 2010b; Ismail et al., 2010; Dolphens et al., 2011).

Most research documented that available workstations at schools do not fit the majority of children (Laeser et al., 1998; Oates et al., 1998; Straker et al., 2002; Kelly et al., 2009). Oates et al. (1998) did a workstation assessment using RULA analysis of 95 learners between the ages of eight and 11 and found that no learners had acceptable postures when using a computer. A large percentage of learners (61%) was found to be in an action level of concern and 39% were considered to be at postural risk. Some of the problems reported were that workstations were inappropriately set-up, monitors were too high (374-512mm) and the chairs and keyboards were not suitable for the learners' body dimensions. These factors put the wrist, neck and legs at risk of pain development. Similarly, Straker et al.'s (2002) workstation dimensions also found that the keyboard height and monitor height (575-325mm) were too high for the learners aged between 4 and 17 years of age. In their study (n=33), Straker et al. (2002) found that adjusting desk height to the subject's height, (which is age related) and elbow level, made a difference. The value of the above studies is that they both showed that with appropriate adjustments to workstations, the physical stress on the children's' bodies can be reduced and their postural positions can improve significantly. Straker et al. (2002) concluded that the desk height should be at the elbow height of the child so as to reduce the upper trapezius activity, however, an appropriate monitor height level was not found due to conflicting evidence in the literature.

In contrast, two studies that have compared "ergonomic" and traditional furniture designs found there to be no significant postural differences despite the fact that the learners preferred the comforts of the ergonomic furniture compared to the traditional furniture. However, learners using the ergonomic furniture reported less musculoskeletal pain relative to the control group ($p<0.04$) (Linton et al., 1994; Troussier et al., 1999). In the study by Troussier et al. (1999), there was no change in the prevalence of back pain or musculoskeletal symptoms between the control and intervention groups using traditional and ergonomic furniture, over a period of five years.

Numerous studies have found that one of the most common risk factors for developing upper quadrant musculoskeletal pain among children and adolescents is prolonged awkward sitting posture (Hakala, 2006; Briggs et al., 2009b; Jacobs and Baker., 2002). With school curricula changing to incorporate e-learning and access to computer use in school children across the world growing, epidemiological studies on posture and the impact that computers are having on children and adolescents is on the increase. Recent epidemiological research has shown associations between sitting and back pain in the adult population as well as in children and adolescents (Balague et al., 1999; Sjölie and Ljunggren, 2001; Kelly et al., 2009; Straker, 2006). Research in biomechanics has shown that increased spinal loads while sitting poorly for prolonged periods of time can be a risk factor for back and neck pain. Based on these biomechanical studies, epidemiological evidence suggests that there is an association between pain and poor sitting positions in children.

A cross-sectional study of children by Murphy et al. (2003), found that prolonged sitting and poor postures are risk factors for causing back pain. Not only does the literature indicate that prolonged and poor postures produce negative biomechanical and musculoskeletal effects, but they also result in circulatory and psychosocial consequences. This is supported by the studies of Salminen et al. (1999), who showed that individuals with disc degeneration at a young age are at risk of experiencing recurrent lower-back pain, both in their youth and over the longer term into adulthood.

Sitting postures of adults and children have shown that children behave differently from adults when sitting in a school classroom or in front of a computer. They tend to fluctuate between dynamic and static sitting postures while adults incline towards a prolonged static sitting posture (Straker et al., 2002; Greig et al., 2005; Straker et al., 2009b). However, studies have shown that children do mimic the prolonged static sitting postures of adults, thus putting them at risk of developing musculoskeletal pain (Briggs et al., 2009a; Greig et al., 2005; Harris and Straker, 2000).

Results from a study by Geldhof et al. (2007) using a randomly selected learner sample of eight to 12 year old school children (n= 105, mean age 9.9. years, SD= 0.8, range 8.5 to 12.5 years) from 41 different class groups, showed that learners sat statically for 85% of the time, 28% of which was spent with the trunk in a forward flexed posture. They also found that children sat dynamically for 9% of the time and 36% of the time they used a back rest. This study used the reliable method of postural ergonomic observation (PEO) with a video tape, which has been shown to have a high intra and inter observer reliability (Geldhof et al., 2007). Self-reported neck and back pain were also studied by Geldhof et al. (2007) and they found that children who spent more time with flexed trunk posture reported significantly more thoraco-lumbar pain when compared with pain-free children and those children with cervical pain ($p<0.05$).

Harris and Straker (2000) used a self-designed questionnaire in conjunction with direct observation of the postural angle for measuring sitting posture in children using laptops in different postural positions (sitting, lying, sitting on the floor) and at different locations (school, home). They found a significant association between the maximum time spent in static sitting while using a laptop computer, and neck/shoulder discomfort (x^2= 16.51, $p<0.01024$). Cho et al. (2003) found that students considered posture to be the most important contributing factor to neck pain (43%) and shoulder pain (15.1%).Similarly, Ramos et al., (2005), used a large sample of learners (n=479) aged between six and 14years, and by way of a self-designed questionnaire, found an association between the duration of sitting in front of a computer and the prevalence of discomfort in the neck and uppe back. Furthermore, neck discomfort was found to be statistically significant in respect of time spent on the computer at school ($p<0.011$) and at home ($p<0.018$).

Prins et al. (2007) used the portable posture analysis method (PPAM) for measuring postural alignment among learners using a computer. They conducted a six-month prospective study of secondary-school grade 10 learners (n=104) who were enrolled for computer studies in the Western Cape, South Africa. This method of postural measurement has been found to be a reliable and valid measure of sitting posture (Van Niekerk et al., 2008). The study found that extreme cervical angles, referring to cervical angles of less than the degree at the 25% quartile (<34.75 degrees) or greater than the degree at the 75% quartile (>43.95 degrees), was a significant risk factor for the development of upper quadrant musculoskeletal pain among the group of learners (OR 2.6; CI: 1.0 to 6.7). These mean values for cervical angle (39.3 degrees) and head tilt (13.8 degrees) found in this study are comparable with the mean values found in studies conducted by Straker et al. (2002), Briggs and Greig (2002) and Briggs et al. (2004). In addition learners who had a combination of an extreme cervical and extreme thoracic angle (<63.1 degrees or >71.1 degrees) were at an increased risk of developing upper-quadrant musculoskeletal pain (OR 2.19; CI: 1.0-5.6) (Prins et al., 2007).

Other more recent studies investigating posture and musculoskeletal discomfort in learners while working at computers in a school environment have been conducted in Ireland, Australia and Malaysia (Dockrell et al., 2010a; Dockrell et al., 2012; Straker et al., 2009b; Ismail et al., 2010; Straker et al., 2011b). A review of these studies has shown that over time RULA is being more commonly used. For example, the study by Dockrell et al. (2010a) in Ireland used a sample of 40 learners and their study provided valuable information on the reliability and validity of the RULA method of postural measurement.

Dockrell et al. (2010a) used RULA to assess posture among secondary school students (n=40) working at computers in a school environment. Reliability and validity of the RULA tool has recently been established. It has been used in numerous studies on posture in the past (Dockrell et al., 2010a; Oates, 1998b; Laeser et al., 1998). The students were observed during their normal class times, which ensured high levels of external validity for the application of this study, while one researcher carried out all the RULA observations, thus ensuring high intra-rater validity. Measurements of body discomfort and pain intensity using a body-discomfort chart and a visual analogue scale were done at the beginning and end of the computer lesson. Each learner was observed for 10 minutes during the computer lesson and the Hawthorne effect on the learners was accounted for by use of the same researcher being present at the stages of consent from distribution and data collection (Dockrell et al., 2010a).

The results from reviewing the Dockrell et al. (2010a) study provide an awareness of how posture and discomfort in this sample group are related. The results can be compared with other studies that have been done using similar observational methods. None of the learners in the sample was found to be in an acceptable postural position (action level 1) and the majority of the learners (65%) were found to be in action level 2, whilst a minority (5%) was found to be in action level 4. Forty-five per cent of the learners reported musculoskeletal discomfort prior to the computer lesson and 80% of the learners indicated that they had musculoskeletal discomfort at the end of the class. The mean discomfort level was 2.6/10 (SD= 1.04) and thoracic spine (38.9%), cervical spine (22%) and lumbar spine (22.2%) were the most common areas indicated at the beginning of the class. By the end of the computer lesson this had changed to a mean discomfort level of 3/10 (SD=1.94) with the most common areas of discomfort being cervical spine (50%), lumbar spine (34.4%), thoracic spine (21.9%) and right and left shoulders (18.8% each). The results showed an increasing frequency of action level coincided with an increase in the discomfort scores.

In comparison to the Jacobs and Baker (2002) and Dockrell et al. (2010) studies above, the studies done by Straker et al. (2011) and Ismail et al. (2010) used larger sample sizes, 1 423 and 229 participants respectively and different postural methods of measurement. The researchers from both the Dockrell et al. (2010) and Jacobs and Baker study (2002) indicated in their conclusion that further investigation is required with a larger population. The findings from the Dockrell et al (2010) study contrast with the findings by Ismail et al. (2010) who found no significant association between reported musculoskeletal pain and incremental RULA score (Ismail et al., 2010). The discomfort scores, reported in Ismail et al.’s (2010) study was similar to those reported by Jacobs and Baker (2002) in a study examining the discomfort experienced by learners’ postural positions while working on a computer.

A review of the literature relating to studies finding a mismatch between anthropometric measurements of learners and the dimensions of school furniture (Oates, 1998; Laeser et al., 1998; Barrero and Hedge, 2002; Harris and Straker, 2000; Straker et al., 2002; Smith et al., 2007; Straker et al., 2009) as well as heavy schoolbags (Sheir-Neiss et al., 2003; Parcells et al., 1999; Mackie and Legg, 2007) increasing the risk of learners developing musculoskeletal discomfort shows that these risk factors are an important consideration when planning an ergonomic intervention study. The effect of the schoolbag weight can act as a confounding variable and it must be examined as part of a needs assessment prior to the implementation of an intervention (Sheir-Neiss et al., 2003; Parcells et al., 1999; Mackie and Legg, 2007). For example, Ismail et al. (2010) assessed schoolbag weight prior to an ergonomic intervention. They found that carrying a heavy schoolbag in addition to the effect of posture at a computer impacted on musculoskeletal pain. Ismail et al (2010) used a large sample (n=229) and learners ranged between eight and 11 years of age. A limitation of this study, despite that it was conducted over a period of four months, was that not all the learners were measured with the RULA tool and there was no description of how the RULA assessment was carried out, which is important for internal validity and consistency (Ismail et al., 2010).

In terms of workstation design, there is an association between postural factors, workstation set-up and musculoskeletal disorders among adult computer operators (Gerr et al., 2002). There is paucity of literature on workstation design and the effect of posture and muscle activity in children using computers (Oates, 1998a; Laeser et al., 1998; Straker et al., 2002). Oates (1998) and Laeser et al. (1998) both looked at the ergonomic appropriateness of computer workstations in a school facility. Oates (1998) specifically used a sample of grade 3 to 5 learners in six elementary schools based in New York and Michigan. They found that the computer-equipped classrooms were associated with high risk for the development of musculoskeletal disorders. The study by Laeser et al. (1998) was more thorough in that it examined the effects of workstation design on overall seated posture, task performance, engaged behaviour and the user preferences by grade 6 to 8 learners in a school environment. Each student performed a keyboard and mouse task at two different workstations; one that was a standard desktop and one that had been anthropometrically adjusted to suit the students' physical requirements. They found that the posture of the student improved at the workstation that was fitted to the student's anthropometric requirements. In comparison to the above studies, the study by Straker et al. (2002) was different in that this study compared posture and muscle activity resulting from a typical workstation set-up, with values of what was recorded when the chair and desk height of a computer workstation were adjusted for an individual child. The findings indicated that the adjusted workstation resulted in postures that were closer to a more resting alignment. However, the results for decreased muscle activity in the upper trapezius muscle were not significant, but there was a trend of reduced muscle activity when workstation set-up had been adjusted for the individual. This supports the conclusion by Straker et al. (2002) that adjusted workstations can reduce the postural strain in the neck and shoulder area of learners using computers.

In addition to studies examining the effects of adjusting a learner's workstation to reduce postural strain, studies have found evidence endorsing the use of a supporting surface under the forearm to reduce strain on the postural muscles of computer operators (Rempel et al., 2006; Aarås, 1997; Marcus et al., 2002). Following on from the Straker study in 2002, Straker et al. (2008) conducted a more comprehensive study using a mixed-model design to test the effect of forearm support on head, neck and upper limb posture as well as muscle activity during computer use among children between 10 and 12 years of age (n=24). The sample size used was small however, the study used a three-dimensional postural analysis method. A camera with an infrared motion-analysis system was used to measure posture by way of visible, reflective markers that were anatomically positioned on each learner during their computer activity. Posture was the dependent variable and forearm support was the independent variable. A univariate mixed model analyses of variance was done. This form of analysis was valuable as it showed that there was an unexpected gender difference in the effects of forearm support in males and females in this study. Lower muscle activity was found among males with forearm support when this was compared with the muscle activity of females in the study. However, there was no significant difference found in postural variability among male and female learners although Straker et al. (2011a) found, gender differences in habitual spinal posture and computer use between the male and female adolescents. The researchers noted that a limitation of this study was the omission of postural variability measurement, which could reduce musculoskeletal stress. Furthermore, no discomfort measurement was done that could have indicated a change in discomfort levels among the learners during prolonged tasks. Nevertheless, this was the first study to look at the effect of forearm support among children working on computers. In addition to considering risk factors associated with computer use such as schoolbag weight, posture and positioning, which can be considered as physical factors, psychosocial factors (Sullivan et al., 2001; Smith et al, 2007; Harris et al., 2010) shall be included in the assessment for developing musculoskeletal pain in children using computers (Louw et al., 2007).

2.4 ERGONOMIC BEHAVIOUR OF ADOLESCENTS

Anthropometric differences account for differences in the way children use computers compared to adults (Harris and Straker, 2000; Briggs et al., 2009b). In most schools the introduction of computers and laptops, and more recently iPADs, has not been accompanied by an introduction of ergonomic furniture or ergonomic awareness education. Most often, computers have been placed on classroom desks or tables with little attention given to potential postural problems that could result. In the last five years there have been a growing number of studies initiated worldwide on the issues of workstation design and set-up in schools. Smith et al. (2007), Kelly and Dockrell (2009), and Ismail et al. (2010) have presented valuable research on the impact of workstations in the school environment on posture and musculoskeletal pain in children.

Heyman and Dekel (2001) believe that educating children towards balanced posture, body function and movement patterns, as well as their ergonomic implications, can minimize and even prevent these musculoskeletal problems in children. They propose that an ergonomics awareness educational programme, as part of a prevention effort, should begin during childhood and should be an integral part of the curriculum in schools. One of the proposed interventions is participatory ergonomics.

Intervention studies conducted by Heyman and Dekel (2001) and Shinn et al. (2002), in a school environment, had a positive outcome on increasing children's awareness of body mechanics, movement and posture. The intervention was not measured for effectiveness in the long term. An educational in-service programme, which was implemented, showed statistically significant differences ($p<0.011$) in results of pre and post test scores post-intervention (Shinn et al., 2002). Furthermore, the study concluded that there is a need for preventative education on computer use for children of school-going age.

Several studies illustrate the importance of paying attention to different aspects that relate to back pain in children (Zandvliet and Straker., 2001; Heyman and Dekel., 2009;

Dockrell et al., 2007; Dockrell et al., 2010a; Ismail et al., 2010). These studies outlined that other aspects relating to back pain prevention in children, such as adapting school furniture to students' needs, is important, however, training in ergonomic subjects and long-term prevention programmes, forming part of the school curricula, are also important. Merely adapting school furniture has, on its own, proved to be neither viable nor sustainable for preventing back pain in adolescence (Linton et al., 1994; Milanese and Grimmer. 2004).

It is therefore important to assess the posture and ergonomic behaviour of adolescents in a school environment so that an effective ergonomic intervention programme can be designed and implemented at a sustainable level with the concomitant reduction in unnecessary healthcare costs over the longer term. In addition to assessing the ergonomic behaviour of adolescents through monitoring their posture, knowledge and awareness of teachers' computer-related ergonomics is essential. Training teachers will assist in sustaining a culture of good ergonomic practice in a school environment after the implementation of a computer-related ergonomics intervention programme (Dockrell et al., 2007).

2.5 ERGONOMIC AWARENESS AMONG TEACHERS AND PRINCIPALS IN THE SCHOOL ENVIRONMENT

There is not a great deal of literature on teacher or student awareness of computer ergonomics. Concern has been expressed about how little knowledge there is of computer ergonomics and installation in the school environment (Bennett, 2000). Dockrell et al. (2007) investigated the education of school teachers in computer-related ergonomics in Ireland. The study found that most teachers had computer training, but ergonomic information was not included in the training. They also found that there is a great need for the inclusion of ergonomic teaching in computer training initiatives for teachers and school principals (Dockrell et al., 2007).

SECTION B: MEASUREMENT TOOLS USED TO ASSESS OUTCOMES MEASURES OF PAIN AND POSTURAL CHANGE

2.6 MEASURING PAIN IN CHILDREN AND ADOLESCENTS

Pain scales are commonly used among adults and that children can reliably use pain scales from the age of about three or four years of age (Carolyn, 1997; Neumann et al., 2007; Hettiarachchi et al., 2006). There are a variety of measures for pain that can be categorised as: self-report (what children say), biological markers (how their bodies react), and behaviour (what children do). The literature does not suggest that any one scale is better than any other (Reid et al., 1998).

The reporting of pain is subjective and influenced by environmental and psychosocial factors. Therefore self-report is best if a child is older than three years of age and does not have any cognitive or physical impairment. From the age of six or seven years, children can use word-related rating scales (Neumann et al., 2007). Children are asked to indicate how much pain they have on a line with five verbal anchors. At this age, children can use zero to10 or zero to 100 scales, with zero being “no pain” and 10 or 100 being “the worst possible pain.” Similarly, a 10cm long line with anchors of “no pain” and “the worst pain possible” (a visual analogue scale) can be used (Neumann et al., 2007).
Another form of self-reporting assessment for the measurement of pain in children, and one that has been shown to be reliable as well as valid for use in normal and clinical paediatric populations aged between four and 16 years, is the Faces Pain Scale – Revised (2010). This scale uses facial expressions to assess pain intensity. Studies among adolescents have used a variety of approaches to measure pain. Some of the approaches included a body-map diagram showing the area of pain (Harris et al., 2005) and numerous researchers have used a structured pain questionnaire, incorporating a visual analogue scale or numerical rating scale to assess musculoskeletal pain (Jeffries et al., 2007; Grimmer et al., 2006; Dockrell et al., 2010a). In their study on the impact of computer usage and electronic games on musculoskeletal pain in children and adolescents, Gillespie (2006) acknowledges that in the case of subclinical musculoskeletal symptoms there is no accepted objective measure of outcome and that self-report may be the only way to elicit information from a subject on the pain experience.

A Computer Usage Questionnaire (CUQ) which was developed by Smith et al. (2007), from the University of the Western Cape, was used to determine the prevalence of musculoskeletal pain among the learner sample, as well as the prevalence of pain related to computer use, the areas of the body where pain was experienced and the amount of computer exposure at school. The CUQ had been tested previously for content and face validity and reliability (stability) by Smith et al. (2007). For the purposes of this study, the intra-rater reliability of the CUQ was tested in the pilot study and found to be reliable (ICC=0.99, p<0.01) (see Appendix B). Table 2.5 below illustrates the variables obtained by using the CUQ.

Table 2.2: Variables of Measurement Assessed by the CUQ

Dependent variable:	Prevalence of musculoskeletal pain related to computer use in adolescents
Independent variables:	- Demographic variables - Pain - No. of hours exposed to computer usage - Participation in a physical activity - Psychosocial risk factors - Backpack weight
Measuring instrument:	Validated questionnaire (peer review and learner focus group in study by Smith et al(2007); scale- schoolbag

2.7 THE PAIN CATASTROPHISING SCALE FOR CHILDREN (PCS-C)

Adolescents frequently experience and report pain (Neumann et al., 2007, Goodman and McGrath, 1991). For a minority of adolescents, it has been found that the pain that persists for over three months can become chronic pain (Astfalck et al., 2010). The prevalence of pain in childhood is well documented, however, little is known about ways in which children and adolescents adapt to pain or how chronic pain is maintained. Pain catastrophising has been found to be a critical variable in understanding and adjusting to pain in both adults and children (Ehrmann Feldman et al., 2001, Tremblay and Sullivan, 2007).

In 1995, Sullivan et al. (1995) developed the Pain Catastrophising Scale (PCS) in an effort to develop a comprehensive evaluation instrument that would encompass all aspects of catastrophic thinking. However, Crombez et al. (2003) found the current methods of measuring pain catastrophising relied on brief subscales of larger coping inventories. Therefore, they adapted the PCS (Sullivan et al., 1995) for use in children and investigated its construct and predictive validity in two different studies. The results of the first study suggested that the PCS-C is a valid and stable instrument for assessing catastrophic thinking about pain in children and adolescents. The second study revealed important correlations with pain catastrophising, pain intensity and disability (Crombez et al., 2003).

The PCS-C instrument assesses three dimensions of catastrophic thinking, namely:

Rumination – a constant focus on the threat value of pain (a primary appraisal process)

Magnification – an exaggerated experience of the threat value of pain (a primary appraisal process).

Helplessness – is related to a secondary appraisal process in which individuals negatively evaluate their ability to cope effectively with their pain.

Rumination, magnification and helplessness are independent but strongly related dimensions of a higher-order construct of pain catastrophising (Sullivan et al., 1995). Despite gender and age differences in catastrophising, the three-factor model was found to be invariant across age and gender (Crombez et al., 2003).

For this study, the PCS-C was not tested for validity and reliability as this tool has undergone extensive validity and reliability testing over the years and findings have revealed that the 3 factor structure of the PCS-C was replicated in the PCS-C and that it was invariant across age group and gender (Crombez et al., 2003; Verhoeven et al., 2011). It has recently been translated into 11 different languages around the world. However, it has not been validated in the South African context. For this reason, the feasibility of using the PCS-C tool was tested in a South African school environment during the course of the pilot study. The aim of the feasibility study was to objectively and rationally uncover the strengths and weaknesses of using the PCS-C tool in the South African school context.

A visual numeric pain rating scale (VNPS), which is supported by the literature and has been used extensively over the last two decades in many studies measuring pain, was included with the CUQ to measure pain intensity in the numerical form (Neumann et al., 2007; Mercer and Holder, 1997; Kanarek, 2005; Esposito et al., 2003). Holdgate et al. (2003) found the VNPS to be very similar to the visual analogue scale, but the VNPS was a more practical tool. Williamson and Hoggart (2005) reviewed research relating to three commonly used pain rating scales, the visual analogue scale, the verbal rating scale and the numeric rating scale. Their review found that all three pain rating scales are valid, reliable and appropriate for use in assessing pain, but the numerical pain rating scale was found to have better sensitivity and generated data that can be statistically analysed for audit purposes. In support of these findings, a more recent study by Hjermstad et al. (2011) on unidimensional pain rating scales found that when compared with the visual analogue scale and the verbal rating scale, numerical rating scales had better compliance in 15 of 19 studies. This tool was also the recommended tool in 11 of the 37 studies on the basis of higher compliance rates, better responsiveness and ease of use, as well as good applicability relative to visual analogue scales/verbal rating scales. Many of the studies showed wide distributions of numerical rating scores within each category of the verbal rating scales (Hjermstad et al., 2011).

This study sought a more accurate measure of pain intensity in a numerical form rather than simply using the faces pain scale assessment before and after the computer-related ergonomic intervention programme.This would support the measurement of the quality of responsiveness in terms of self reported pain by the learners. The CUQ uses a body discomfort chart, a faces pain scale as well as an additional numeric pain rating scale, thus ensuring that pain intensity is measured as accurately as possible. A review of the literature supports the use of multiple recording methods of symptoms in studies on musculoskeletal pain outcomes, computer use, and ergonomic intervention studies (Hjermstad et al., 2011, Marchand et al., 2012). A common method of multiple recording of symptoms has been by way of three methods: by marking on a body discomfort chart indicating symptoms felt in the last month, by recording symptom frequency and by recording symptom intensity (Harris et al., 2005; Straker, 2006; Dockrell et al., 2010a; Ismail et al., 2010). Another important aspect that needs measurement when assessing musculoskeletal pain is posture.

2.8 MEASURING POSTURE IN A SCHOOL ENVIRONMENT

Posture reflects the relationship between spinal segments and the influence of the environment on spinal segments (Cook and Burgess-Limerick, 2004). Correct upright posture is considered to be an important indicator of musculoskeletal health. Costs associated with musculoskeletal impairments in health and loss of work have contributed to a growing interest in optimizing posture, particularly in relation to sitting positions associated with the use of visual display units (Straker and Mekhora, 2000) and standing postures in children in relation to backpack use (Prins et al., 2008).

Guidelines for evidence-based interventions relating to posture and ergonomic behaviour rely on a primary physical examination procedure that includes a postural measurement method. However, there is no standard approach to measuring posture. Photographic observations of ideal posture have been ranked visually or with equipment such as a tape measure, pencilled landmarks, a plumb-line, simple goniometers, inclinometers and various computer assisted methods have been used (Phillips et al., 2004; Larson et al., 2007). The linking of body landmarks has provided angular measurements, allowing a more quantitative assessment of posture (Larson et al., 2007).

A review of the literature has shown that there are many factors that may influence the reliability of photographic posture assessment in children. These include maturation and developmental factors such as age, gender, height and the development of postural control and co-ordination. The presence of pain and the testing environment may also have an effect. Factors associated with the measurement process, including palpation of bony landmarks for marker placement and reproducibility of the digitization process, may also contribute to the reliability (McEvoy and Grimmer, 2005). Asundi et al. (2010) examined the upper extremity posture of 15 adult participants using a laptop using an infrared three-dimensional motion analysis while Straker et al. (2009a) also used an infrared motion analysis system to examine the effect of forearm support of the upper extremity of 24 adolescents (Straker et al., 2009a; Asundi et al., 2010). Andrews et al. (2012) examined the accuracy of using postural video observation analysis and found that adding a grey border to the postural frame enhanced the observational accuracy of the postural analysis method.

The above studies of postural analysis have all used small sample sizes ranging from 12 to 24 participants and in the study by Andrews et al. (2012) used a sample of 99 university students to observe video analysis for accuracy of posture classification. Another review of the literature for a more practical, economical and reliable postural observation tool, showed that RULA is a reliable method for postural analysis of computer use posture. The RULA method, developed by McAtamney and Corlett in 1993, is a subjective observation method that focuses on the upper body and is designed to assess a person working at a visual display unit (VDU). The method uses a series of illustrations of body postures and a numerical score to represent posture. The body-posture scores are combined and if appropriate, a score for static muscle load and force is added to provide a grand score. The grand score is used to allocate a person's posture into an action level. Ismail et al. (2010) found that by using the RULA method of postural analysis, good inter-reliability results were obtained (Cronbach alpha = arm analysis - 0.8120, wrist - 0.7951, 0.7851, 0.8141, 0.8310, 0.7931 for arm analysis, wrist, neck, trunk, and leg muscle, respectively) (McAtamney and Corlett, 1993). Authors such as Oates et al. (1998b), Laesar et al. (1998), Kelly and Dockrell (2009) and Ismail (2010) have also used the RULA method of postural analysis in studies observing posture while using computers, and found it to be reliable.

A variable number of time frames have been used in previous studies above reveiwed for the RULA observation method, ranging from short time intervals such as one minute to longer time intervals of ten minutes. In all the studies reviewed, reliability of the RULA measurement was tested prior to it's use in the main study and the various time frames were found to be reliable. For this reason, the one minute observational measurement was tested for reliability in a pilot study, prior to its use in this current study and found to be reliable. A ten minute waiting period after the class had been in progress was implemented prior to the start of RULA measurements so as to allow the learners to settle into a working posture.

A significant reason for the current study's choice of the RULA method for assessing the postures of learners in a school environment was that it is a cost effective and reliable method for evaluating posture when dealing with a large number of learners. This is particularly relevant and suitable for the South African context as there are on average

24 learners per class, which calls for a simple, effective and non-costly method of postural analysis.

In addition to measuring the posture of learners in a school environment, it is important to assess the workstation design of computer laboratories in schools so that one can ascertain what modifications and ergonomic adjustments can be applied in a flexible and cost effective way (Smith et al., 2007; Straker et al., 2002).

2.9 THE COMPUTER WORKSTATION DESIGN ASSESSMENT FORM (CWDA)

Workstations at school are one of several factors that contribute to the development of musculoskeletal symptoms among children of school-going age (Saarni et al., 2007). Smith et al. (2007) developed CWDA form as part of her study on computer-related musculoskeletal pain among adolescent school learners in the Cape metropolitan region. CWDA was the product of the adaptations made to the Computerized Classroom Environment Inventory (CCEI) developed by Zandvliet and Straker in 2001. The main developer of the CCEI, Dr David Zandvliet, gave Smith permission to use and adapt his assessment tool in 2005 (Zandvliet and Straker, 2001). Smith gave Sellschop permission in 2011 to use the CWDA (Smith, 2011)

The aspects of the computer laboratory assessed within the CWDA included the working environment, spatial environment, workspace environment and visual environment. The content validity of the CWDA was assessed by McDonald in 2005 and the intra-rater reliability of the CWDA form was tested during the course of a pilot study prior to being used in 29 computer laboratories Smith's study in 2007, although no actual data were provided with regards to the reliability testing. It was found to be both reliable and stable. Table 2.6 below illustrates the variables obtained from using the CWDA form.

Table 2.3: Variables Measured by the CWDA Form

Dependent Variable	- Design of computer workstation
Independent Variables	- Position of computer - Adjustments of chair and computer workstation - Computer laboratory environment
Measuring Instruments	- A validated Computer Workstation Design Assessment form (CWDA)

2.10 THE TEACHER/PRINCIPAL QUESTIONNAIRE ON ERGONOMICS IN THE SCHOOL ENVIRONMENT

There is currently a dearth of knowledge among teachers about ergonomics in the South African school environment. Teachers are trained in the use and prescriptions of the IT curriculum. However, knowledge and training on ergonomic principles and their application is lacking (Isaacs, 2007). The international computer driver's license (ICDL) curriculum is taught in a few schools in South Africa. However, there is currently no research on the number of schools teaching the ICDL license requirements to learners. Incorporated into the ICDL curriculum are ergonomic awareness applications for learners and teachers. Future research in this area will possibly demonstrate if ergonomic awareness among teachers in the South African context will improve the ergonomic knowledge and practice of learners in schools. For the purposes of this study, a questionnaire for ergonomic awareness among teachers in schools in the Gauteng area was included. The questionnaire was developed by Dockrell et al. (2007) with face and content validity tested for in Ireland during the course of their study using 205 schools. Table 2.7 below illustrates the variables obtained from the teacher/principal questionnaire.

Table 2.4: Variables Measured using the Teacher and Principal Questionnaire

Dependent variable	- Teacher attitudes and knowledge of ergonomics in school
Independent variables	- Attitude of teachers - Amount of exposure to computers - Training of teachers in ICT and ergonomic practices
Measuring instruments	- Questionnaire

The questionnaire examines the ergonomic attitudes and knowledge of the teacher/ principals in the school environment. Teachers were asked to indicate if they had received any training in information and communication technology and good ergonomic practice. The teachers' attitude towards the implementation of future ergonomic training in the schools was also enquired about.

2.11 CONCLUSION

This literature review presented the evidence supporting the need for research on the implementation of ergonomic interventions in schools and the effect they may have on reducing risk factors such as awkward sitting postures and increased exposure to computers amongst children in a school environment. The key findings of current and past research on ergonomic interventions and their effect on reducing musculoskeletal pain and improving posture amongst learners in schools was found to be optimistic. In addition learners' knowledge about ergonomics and workstation adjustment when working on computers was found to increase following an educational ergonomic intervention.

The measurement tools used in this current study were reviewed and discussed in terms of their relevance and validity for measuring pain, pain catastrophising and posture as measurable outcomes for the effect of the computer-related ergonomic intervention programme. Chapter three will present and discuss the methodology of the two phases of this current study.

CHAPTER 3

3. METHODOLOGY

3.1 INTRODUCTION

The methodology of the main study will be presented in detail in this chapter and a brief outline of the pilot study and the lessons learnt from the pilot study will be discussed (see detail of the pilot study in Appendix C). The main study consisted of two phases: phase one, which consisted of a prevalence study, and phase two, an intervention study. Each phase will be discussed separately. The first phase entailed establishing the prevalence of musculoskeletal pain in grade eight learners in a school environment in South Gauteng, and involved the completion of the Computer Usage Questionnaire (CUQ). The second phase of the study involved a randomised control trial to measure the effect of a computer-related ergonomics intervention programme in a school environment, over a prolonged period of time. The measurement tools used to assess posture, pain catastrophising of the learners' pre and post intervention, and the Computer Workstation Design Assessment form (CWDA) will be discussed in this chapter. A detailed description of how these instruments were administered and interpreted is given. The development of the ergonomic intervention programme will be discussed in detail in chapter four.

The first part of this chapter will describe Phase 1 – the prevalence study. A pilot study of the instruments and measurements was done prior to conducting the prevalence study. The pilot study and subsequently the tools used in the main study are discussed in Appendix B for clarity. The key findings from the pilot study will be highlighted in this chapter. Following the prevalence study, the second part of this chapter will discuss Phase two – the intervention study.

3.2 STUDY DESIGN

This study comprised two phases.

3.2.1 Phase One: Methodology – A Prevalence Study

3.2.1.1 Aim of study

To establish the prevalence of musculoskeletal pain among adolescents in a private school environment in Johannesburg, South Africa.

3.2.1.2 Research design

A cross-sectional observational quantitative study design.

3.2.1.3 Objectives of the study

a) Musculoskeletal pain

- To determine the prevalence of musculoskeletal pain among adolescents routinely exposed to computer usage in the school and home environment.

- To determine the body areas most commonly affected by pain among adolescents routinely exposed to computer usage in the school and home environment.

- To determine the prevalence of pain catastrophising in adolescents in a school environment.

- To determine the risk factors for developing musculoskeletal pain during computer use.

b) Posture

- To establish the posture of adolescents while working on a computer in a school environment.

c) Ergonomics of the school environment

- To evaluate the ergonomic set-up of workstations in a school computer laboratory.

- To establish the attitudes and knowledge of tecahers and principals in respect of ergonomics in the school environment

3.2.1.4 **Sample**

This section describes how the schools with individual learners were selected for inclusion in the prevalence study. A flow diagram depicting the overlap of the prevalence study and RCT is shown in Figure 3.1 below.

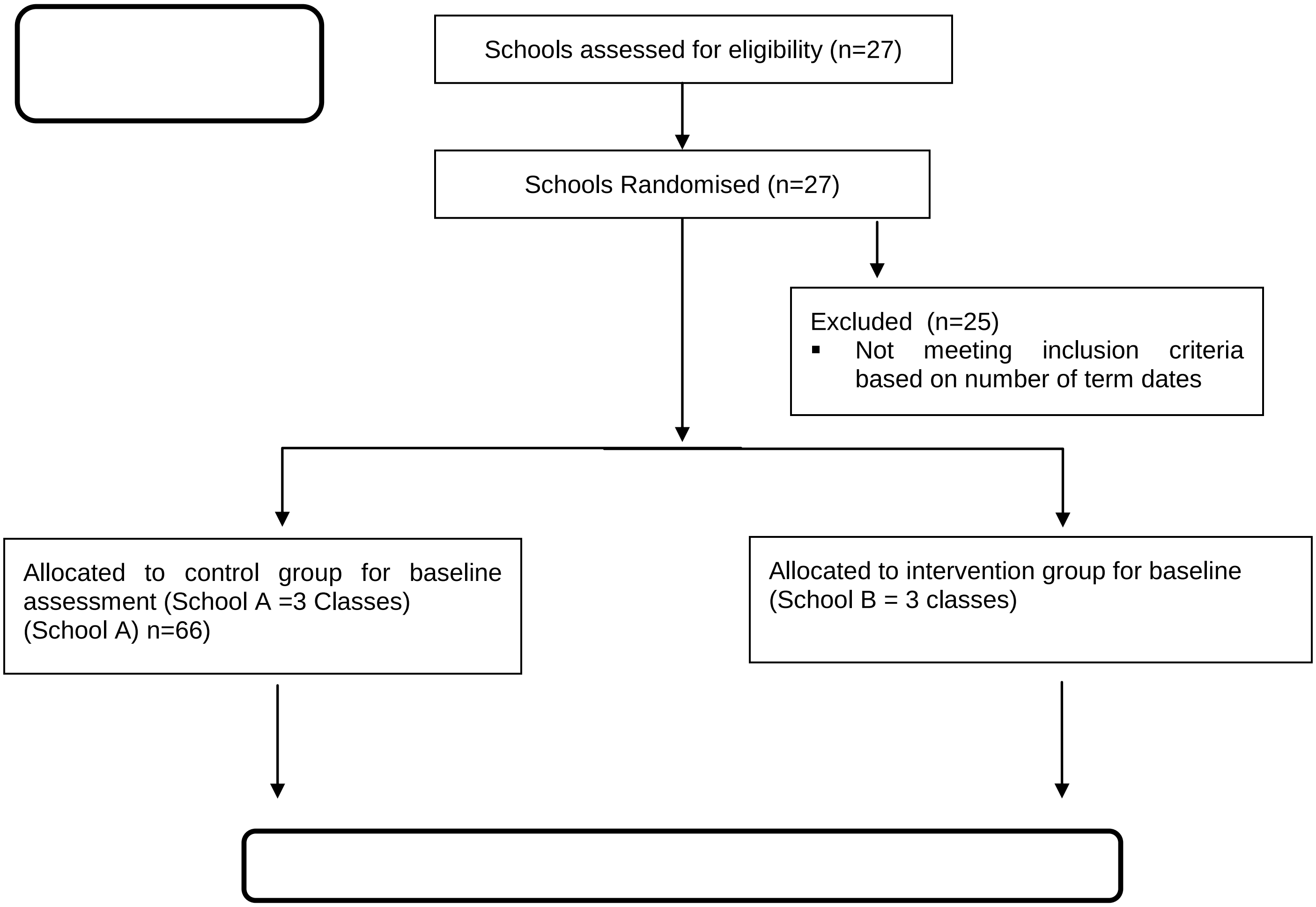

Figure 3.1: Figure showing Phase 1 for Prevalence Study

A) Clusters (School sample)

Two Independent, private schools (using stratified randomised cluster sampling) from a population of 27 independent co-educational secondary schools in the greater Johannesburg region were selected to participate in the study because principally they have similar socio-economic ecologies. Significant disparities in the socio-economic status of school communities present a confounding variable in the research. The particular populations of learners selected for this study are exposed more frequently and with higher intensity to computer use, both at home and at school, than is currently the case in less privileged socio-economic environments (Isaacs, 2007).

3.2.1.4a) **Random sequence generation**

- Type of Randomisation: Stratified randomised cluster sampling.

- Details of matching/stratification used :
  - Co-educational private schools
  - Access to schools
  - Grade eight learners
  - Increased computer usage amongst learners.
  - Socio-economic homogeneity

- Restictions: Schools were excluded if the number of terms did not match the other randomly selected school.

- Allocation: An independent research assistant conducted the concealed allocation and consecutive sampling method. Each school was selected by picking names randomly. The names of all schools on the register were written on pieces of paper and placed in a sealed envelope. The independent research assistant then pulled two random schools from the envelope and checked that all the schools had the same number of school terms to ensure continuity of the study over a period of nine months. The researcher was blinded to the allocation sequence.

3.2.1.4b) **Sample size determination for school sample**

The sample size was calculated to be at 80 subjects for each group with alpha set at 0.05 and the power set at 85%. The sample size calculation was based on the prevalence of musculoskeletal pain amongst children. Using information on the prevalence rate of 74% and 86.9% obtained from studies by Kelly et al. (2009) and Smith et al. (2007) the above sample calculation was formulated.The effect of clustering among classes/schools was taken into consideration in the final analysis.Based on this calculation and the number of learners in grade eight at secondary schools in Johannesburg, two schools were randomly selected to be used in this study. Thus study subjects included all grade eight pupils enrolled at two private, high-fee paying co-educational schools to fulfil the sample size determination. Three classes of grade eight learners from one of the two schools formed part of the intervention group comprising approximately 20 learners per class, and three grade eight classes from the second school formed the control group. The study pertained to grade eight learners in the private co-educational secondary schools selected.

3.2.1.5 **Ethical considerations**

Ethical clearance was granted by the Human Research Ethics Committee (HREC) of the University of the Witwatersrand for phase one and phase two of the study (ethical clearance number: M110128). Permission was obtained from the head of the Independent School Association to conduct research in the independent schools. The principals of the selected schools granted permission for the study to be conducted in their schools. Only children who signed assent, and whose parents signed informed consent were included in the study. Each child was informed and had to agree to participate and were made aware that they were free to withdraw from the study at any time and that no adverse consequences would result from their withdrawal. Letters were sent to each of the learner's parents explaining the reason for the study and asking them for consent for their child to participate in the study. In addition, each learner was given a consent form and a verbal explanation by the researcher as to what the study entailed, in terms of the the measurements to be done and the proposed intervention, and why it was of importance to them as learners. Four learners from the one school declined to participate in the study for religious reasons.

The researcher was available to answer any queries or concerns parents or pupils had regarding the study. All information and data remained strictly confidential by removing all information that could identify the children. Once the parent/child had signed informed consent/assent for both the prevalence and the RCT studies, the child was allocated a number, which was used on all documents, data collection sheets and related data for the rest of the study. The schools used in the study remained anonymous.

3.2.2 Data Analysis

Descriptive statistics were used to establish the prevalence of musculoskeletal pain,pain catastrophising, body areas associated with pain and postural measurements whilst using a computer, amongst the learner sample.

Table 3.1 below presents the type of data and analysis that was used:

Table 3.1: Objectives and Data Analysis for Prevalence of Musculoskeletal Pain

Objective	Type of Data	Analysis
Prevalence of musculoskeletal pain and body areas of pain, pain intensity and pain catastrophising	categorical discrete data summarised as numbers and percentages.	Descriptive analysis was used to establish prevalence of the categorical variable (Pain working on computer) at baseline.
	Continous data such 73 sage,gender,weight of learners and school bag weight were summarised as means and standard deviations	Descriptive statistics

Table 3.2 shows the objectives and data analysis of the instruments used to measure posture.

Table 3.2: Objectives and Data Analysis of Posture Measurements

Objective	Type of Data	Data analysis
Measure posture while working on computer RULA	Done using RULA Action Levels- categorical discrete data were summarised as numbers and percentages	Descriptive statistics

3.2.3 Study Instruments and Procedures

The study instruments, respective outcome variables used in testing, the procedure or the tool and the instrument validity and reliability will now be summarised in the tables according to the variable they tested. Table 3.3 below illustrates the instruments used for measuring variables that were considered as factors influencing pain.

Table 3.3: Study Instruments Measuring Variables Considered to Influence Pain

Study Instrument	Outcome Variables Tested	Tool/Procedures:
Computer Usage Questionnaire (CUQ)	i. Prevalence of musculoskeletal pain. ii. 1.2. Frequency of computer use. iii. 1.3. Types of computer use.	A self-administered questionnaire was given to the learners to complete during the duration of the Life Orientation lesson (45 min).
Tanita digital measuring scale and tape measure	Weight and height of learners i. 2.1 School bag weight	Learners were weighed and their height measured by research assistant. Learners' school bag weight was weighed individually.

3.2.3.1 Tanita measuring scale

A digital weighing measuring scale (Tanita model) with an accuracy of ± 0.1 kg was used to measure the weight of each learner. This digital scale is used world-wide by health professionals and is a reliable product for scientific research (Lake et al., 2006; Lee et al., 2007). The Tanita scale was checked for reliability by testing the weight of a schoolbag three times over a period of two minutes, to ensure consistency of results. The research assistant conducted all weight measurements of the learners during the course of the pilot study and the main study to ensure reliability and consistency of measurements.

3.2.3.2 Stramm measuring tape

A Stramm measuring tape (Model 3m x 13mm, code smm2546) held against a wall was used to measure the height of each learner. Measurements were recorded in centimetres (cm). The measurements were done by the research assistant throughout the pilot and main study to ensure reliability and consistency of measurements.

3.2.4 Questionnaires

3.2.4.1 Administration of the computer usage questionnaire

The questionnaire (Appendix D) was handed out to each learner at baseline, three months and six months during the 45 minute Life Orientation lesson. An additional numerical pain rating scale (NPRS) was included in the questionnaire pack for each learner to record pain intensity when answering the question with regards to pain while using a computer

3.2.4.2 Administration of the pain catastrophising questionnaire for children (PCS-C)

The PCS-C instrument (Sullivan et al. 1995) assesses three dimensions of catastrophic thinking, namely:

1. Rumination – a constant focus on the threat value of pain (a primary appraisal process)

2. Magnification – an exaggerated experience of the threat value of pain (a primary appraisal process).

3. Helplessness – in relation to a secondary appraisal process in which individuals negatively evaluate their ability to cope effectively with their pain.

The PCS-C questionnaire is a short questionnaire and was given to the learners to complete, along with the CUQ, during the course of the 45 minute Life orientation lesson. This was repeated at the three and six months intervals.

3.2.4.3 Procedure

The researcher attended each session when learners were completing the questionnaire so as to assist learners if they had any difficulty understanding a question. The learners were given the full 45 minute session to complete all the appropriate questions, including the PCS-C questionnaire.

While the learners were answering their questionnaires, the research assistant took one learner out at a time to a separate room next door to the classroom, to do the height, bodyweight and schoolbag weight measurements. The use of a separate room for these measurements was a request from the ethics committee and fulfilled the ethical requirements for this study. The measurements were done using a Tanita scale and a Stramm tape measure attached to a stable point on the wall. The measurements were also repeated at three months and six months during the Life orientation lesson.

3.2.4.4 The teacher/principal questionnaire

The questionnaire examines the ergonomic attitudes and knowledge of the teacher/principals in the school environment. The self-administered questionnaire was emailed to the respective schools for the teacher and principals to answer the questionnaire and then return it by email to the researcher.

Two assessment tools to measure workstation set-up and posture were used during the study. The methods and procedure for each tool are described in 3.2.4.5 and 3.2.4.6 below.

3.2.4.5 The computer workstation design assessment form (CWDA)

Workstations at school are one of the factors that contribute to the development of musculoskeletal symptoms among school aged children (Saarni et al., 2009). Smith, (2007) developed the CWDA form (Appendix D) as part of her study on computer-related musculoskeletal pain among adolescent school learners in the Cape metropolitan region. CWDA was the product of adaptations made to the computerised classroom environment inventory (CCEI) developed by Zandvliet and Straker in 2001 (Zandvliet and Straker, 2001). MacDonald (2005) tested the CWDA for content validity and found the assessment form to be valid for use in a school environment.

Table 3.4 below outlines the variables obtained from the CWDA form.

Table 3.4: The Variables Obtained from the CWDA Form

Study Instrument	Outcome Variables Tested	Tool/Procedures:
Computer Workstation Design Assessment form	Position of computers. Chair adjustments. Computer laboratory environment.	A validated Computer Workstation Design Assessment form was completed by the researcher over a period of 30 minutes in the school computer laboratory.

The areas assessed by the CWDA form included working environment, spatial environment, workspace environment and visual environment. The researcher conducted the workstation assessments at all participating schools to ensure consistency in measurement procedures and photographs of the workstations were taken.

3.2.4.6 The rapid upper limb assessment tool (RULA)

The rapid upper limb assessment (RULA) (Appendix D) is a postural survey method developed for use in ergonomic investigations. RULA uses a series of diagrams of different body postures and a numerical score is allocated to the most commonly observed posture. It has two parts to it, group A, which consists of the upper arm, lower arm and the wrist, and group B, which consists of the neck, trunk and legs.

The score for groups A and B postures and the scores for static muscle work and force are added as appropriate to give a score 'C' (upper limb) and a score 'D' (neck, trunk and legs). The C and D scores are then combined in a table to give a grand score. The grand score is used to assign the observed posture into an action level that indicates the required intervention (McAtamney and Corlett., 1993). Table 3.5 below outlines the tool used and the procedure.

Table 3.5: RULA Instrument and Variables Tested

Study Instrument	Outcome Variables Tested	Tool/Procedures:
Rapid upper limb assessment (RULA)	Measures the observed postural position of learners while working on a computer	A validated RULA assessment form was completed by the researcher for each learner sitting at a computer during the computer lesson period. Each learner was observed for one minute while operating a computer.

Before the main study commenced, a pilot study was conducted to test the five study instruments used prior to conducting the main study.The aim of the pilot study was to test the feasibility of the study and to establish the reliability and validity of the tools to be used in the main study In addition the pilot study gave insight into difficulties or good practice arising when conducting intervention studies' research in the school environment. The methodology of the pilot study is in Appendix B for clarity.

3.2.5 Summary of Important Findings from the Pilot Study

The findings indicated that RULA (ICC=0.84) is a reliable tool to use on school children aged between 14 and 16. Procedural issues relating to time constraints for individual class times and insufficient manpower for doing baseline measurements, and difficulty accessing the classroom environment owing to poor classroom design and inadequate spacing between computers were noted as potential impediments to the data collection process. To counteract this problem, the learners were asked to leave their school bags outside the classroom when the RULA measurements were done. It was found that RULA demonstrated good intra-rater reliability for this study, and it will be useful as part of an ergonomic assessment of older children (> 7 years) working at computers.

The lessons learnt from the pilot study regarding time constraints and issues relating to insufficient manpower for doing the height, weight and schoolbag weight measurements were accommodated by engaging a research assistant to do the above measurements for the duration of the main study. The school principals were approached and sufficient time was allocated during a computer or life orientation lesson for collecting data during the main study.

The results obtained from piloting the PCS-C questionnaire suggest that there were no differences between the mean (independent sample t-test) of the two TPCS-C test scores ($p < 0.112$) for the sample group. This indicated that the learners understood the PCS-C. The feasibility of using this tool in the South African context was appropriate for use in the main study, which evaluated pain catastrophising in adolescents working on computers. The results of this feasibility study suggested that with appropriate instructions, the grade eight learners in an independent school environment were able to complete the TPCS-C successfully and accurately.

The results obtained from the reliability test of the Computer Usage Questionnaire (CUQ), showed that the repeatability between the first and second questionnaire outcomes were stable and good. The CUQ had good stability as the results showed a correlation of 0.99 ($p<0.001$) between the first and second questionnaires for computer usage and hours spent on the computer. The section of the CUQ that demonstrated moderate repeatability was the section on ‘where do you experience pain’ and ’how bad are these feelings of discomfort, pain?’ This is demonstrated by the intraclass-correlation coefficient ICC for the presence of headaches between the two questionnaires of ICC=0.658 ($p<0.013$). This result could be caused by the fact that there was a one day delay between the first and second CUQ and in that time the symptoms experienced by the learners could have changed.

The results from testing consistency and intra-rater reliability of the teacher/principal questionnaire showed that there were no differences between the repeated teacher/principal questionnaires. None of the participants had received ergonomic training in computer education and they all indicated that they would like to have more information on computer-related ergonomics. A focus group comprising four experts in the field of education were asked to view the content of the teacher/principal questionnaire to check that the contents were valid for the South African context.

The comments from the focus group were:

“The teacher/principal questionnaire is user friendly.”

“The explanation on what ergonomics is all about is well written and easy to understand.”

In the teacher questionnaire, question number 10, “Who provided you with the training?” needed to have the National Computer Training Evaluation (NCTE) tutor option changed to ICDL (International Computers Drivers Licence training), to be appropriate for the South African context.

In the principal questionnaire, question three needed to be amended from “community/ comprehensive school” to preparatory school. In addition, the use of the word “vocational school” needed to be changed to “pre-primary school” for the questionnaire to reflect the South African context.

In conclusion, the repeatability (ICC=0.98, $p<0.001$) of the teacher/principal questionnaire was found to be good and the results from the focus group were positive with only minor adjustments necessary to certain phrases so that the questionnaire was suitable for the South African context.

The results of the test for the appropriateness of using the Computer Workstation Design Assessment form (CWDA) in assessing the current situation of computer laboratories in independent private schools in Gauteng were such that the measurements were completed successfully, even though the one school’s (school A) laboratory was designed poorly in terms of accessibility and spatial layout. Both schools scored poorly in the workspace environment and spatial environment sections of the CWDA, and the scores for the input device and the visual environment section scored best in terms of compliance. School A (23/40, 57% compliance) and school B (19/40, 47.5% compliance), demonstrating that both schools had very poor compliance in terms of the ergonomic set-up of computer laboratories and workstation set-up.

The positioning of the actual computers on the desks in the laboratory differed greatly between the two schools and the furniture used in the computer laboratories were fixed such that the chairs used were non-adjustable and had no arm rests. At the one school, the computer monitor was positioned under the desk and the learners had to look down through a glass pane to see the monitor, encouraging increased cervical and thoracic flexion. At the second school, the monitors were positioned on top of the desk, but there was very limited room between the computer workstations and poor legroom underneath the desks. The implication of this on the main study was to ensure through communication with the Principals of the randomly selected schools that they had similar settings for their computer laboratories and workstations, to ensure that the RULA observations were homogenous with regards to the type of computer workstations being used by learners otherwise this could be considered a confounder for RULA measurements in the main study.

Testing the appropriateness of the CWDA form for use in independent schools in Gauteng proved successful, but it also highlighted significant risk factors for the development of musculoskeletal pain among learners in a school environment.

With regards to the testing of the appropriateness of the ergonomic intervention programme for grade eight learners in a school environment, the results showed that the learners responded with interest and enthusiasm to the ergonomic intervention programme. They participated in the activities as prescribed by the intervention and asked insightful questions following the intervention programme. The time taken to deliver the intervention programme was 45 minutes, which was longer than originally intended. This was an important consideration for the main study and additional time was catered for in delivery of the intervention in the main study.

In terms of the questions asked by the learners, and input from the research assistant who delivered the intervention programme, it was suggested that a basic post-intervention multiple choice test be formulated for the learners to enhance the learning process and reinforce the concepts learnt from the intervention. Furthermore, two large wall posters demonstrating correct workstation set up and how to carry a schoolbag correctly were provided to the computer laboratory at the school to serve as reinforcement of the knowledge gained from the ergonomic intervention session.

The focus group comprising four experts in education, revealed valuable lessons such as suggestions made to include a multiple choice test following intervention to reinforce the learning process. With the assistance of the four educators, the researcher developed a short multiple choice questionnaire to be added to the intervention group in the main study.

A Professor of Occupational Therapy, with expertise in ergonomic interventions for school children, gave feedback in terms of the content validity of the computer-related ergonomics intervention programme. The word ’discomfort ‘rather than just pain was recommended to be added to the programme. The content of the programme was found to be suited for the purpose of the study and for the grade eight learner level. Suggestions made from the external validity process included: adding in a free software download link to the intervention programme, to remind learners to do stretches and to check their ergonomic set up.

3.3 Phase Two: METHODOLOGY - THE INTERVENTION STUDY

3.3.1 Aim of the Study

The aim of phase two of the study was to establish the effect of the computer-related ergonomic intervention programme on adolescents in a school environment.

3.3.2 Research Design

A randomised control trial

3.3.3 Objectives of the Study

- To assess the content validity of a computer-related ergonomics intervention programme developed for grade eight learners in a South African school environment.

- To determine the effect of the intervention programme on musculoskeletal pain and pain catastrophising in adolescents.

- To determine the effect of the intervention programme on posture in adolescents while using a computer during the duration of their 45 minute computer lesson.

A consort diagram is shown below demonstrating the flow of particpants in the RCT study.

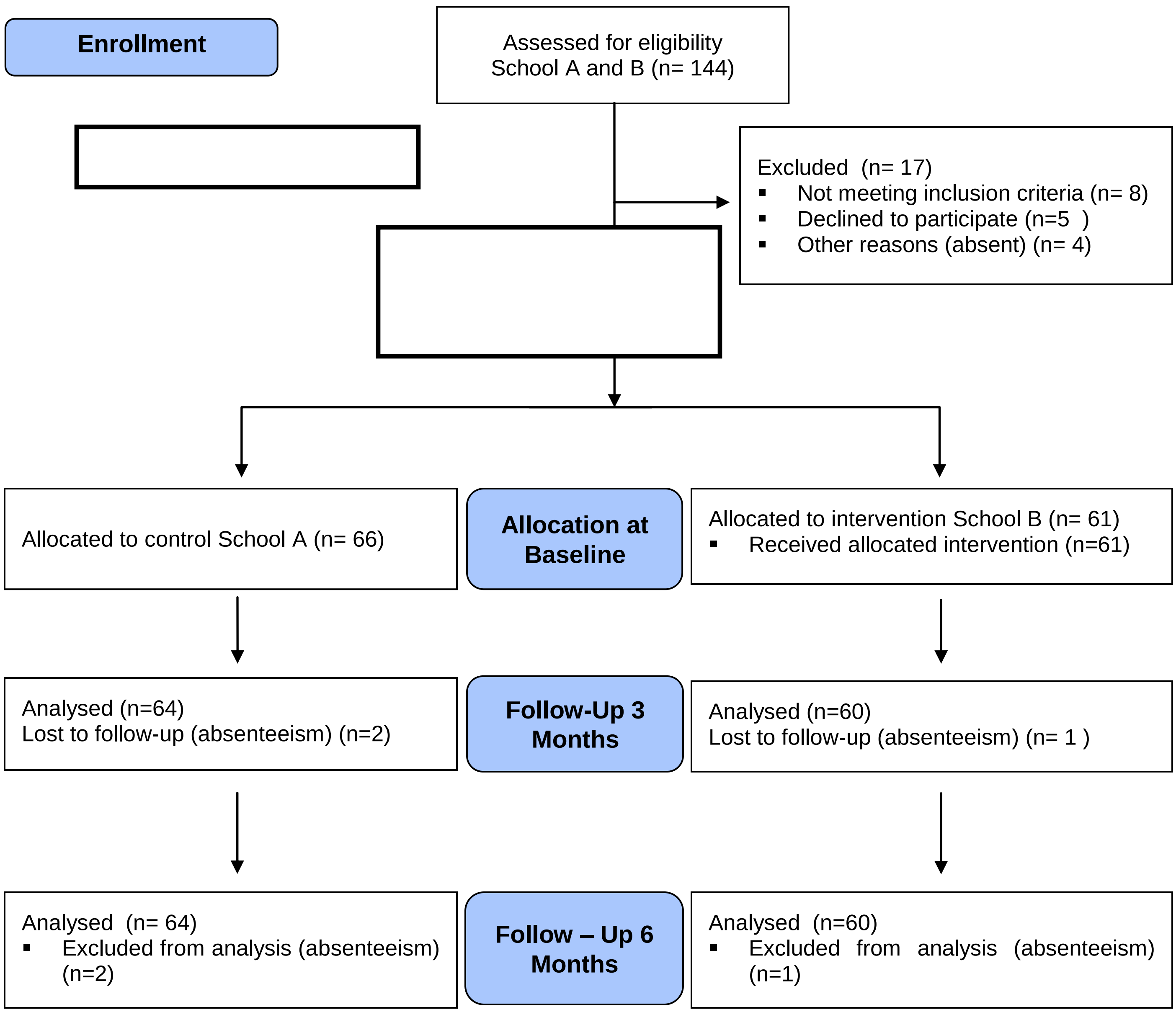

Figure 3.2: Flow of Participants through Phase 1 and Phase 2

3.3.4 Sample for RCT

A) Random sequence generation

- Type of randomisation: Stratified Cluster randomisation
- Details of matching/stratification: All grade eight learners from all three classes at the two, randomly selected private schools in the greater Johannesburg region were invited to participate in the study.
- Allocation of participants: Consecutive sampling was done according to the following inclusion and exclusion criteria. The research assistant and the researcher were blinded to group allocation to limit assessment bias.
- Restriction criteria:
  1. Learners that were diagnosed with any spinal deformity (any change in the structure of the spine relating to a congenitally acquired condition or through trauma, resulting in an excess curvature of the spine.)
  2. Learners that had a sports injury (an injury acquired through playing a specific sport) at the time of the study.
- Inclusion criteria:
  1. All grade eight learners that had no diagnosed spinal abnormalities (any congenital or traumatically acquired change to the veterbra of the spine)
  2. All grade eight learners that used a computer at school and at home.

B) **Sample size** determination for learner sample

A two-group continuity corrected Chi-square test with a 0.05 two-sided significance level had 85% power to detect the difference between a group one proportion, of 0.50 and a group 2 proportion, of 0.74 (odds ratio of 2.85) when the sample size in each group was 80. Using information on the prevalence rate of 74% and 86.9% obtained from studies by Kelly et al. (2009) and Smith et al. (2007) the above sample calculation was formulated. The quantitative study sample size was estimated at 80 subjects with alpha set at 0.05 and power set at 85%. The study subjects would include all grade eight pupils from two independent private secondary co-educational schools.

For a study comparing two means, the equation used to calculate actual sample size was:

$$N = \frac{-}{\qquad}$$

Where N is the total sample size (the sum of the sizes of both comparison groups), σ is the assumed standard deviation (SD) of each group (assumed to be equal for both groups), the Zα/2 value for the desired significance criterion, the Zβ value is that for the desired statistical power, and D is the minimum expected difference between the two means.

The desired power was 85%, that is , = 0.85, with

α

So, N = ——————— = 126

The actual number of learners that participated in the study was 127 with 66 in intervention group and 61 in the control group.The effect size for the sample was estimated at 80 learners, control group (n=30) and intervention group (n=80) for 85% power, to account for a 20% non-compliance and 20% drop-out.

3.3.5 Data Analysis

An intention-to treat analysis was used in this randomised controlled trial (Hollis and Campbell, 1999). The data analysis used for measuring the effect of the intervention is shown in Table 3.6 below.

Table 3.6: Objectives and Data Analysis for Measuring the Effect of the Intervention

Objective	Type of Data	Analysis
Measure the effect of the intervention on musculoskeletal pain, pain catastrophising and posture	Categorical data: Pain while working on a computer	McNemars- test for a shift in number of learners. *Propensity score matching to correct for differences at baseline. *GEE to test for average response of the population to specific covariates.
	Continous data:TPCS-C, Rumination, Magnification, helplessness, RULA wrist/arm and neck/trunk/leg scores). Continous data which were not normally distributed(pain intensity) (non-parametric data) pain intensity	Between group-ANOVAs Within group – ANOVAs, propensity score matching to correct for differences at baseline and GEE to test for average response of population to specific covariates. Mann-Whitney U-test was used to compare the medians.

3.3.6 Study Procedure

A single blind randomized control trial was conducted with (pre and post intervention assessment). Schools were identified and invited to participate in this study prior to the schools being randomly allocated to either a control or intervention group. Consent from all learners was obtained before baseline measurements were done and the school clusters randomised into the control and intervention groups. School A and school B were randomly allocated to either a control or intervention group. Allocation into groups was done using concealed allocation with assessor blinding and the researcher and the research assistant were blinded to group allocation and to the delivery of the ergonomic intervention programme to the participants to limit assessment bias. The study was conducted over a period of six months. The intervention and control groups were assessed at a baseline prior to the intervention and then three months and six months after intervention.

The control group and the intervention group were required to answer a validated Computer Usage Questionnaire (CUQ) (Smith, 2007) and the pain catastrophising scale questionnaire (PCS-C) (Vervoort et al., 2008) at baseline, three and six month intervals post-intervention. All the participants underwent biometric measurements of height, weight and school bag weight and postural analysis using the RULA (McAtamney and Corlett, 1993) method of observation. The learners from the control and intervention group had their postures assessed for one minute each with RULA, while they were using a computer at school during a computer lesson, at baseline, three months and six months.

The computer-related ergonomic intervention programme was developed with reference to the literature from the few intervention studies that have been done (Ismail et al., 2010; Robbins et al., 2009; Heyman and Dekel, 2001) and it was evaluated by four educators, eight learners and an expert in the field of ergonomics during the pilot study and modified accordingly. The development of the computer-related ergonomic intervention programme is discussed in more detail in Chapter four. The intervention was delivered by a research assistant from the University of the Witwatersrand who was trained in the delivery of the intervention programme.

The intervention group received a once off 45 minute participative intervention programme comprising of an educational ergonomics component on posture and workstation set-up and a component of stretches for the neck, shoulders and lower back. This was in the format of a visual power point presentation with planned activities for the participants.

A poster demonstrating correct workstation set-up and a variety of stretches was placed in the computer classroom of the intervention group. Thereafter, each learner participant was given a sticker to place on his/her screen at home and at school. This sticker, in the form of a red dot acted as a reminder to the learner participants to adjust their posture and to do their stretches during the time that they spent on the computer.

A free web based link was given to each participant to download onto their home computer to reinforce the reminder of doing stretches and taking regular short breaks from computer use when at home.

All participants were given a short multiple choice questionnaire test immediately after the intervention, to test the learner's comprehension and understanding of the ergonomic concepts that they had been taught during the intervention programme.

The control group participants were not exposed to any ergonomic intervention programme as they were in a different school. The control group and the intervention group were then required to answer the CUQ and the PCS-C questionnaires at the three and six month intervals post intervention. In addition, all participants underwent biometric measurements of height, weight and school bag weight and postural analysis using the RULA method of observation.

Three months and six months post-intervention, the research assistant repeated all the biometric measurements of the learners with regards to height, weight and school bag weight. In addition, the researcher repeated the RULA analysis of the learners' posture and all the learners who had agreed to participate in the study answered the same questionnaires that they had answered in phase one of the study.

At each school, the questionnaires were answered during the life orientation lesson and biometric measurements were done in a separate classroom next door to the life orientation classroom, to ensure privacy of all participants. The life orientation lesson was 45 minutes in length, which provided adequate time for participants to answer the questionnaire and for the research assistant to conduct the biometric measurements. The same venue at each school was used at each measurement interval to ensure consistency of the environment for accuracy.

The RULA (postural assessment) measurements were conducted during the week following completion of the biometric measurements and questionnaires. RULA measurements were conducted by the researcher during the information technology and design lesson in the computer laboratory of each school. RULA measurements were conducted by observing each learner for one minute while he/she worked on a computer during the computer lesson. The computer lesson was 45 minutes in length and the observation process started 10 minutes after the start of the computer lesson. The learners were observed from the dominant hand side and from the side during the RULA measurement process.

Both the control and intervention schools had computer laboratories for the information technology and computer lesson and the same computer laboratories were used for each measurement session. A challenge during the process of the RULA measurement was that the learners tended to move around and talk to their peers, so the researcher had to ensure that each learner had been accounted for during the lesson.

In summary, the learners answered the questionnaires at three different intervals during the course of the study and underwent all physical measurements. Both the researcher and research assistant were blinded as to which school had received the computer-related ergonomic intervention.

3.3.7 **The Computer-Related Ergonomics Intervention Programme**

A computer-related ergonomics intervention programme was developed, and its contents validated. Chapter four describes how the intervention programme was developed and validated.

CHAPTER 4

4. DEVELOPMENT OF THE COMPUTER-RELATED INTERVENTION PROGRAMME

4.1 INTRODUCTION

This chapter explains the development and validation of the ergonomics intervention programme used in this study. The aims and benefits of the programme will be presented, in addition to the concept of health promotion in schools and the principles that are important in designing such an intervention. The steps that are involved in planning and implementing an ergonomic intervention in a school environment will be discussed as well as a review of the literature of previous ergonomic interventions in a school environment and their effect.

Interest in the field of ergonomics for children and school environments appears to be increasing and over the past five years a few school-based ergonomic intervention programmes have been implemented in the school environment. The International Ergonomics Association defines ergonomics as follows: "to be a scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance" (Bennett, 2000).

An important goal of the World Health Organisation (WHO) since 1950 has been the promotion of health in children in schools (WHO, 1997). The WHO advocates that the health promoting school concept (HPS) is an effective approach to encourage the well-being of both school children and staff. Some of the themes related to the health promotion school concept that have been implemented globally have involved topics such as weight management and nutrition, smoking and drug abuse prevention, vision health, sex education and oral health. Numerous studies have indicated that the implementation of the HPS programme has had a positive impact on students' health behaviours (Lee et al., 2008), on self-reported health (Lee et al., 2006) and on various aspects of health for the school community (Mukoma and Flisher, 2004).

The school environment provides an opportunity for encouraging healthy behaviours amongst school children. There have been many recent studies that have sought to investigate the potential effects of musculoskeletal pain and poor posture associated with the ergonomics of computer use by children (Harris and Straker, 2000; Straker et al., 2009; Dockrell et al., 2010a). While the use of technology is essential for improving learners' educational pathways, it can also introduce the possibility of exposing young people to poor postural habits and repetitive strain injuries resulting in musculoskeletal pain. Thus it is essential to explore ways to develop and implement an ergonomics intervention programme which will promote the concept of health within the school environment. Todd (2011) states that it is important to take responsibility for shaping the ergonomic landscape of South Africa so that we, as a community, can encourage the implementation of preventative strategies for a healthier population and, in particular, this concept is applicable to children within a school environment.

4.2 HEALTH PROMOTION IN SCHOOLS

The World Health organisation defines a health promoting school as one that is constantly striving to strengthen its capacity as a healthy setting for living, learning and working (WHO, 2003). In light of the health promotion concept, and the fact that it is easier to inspire good behaviour in the early years of life rather than to try to affect less desirable behaviours once they have become entrenched later in life, it is essential to encourage schools to implement evidence-based ergonomic practice as a preventive and health promotion strategy for reducing the effect that poor ergonomics is having on children in the school and home environment. However, factors influencing the adoption and dissemination of a health promotion school programme or intervention, such as leadership, goals, resources, competencies, beliefs in collective efficacy, school investment in healthy lifestyles, perceived school contextual barriers and conceptions of health promotion for schools among different stakeholders, are essential components to consider when developing a health promoting school intervention programme (Chang et al., 2012).

Furthermore, when developing a health promoting school intervention programme, it is important to consider what the aims of implementing this school intervention are:

- To implement evidence-based practices (Du Toit et al., 2010)

- To increase teacher and student engagement (Du Toit et al., 2010)
- To promote student and teacher self-efficacy (Phillips et al., 2010)
- To empower teachers and students to promote changes from within (Cardno, 2006).

In addition to the above, there are numerous benefits to engaging student involvement in an attempt to inspire good ergonomic behaviour, such as:

- Enhanced student motivation
- Encouraging problem-solving capabilities
- Greater acceptance of change
- Greater knowledge of the learning and work environment
- Empowering learners (Du Toit et al., 2010)
- Influencing the individual determinants of health-related behaviour

The following section will introduce each step in the development of the ergonomics programme, outline the framework and discuss theories, concepts and principles that inform the steps and describe the way in which they have been applied in developing this programme. The steps that were followed in the development of the programme define the programme approach, the concepts and the principles applied. In addition, the lessons learnt from other existing published intervention programmes are outlined below. The programme development model depicted in Figure 4.1 below outlines the steps taken to develop the ergonomic intervention program within a health promotion planning framework.

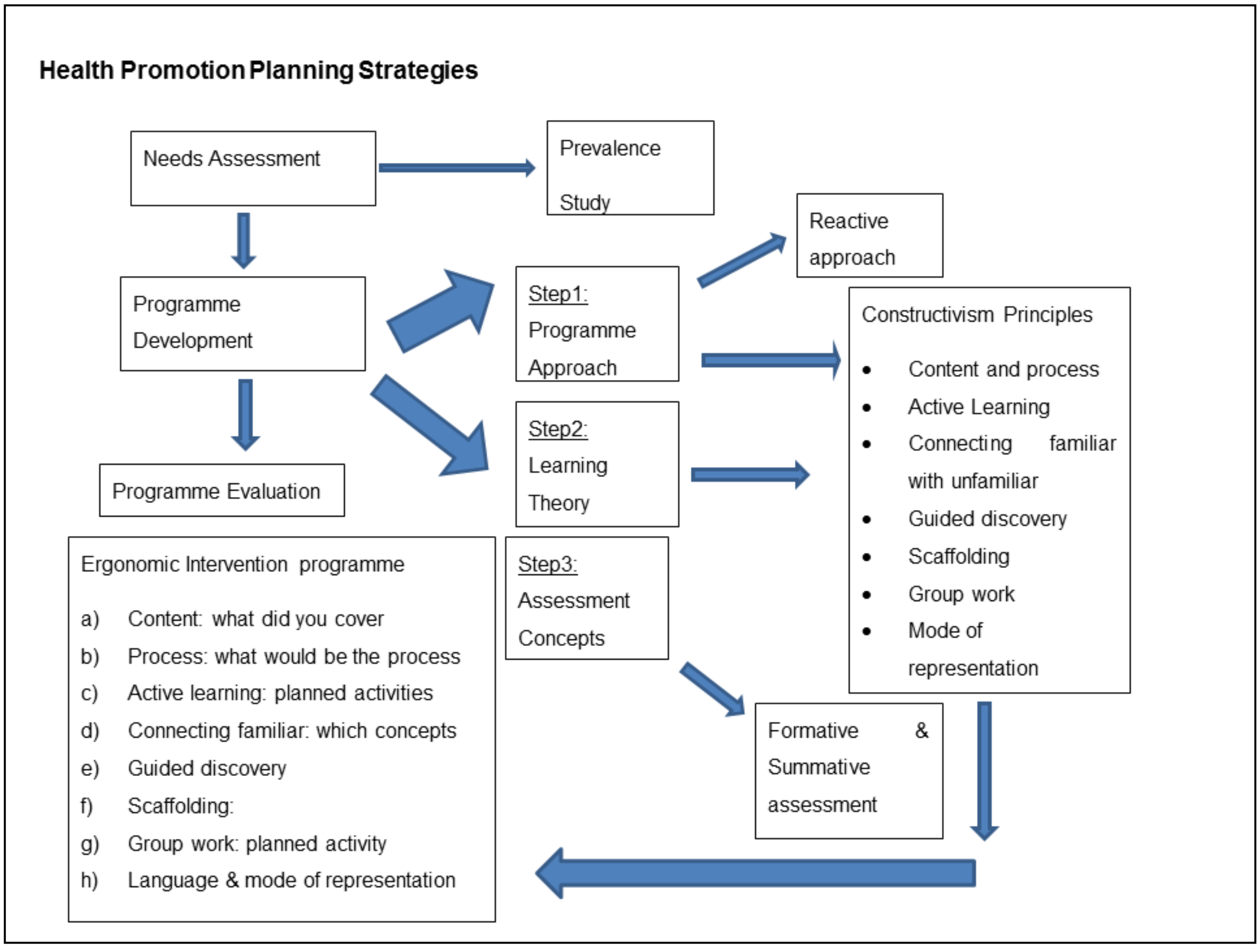

Figure 4.1: Ergonomic Intervention Programme Development Model

4.3 AIMS AND BENEFITS OF THIS COMPUTER-RELATED ERGONOMICS INTERVENTION PROGRAMME

The intended aims of this intervention were to encourage each learner to achieve the following learning objectives:

1. To understand the concept of musculoskeletal pain or discomfort
2. To identify and describe musculoskeletal pain or discomfort
3. To identify risk factors for developing musculoskeletal pain related to computer use, prolonged awkward sitting postures, as well as carrying heavy school bags
4. To apply good ergonomic practice and healthy computing skills such as rearranging the workstations at school and at home to optimize comfort and reduce the risk of developing musculoskeletal pain or discomfort

5. To understand the importance of rest breaks, visual breaks and doing stretches.

In achieving these objectives, the proposed benefit of the programme was to reduce the occurrence of musculoskeletal pain over a period of time and to prevent any progression of dysfunction at a neuro-musculoskeletal level. In light of the above benefits of the programme outlined above, the steps taken in developing this intervention programme within the framework of a health promotion strategy will be discussed below.

4.3.1 Needs Assessment

The practice of health education involves three major programme planning strategies namely, needs assessment, programme development, and evaluation. Prior to the design and implementation of the computer-related ergonomics intervention programme in a school environment, a prevalence study was done as part one of this study, to determine the prevalence of musculoskeletal pain and key risk factors associated with poor ergonomic/computing behaviour in adolescents in a school environment, and the prevalence of musculoskeletal pain in the target population. In addition, risk factors identified in the pilot study prior to the current main study, and the information from the literature such as the prevalence study of musculoskeletal symptoms in learners in the Western Cape, South Africa, were considered in the design of this ergonomic intervention programme (Smith, 2007), The risk factors identified were:

1. High exposure to computer use
2. Prolonged awkward sitting postures during computer use at school
3. A significant prevalence of musculoskeletal pain in the students
4. A significant indication that the adolescents do catastrophise about their pain, which has implications for developing chronic pain
5. Computer workstations are poorly designed and variable in terms of the desks that the computers are placed upon and the variable types of chairs in the computer laboratories
6. Heavy school bags carried by the students
7. A lack of ergonomic knowledge of computer teachers and principals at the schools.

Based on the above identified risk factors (needs), the intervention programme design included educating learners about the risk factors associated with the development of musculoskeletal pain such as poor posture when working on a computer and carrying a heavy school bag. Measurable outcome indicators were identified from the needs assessment to evaluate the effect of the intervention programme after it had been implemented over a repeat measurement period of three months and six months for the main study sample groups.

The outcome indicators were:

- Prevalence of musculoskeletal pain
- Pain intensity per body area
- Pain catastrophising scores
- Posture.

Once the outcome indicators for evaluating the effect of the intervention programme were identified, the development of the ergonomics intervention programme was researched.

4.3.2 Development of an Ergonomics Intervention Programme

Within the development of an ergonomics intervention programme, there are a number of steps involved (Jacobs et al., 2008). Comprehensive and systematic principles from current literature on different approaches to ergonomic interventions, learning theory, changing beliefs and behaviour, evidence of school-based ergonomic interventions, and the different types of delivery for the intervention are all important to consider when developing an ergonomic intervention programme(Jacobs et al., 2008). Defining the approach to be used in the ergonomic intervention programme is important in the development process (Cohen et al., 1997).

4.3.2.1 Step 1: Define programme approach to ergonomic intervention

The first aspect to consider in the development process is to decide which approach is the most appropriate for the particular environment in which the programme will be delivered, in this case, a school environment (Cohen et al., 1997). Cohen et al. (1997) refers to two approaches of ergonomic interventions: the reactive approach and the proactive approach. The reactive approach involves identifying problems, specifically musculoskeletal pain and risk factors linked to them, and selecting and implementing measures for controlling and reducing their impact.

The proactive approach involves the prevention of these kinds of problems from occurring in the first place. Proactive ergonomics assesses issues at the design stage of work processes to identify needs for avoiding risk factors that may lead to musculoskeletal pain. The process makes use of designing operations that ensure proper selection and use of tools, workstation layouts, and actions that may predispose an individual to unnecessary strain, for example with a learner at school, lifting heavy schoolbags (Cohen et al., 1997). The proactive approach, which seeks to anticipate and prevent problems occurring, should be the ultimate goal of any intervention programme.

In the current South African school environment, the reactive approach has been implemented and imposed on the prevailing environment However, by increasing awareness about correct ergonomics, workstation assessment and behaviour modification relating to encouraging good ergonomic practice, this may eventually instil a more proactive approach. In a sense, the education of learners in good ergonomic practice is a proactive step towards reducing the risk factors that may lead to musculoskeletal pain.

In view of the appropriate environment for the implementation of the reactive and proactive approaches discussed above, it is essential to understand the different elements of developing an intervention programme that support the approach that one chooses, in this case, the reactive approach. The first important element to consider is the aspect of learning theory pertaining to the understanding of and knowledge acquisition process that involves an active, motivated, constructive and self-directed process of learning that will encourage a change in behaviour (Harris et al., 2010b). In order to do this effectively, learning theories and their underlying concepts and principles should be applied.

4.3.2.2 **Step 2: Examination of learning theories and concepts underlying the development of the programme and their application**

Learning theories are conceptual frameworks that describe how information is absorbed, assimilated and retained during the learning process. Cognition, emotion, prior experience or knowledge and the environment can all influence the learning process (Donald et al., 2010).

Behaviourists define the learning process through a system of rewards and targets in facilitating the learning process through a change in behaviour. From a behavioural teaching perspective, the transmission of information from teacher to learner is facilitated by the response appropriate to a certain stimulus. This teaching method has been successful in helping learners to learn scientific concepts and facts and formulae (Skinner, 1976). In contrast, cognitive based educators are more concerned with an individual's perspective and not necessarily a change in behaviour whereas transformational learning theorists focus upon the change that is required in a learner's perception and view of the world for learning to take place. Humanists, emphasize the importance of self-knowledge and relationships in the learning process compared to constructivists who believe that a learner's ability to learn relies to a large degree on prior knowledge and understanding (Donald et al., 2010).

The constructivist approach supports an active learning process and the reason for choosing this style of teaching was that the principles aligned with an outcomes-based approach to education, which requires a student-centred environment emphasizing an active teaching and learning process. Furthermore, constructivism is an approach that considers 'how' students learn and it is a teaching strategy that creates a learning environment in the classroom and it is a commonly used method in teaching, which specifically speaks to the local context (Donald et al., 2010). This is an important consideration when designing an evidence-based, computer-related ergonomic intervention programme, to ensure that it encompasses the principles that will facilitate and support an active learning process, in retaining information and changing behaviour relating to poor postural habits, and a lack of knowledge of ergonomics and healthy computing skills (Zandvliet and Straker, 2001). Thus it has implications for the theory of instruction (Donald et al., 2010) and will be discussed in more detail below.

Constructivism is a theoretical perspective essential to the field of education and educational psychology. It encourages learners to use active techniques (experiment, problem-solving activities) to create more knowledge and then to reflect on and talk about what they have learnt and how their understanding is evolving. A learner's prior knowledge and experience, as well as beliefs and culture, are an important foundation in the active learning process (Takaya, 2008). Thus, constructivism is a theory that explains the way in which knowledge is constructed in a human being when information comes into contact with existing knowledge that has been obtained through experience.

Psychologists like Piaget, (1953) and Bruner et al. (1967) have shown that knowledge is actively and continuously constructed and reconstructed as individual progresses to a higher cognitive learning capacity (Donald et al., 2010; Bruner, 1967). Thus, people are rational beings that require active participation in order to learn and their behaviour is a consequence of thinking. More recently, Merzenich's (2001) concept of neural plasticity has shown that the brain is always "learning how to learn" (Merzenich, 2001; Donald et al., 2010; Bruner, 1967) and thus information can be processed in many different ways to produce a variety of outcomes.

Donald et al. (2010) refer to the fact that it is imperative to acknowledge that children are active agents who, "make meaning of their lives within and through their socio-cultural contexts" (Donald et al., 2010). Bruner, the influential constructivist theorist (1967), supports this theory as he refers to the child as an, "active explorer and strategist". Furthermore, he views a child's social context and the mediation that a child experiences as a way of shaping the ideas and effectiveness of his/her cognitive strategies (Bruner, 1967; Donald et al., 2010). In light of this theory, the ergonomic intervention programme needs to encourage exploration amongst learners with respect to applying ergonomic principles in the classroom and home environment; and facilitate the learners active involvement in actively getting moving and having rest breaks from repetitive tasks, implementing stretches and adjusting their computer workstations and posture appropriately so as to reduce the risk of developing musculoskeletal pain. The key constructivist concepts outlined below are content and process, active learning, connecting familiar to the unfamiliar, guided discovery and scaffolding. These concepts are the foundation for the principles of practice in teaching and learning that were used when designing the content and structure of the computer-related ergonomic intervention programme for adolescents in a school environment. The teaching process, mediates an approach that blends the 'what' with the 'how'. The seven constructivist principles of practice applied in the design of the ergonomics programme that will be discussed are (Donald et al., 2010):

- Content and process
- Active learning
- Connecting familiar to unfamiliar
- Guided discovery
- Scaffolding
- Group work and co-operative learning
- Language interaction and mode of representation.

Each of these principles will be explained with illustration of each one's application in the development of this programme.

a) **Content and process**

Bruner (1967) shows that knowledge is not just about facts and information; it is important to assist the students to understand key concepts and relationships for learning to take place. For example, in the design of this ergonomic intervention programme, the content is taught to the learners in the form of a theme, 'feel it, move it, fix it'. This theme is communicated throughout the structure of the programme to help students understand the topic of 'healthy computing habits and ergonomic considerations' as well as a means of learning to identify when 'to move' and how to 'fix it'. In addition to helping students to understand the structure of a specific topic, the process of prediction, a powerful learning strategy, was used. This is shown by encouraging students to predict what a certain behaviour, like prolonged awkward sitting posture at their workstation, will produce and what strategy ('move it') can be used to counteract a negative outcome, in this situation, pain and discomfort ('fix it') (Donald et al., 2010; Bruner, 1967). Straker et al. (2010) in their evidence-based guidelines for the wise use of computers by children recommend encouraging learners to implement frequent task variety, postural variety and breaks or pauses from computing/sedentary behaviour. The theme of "Feel it, Move it, Fix it", supports these recommended guidelines by Straker et al. (2010) throughout this ergonomic intervention programme (Straker et al., 2010).

Figure 4.2 below demonstrates the slide used to introduce the theme of "Feel it, Move it, Fix it" in the visual presentation of the ergonomic intervention programme

Figure 4.2: Demonstration of Theme used in the Ergonomic Intervention Programme

b) **Active learning**

Active learning refers to the concept of challenging students to engage in the thought process while they are being taught a particular concept. In addition, metacognition is a constructivist concept that refers to making students aware of their thought processes while they are thinking about a topic. The students can engage with their own thinking on a higher level if they are aware of their own thought processes. Relating this concept to ergonomics and health, it is important to facilitate the process of metacognition so that they are more conscious of their own strategies when applying good ergonomic practice and in doing so they can learn from others, and adapt and refine their strategies. An example of how this is facilitated in the intervention programme is shown below in Figure 4.3. It involves the use of a variety of activities, some involving whole class interaction, illustrated by the 'red sticker activity' in the ergonomics intervention programme; some group activities, illustrated by 'how heavy is your schoolbag' (see Figure 4.3 below) in which the class is broken up into groups to work out how heavy their bag should be based on their weight, and the activity on problem solving a workstation set-up; and some individual activities such as doing a stretch for a specific area of their bodies that feels discomfort or pain (Donald et al., 2010).

Figure 4.3: Activity for Feeling - 'How Heavy is Your Schoolbag?'

Part of the active learning process is the ability to connect a familiar form with an unfamiliar content to facilitate exploration within a given framework or structure to ensure that the learning process takes place (Donald et al., 2010)

c) Connecting familiar to unfamiliar

Connecting familiar to the unfamiliar is one of the most basic principles of constructivist theorists like Piaget and Bruner (Donald et al., 2010). They state that teaching must connect to where the students are in their understanding; it must connect the familiar to the unfamiliar and the three aspects that can be used to connect familiar with unfamiliar are (Donald et al., 2010):

- Connecting individually, where students are challenged and guided in their understanding to transform to a higher level of cognition.

- Connecting form by which a familiar form (for example a computer) can be combined with an unfamiliar form (for example modifying their workstation set-up) to facilitate the process of learning.

- Connecting through cognitive conflict (Piaget's concept), which suggests that, "equilibration does not occur unless a person's cognitive 'map'is challenged." This infers that a student's equilibrium must be disturbed before he/she is motivated to adapt and thereby re-establish equilibrium.

Thus, if connection has been adequate, then presenting students with information or concepts that conflict with what they currently understand can greatly stimulate their learning. An example of this concept of connecting familiar to the unfamiliar is illustrated in the programme by asking the learners to feel the weight of their schoolbag and then to work out what their schoolbag weight should be using the formula of less than 10% of their body weight. Figure 4.4 and 4.5 below illustrates the slide used to in the intervention programme to facilitate the concept of connecting the familiar to the unfamiliar.

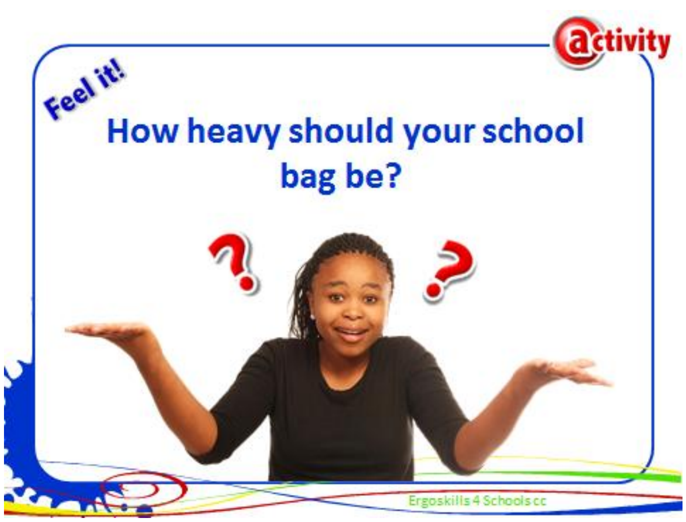

Figure 4.4: "What Weight do You Think Your Schoolbag should be?" (familiar form)

Figure 4.5: 'Now Let's do the Sum' (unfamiliar content and high level of cognition)

In addition to facilitating the process of learning through connecting familiar with unfamiliar content, the principle of discovery learning, is another form of constructivism through which free exploration of a concept within a given framework is facilitated (Donald et al., 2010). An example of discovery learning is facilitated in the exploration of a correct computer-workstation set-up, which is discussed below in "guided discovery".

e) **Guided discovery**

Guided discovery is a model of discovery learning that uses a method of inquiry-based instruction to help students to discover facts and relationships for themselves (Bruner., 1967). Teachers are encouraged to guide students to key areas of discovery of elements that need assessment and change, for example, setting up an ergonomically correct computer-workstation. Techniques involved in guided discovery are getting students to move and to try out ideas in terms of problem solving (Donald et al., 2010). This principle is applied in the ergonomic intervention programmes when the students have to correct a workstation that is projected visually onto a screen, by answering the question put to them by the facilitator: "what is wrong with this workstation?". The students then make suggestions verbally to the facilitator, which are then checked by moving a cursor to each section of the workstation that requires modification or adjustment.

Students are then asked to role play in front of the class, by sitting in front of a laptop on a desk and the class then assists verbally in instructing ways of adjusting the workstation appropriately. Other techniques employed in this act of ‘moving, doing and problem-solving (fix it)’, are discussion, reflection, arguing and critical thinking. This helps students to feel more confident to engage in the learning process and it enhances self-efficacy (Bruner, 1967; Donald et al., 2010). An example in which this concept is illustrated in the ergonomic intervention programme is the concept of identifying what is wrong with the computer workstation in the intervention programme (see figure 4.6 below).

Following on from the concept of guided discovery, in which the facilitator engages the learner in problem solving activities, the concept of scaffolding is engaged through mediating knowledge. Mediation in this context refers to the teacher assisting with transferring knowledge to the learner. Once a learner has processed the new knowledge then the mediation during the problem solving activity is gradually withdrawn. Figure 4.6 below illustrates the workstation set-up slide used in the intervention programme. The question ‘what is wrong with this picture” is asked and the students are encouraged to give input prior to the teacher showing the answers (written in small black print on the slide).

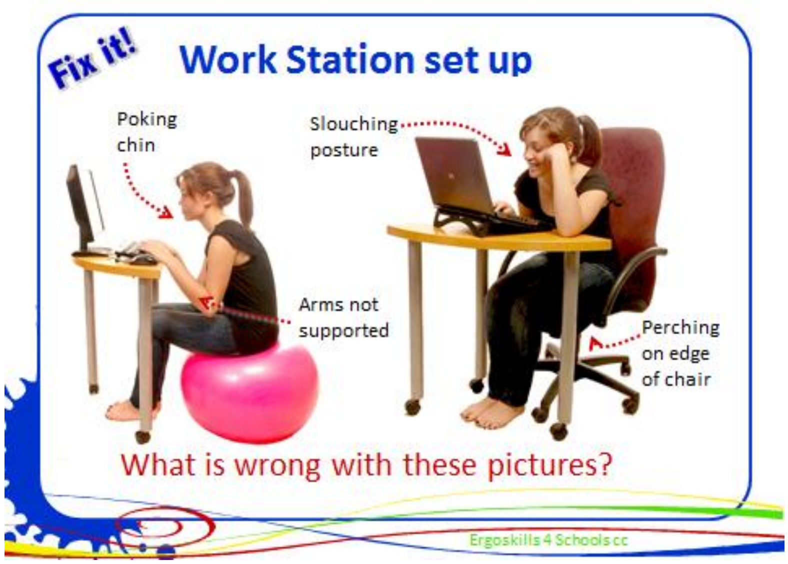

Figure 4.6: Activity Demonstrating the Concept of Guided Discovery and Scaffolding: Workstation Set-Up

f) **Scaffolding**

As mentioned above, scaffolding is a constructivist principle that employs the technique of mediation. A teacher initially models key knowledge structures and strategies for the students, thereby providing support for the learner while this new knowledge is being learnt. Once the learners grasp an understanding of the concept and internalizes it, the teacher (mediator) gradually withdraws the amount of help provided (Donald et al., 2010). This concept is illustrated in this intervention programme by the example discussed above relating to ’workstation set-up ‘and the theme of ’feel it, move it, fix it‘. In terms of scaffolding, not all learning has to happen in the classroom. An important dimension of scaffolding is apprenticeship learning that involves the passing on of culturally accumulated knowledge, skills and values (Donald et al., 2010). This can be encouraged in the teaching of adolescents, by engaging their community, friends and parents, in the new knowledge and skills that they learn at school, and which are applied within their social context outside of school. For example, in this study, as part of the intervention, the learners are encouraged to engage their problem solving activities with their siblings and parents at home, by demonstrating their workstation set-up and stretches, and in doing so they are applying the knowledge that they have learnt, which demonstrates co-operative learning (Donald et al., 2010). Group work and co-operative learning will be discussed below.

g) **Group work and co-operative learning**

Group work is an equally important principle for designing the structure and content of an ergonomic intervention programme for adolescents in a school environment. The concept has been mentioned before in terms of active learning; however, more specifically, group work is a co-operative learning process in which students are given a challenging task such that it is necessary for all of them to jointly interact in resolving the problem presented to them (Donald et al., 2010). In this ergonomic intervention programme, this is illustrated as mentioned before, in the tasks of correct workstation set-up, and ‘what stretches would you do if you had been sitting for a long period of time in front of the computer?’ (see figure 4.7). Figure 4.7 illustrates one of the many activity stretches demonstrated to the learners during the intervention programme.

Figure 4.7: Demonstration of Upper Back Stretches (group activity)

The process of co-operative learning incorporates mediation at the peer level (Bruner, 1967), stimulation of cognitive conflict between students of similar levels of understanding (Piaget, 1953; Piaget, 2012) and it promotes active agency (Donald et al., 2010). Finally, the last principle to consider in the design of an ergonomic intervention programme is the use of language.

h) **Language interaction and modes of representation**

By engaging students in discussion, reflection, debate and interactive problem solving, they are encouraged to develop and refine their grasp of linguistic concepts and the use of language through mediation. In the social context of South Africa, the medium of language chosen for the ergonomic intervention was English as the student participants were proficient in this universal language and it is the medium of language used at their school. Prior to entering the school, the students undergo English proficiency and literacy tests enforced by the school management to ensure that they can cope with being taught in this English (Donald et al., 2010).

Finally, Bruner (1967) refers to the importance of the different modes used to represent certain concepts in the learning process. Bruner's three modes of presentation that need to be encouraged when designing an ergonomic intervention for students to facilitate learning are:

Enactive, for example the use of role-modelling. Role-modelling in this intervention programme is demonstrated by engaging a student to role-model the carrying of a heavy schoolbag, so that the learners can see what it does to the learner's posture. This role-modelling is demonstrated by the slide shown in Figure 4.8 below.

Figure 4.8: Role-modelling How to Carry a School-Bag

- Iconic, for example the use of visual, artistic or music imagery (the use of dynamic colours in the visual presentation of this intervention programme, see Figure 4.8 above).

- Symbolic for example drawing on themes that students can relate to ('feel it, move it, fix it') and storytelling.

Figure 4.9 below demonstrates the symbolic theme of "Feel it, Move it, Fix it" and the storytelling relating to learners' interests and activities.

Figure 4.9: Theme 'Move It'

4.3.2.3 Step 3: Assessment concepts

Having discussed the key principles of practice involved in the learning process, it is also necessary to consider the concepts of assessment (summative vs formative assessment), and motivation. Assessment is an integral part of teaching and learning, and the formative assessment approach using the concept of performance-based assessment technique, was used after the implementation of the intervention. It is performance based and helps students to shape their development as well as facilitating the learning process without creating a fear of failure or undermining a learner's sense of confidence.

In the context of an intervention, Donald et al. (2010) suggest that it is better to consider 'need fulfilment 'within a context of a specific population group. In the case of this ergonomic intervention for adolescents, the researcher had to consider what risk factors the adolescent population were exposed to in this era of information technology and computer exposure as well as the consequences of the exposure. The learners' beliefs and past experiences relating to discomfort or pain, as well as understanding the 'needs'of this adolescent population in a school environment, which in this case, were both health and environmental needs, were an important consideration. In addition to understanding the population's 'needs', it was important to employ positive reinforcement as a behavioural technique for motivating a change of a particular behaviour (Donald et al., 2010).

4.4 STRATEGIES FOR FOSTERING A CHANGE IN BEHAVIOUR RELATING TO BACK PAIN

In light of the above discussion on behaviourism and change of behaviour, it is important to understand that the transition from a belief to a corresponding change of behaviour is a complex process. One needs to understand the factors influencing the process. Two factors have been outlined in the literature:

- The perception that the positive health outcome outweighs the burdens of changing behaviour

- A supportive social, environmental and political context (Gross et al., 2012, Bandura, 2000).

Rothschild (1999), proposed a framework for the management of public health and related social behaviour change, because of the complexities inherent in health-related behaviour change. He views behaviour change strategies as a continuum from public education on one end, to law and health policy at the other end. Furthermore, he argues that social marketing resides in the middle of the continuum, between education and law, incorporating education and contextual modifications to facilitate change. He has proposed a categorisation system that shows the most effective strategy for obtaining behaviour change, which is dependent on the characteristics of the target population, including motivation and readiness to change, and the opportunity and ability to change (Rothschild, 1999).

In addition to considering these strategies, it is important to accept that social determinants of health have been found to influence knowledge and beliefs about back pain (Gross et al., 2012). From the current literature evaluating mass media campaigns about back pain in adults, it has been have found that education is effective in changing beliefs irrespective of social determinants (Dolphens et al., 2011; Jacobs and Baker, 2002; Geldhof et al., 2007a). However, mass media campaigning may have less ability to change behaviour for a variety of reasons besides beliefs, such as attitudes about the condition and the social context of an individual. One can extrapolate Gross's findings on education through mass media with adults to children, as social media and mass media marketing are powerful and accessible tools for adolescents (Gross et al., 2012).

In terms of altering behaviour in adolescents in a school environment, it is essential to consider the influence of their social environment at school and in the home, as well as their attitude towards pain in general. For educational intervention initiatives to be successful, the initiative should position the target audience in terms of their development, attitudes, beliefs and social context (Dunn et al., 2011, Dolphens et al., 2011). The literature supports the concept that educational initiatives need to be implemented during key formative years, when beliefs, habits and attitudes about a particular health risk are being shaped (Dunn et al., 2011). Finally, Gross et al. (2012) suggest that broad societal factors such as cultural differences, ethnicities and religious beliefs, are important considerations when designing an educational 'intervention' or health promotional programme (Gross et al., 2012) .

The United Nations Educational, Scientific and Cultural Organisation (UNESCO) define learning in the 21st Century as encompassing four pillars of learning: learning to know, to do, to be and to live together. Bennett and Tien (Bennett, 2000), in their review paper on activities and research related to children and educational environments, comment that ergonomics is highly compatible with an emphasis on reinforcing the four pillars of learning for the 21st Century.

4.5 EVIDENCE FOR SCHOOL-BASED INTERVENTIONS IN THE LITERATURE

The systematic review on school-based ergonomic interventions in the literature involved the evaluation of 12 papers on school-based spinal health interventions(Steele et al., 2006). At the time of undertaking the review, there were no guidelines available that addressed all methodological issues related to conducting a systematic review of intervention literature, so the Cochrane Collaboration Reviewer's Handbook was used to guide the process. To establish the effectiveness of these interventions, the outcomes measured were:

1. improvement in spinal care knowledge;
2. changing spinal care behaviour; and
3. decreasing the prevalence of spinal pain.

The authors found that school-based health interventions may be effective in increasing spinal health knowledge and decreasing spinal pain prevalence, however, inconclusive results were obtained on spinal care behaviours. The authors also found that none of the interventions described in the reviewed papers targeted the range of modifiable risk factors for spinal pain in children and adolescents that had been identified in in previous epidemiological studies.

In terms of the delivery of the intervention programme, they found that five of the studies used a didactic approach, which is not congruent with current best practice approaches to health promotion in a school setting, as described by Lister-Sharp et al. (1999) in their paper on health promotion in schools. Steele et al. (2006) recommend that intervention programmes based on social learning theory and that take into consideration the effect of social influences, are most effective. This reinforces key theories and concepts considered in the steps to develop the intervention programme, including learning theory, theories and concepts underlying the development and application of the programme, and behaviour modification as the social context supports the process both in the school and home environment.

4.6 IMPLEMENTATION OF ERGONOMIC INTERVENTIONS IN SCHOOLS

When examining ergonomic intervention studies, it is important to examine the process and determine if risk factors were identified in the target population prior to the development of the intervention programme. The question should be asked as to how the sample was chosen, and was there any collaboration with stakeholders and the target population prior to implementation of the intervention, as well as were there any reinforcing agents used to ensure stability in the intervention. A discussion on the review of the literature pertaining to the implementation of ergonomic interventions in schools has been discussed previously in the literature review under point 2.2.2.

4.7 A DESCRIPTION OF THE COMPUTER-RELATED ERGONOMIC INTERVENTION PROGRAMME

The ergonomic intervention programme was designed with the learning objectives based on the identified risks obtained from the prevalence study in the pilot sample. The content of the programme was designed to meet the specific level descriptive (age appropriate level) for the grade eight students as well as the appropriate level and use of language for this particular age group. The facilitator's manual on the intervention programme can be viewed in Appendix I.

Constructivist principles of learning theory (Donald et al., 2010), as discussed in the section on learning theory above, were used throughout the programme to maximize the learning potential of the students. A power point presentation, of 45 minutes, with emphasis on visual stimulus, action learning and role-play was the primary medium employed by a trained facilitator from the University of the Witwatersrand, to deliver the intervention. Activities within the lesson plan included verbal interaction, reflection, role-modelling of new computer skills and carrying a school bag correctly; action learning and co-operative group work with problem solving tasks relating to poor postural habits and computer work such as setting up a workstation correctly and identifying what was incorrect with a particular workstation were shown as part of the programme.

To assist in reinforcing the learning process and facilitate behaviour change, the following positive reinforcement agents were provided to each student during the intervention programme: a red sticker for their home computer, which acts as a visual cue to change their posture or to remember to move if they have been sitting for too long; a free software download (Jacobs, 2012) to remind them to take a break and do a stretch, presented in a visual format and activated at a set time interval controlled by the student. Permission for the web enabled download to be accessed by the students was obtained from the author (Jacobs, 2012) and a stretch card to take home and place in their computing environment.

Posters demonstrating correct workstation set-up and the correct carrying technique of a school bag were placed on the walls of the computer laboratories at the school. An example of the slide demonstration used in the intervention for setting up the computer workstation correctly is shown in Figure 4.10.

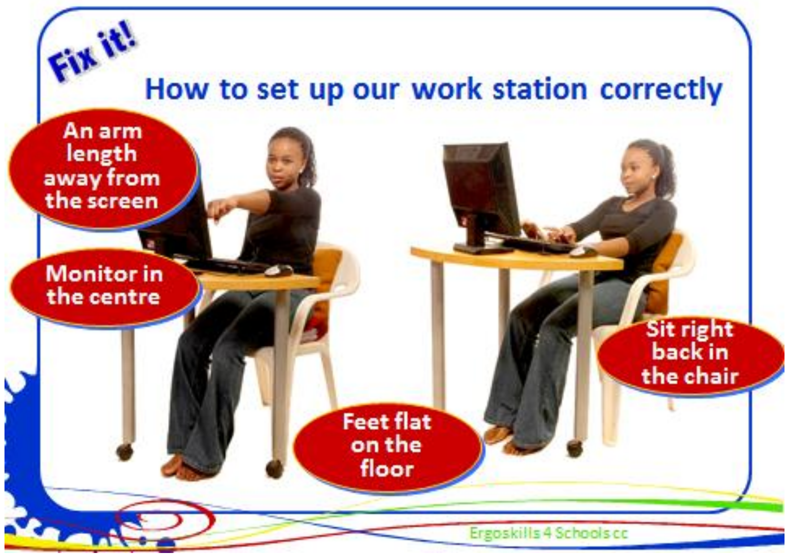

Figure 4.10: Poster Demonstrating Correction Workstation Set-Up

Assessment – at the end of the initial lesson, students were tested by way of a short, 14 question multiple choice quiz to enhance the learning process (see Appendix H).

4.8 FEASIBILITY AND CONTENT VALIDATION OF THE PARTICIPATORY COMPUTER-RELATED ERGONOMICS INTERVENTION PROGRAMME

4.8.1 Aim

1. To test the feasibility of the of the computer-related ergonomics intervention programme in a school environment.

2. To establish the content validity of the computer-related ergonomics intervention programme for grade eight learners in a school environment.

4.8.2 Sample

A convenience sample of eight grade eight learners from one of the schools used in the pilot study were chosen to participate in the content validation of this study. A conveniently selected group of experts comprising four independent teachers; two of which were grade eight teachers, and two were trained facilitators and evaluators of training programmes from the education industry.

4.8.3 **Methodology**

4.8.3.1 **Content validation**

The study approach was qualitative. Eight grade eight learners formed the intervention sample group and an expert group comprising four independent teachers and three experts in the field of ergonomics, namely, a Professor in Occupational Health from Boston University (Jacobs, 2013), and a Professor of Physical Therapy from Curtin University in Australia (Straker, 2013), with numerous publications and expertise in the fields of ergonomics, and a South African Professor of Physiotherapy (Louw, 2013), at Stellenbosch University, with expertise in Physiotherapy and a researcher in the field of ergonomics, were all asked to evaluate the intervention programme. Consent was obtained from the group of experts prior to their involvement in the validation process.

4.8.4 **Procedure**

Written informed consent was obtained from the students and their parents/guardians and the principal prior to delivering the computer-related intervention programme to the learners. Students were also informed that their participation in this study was voluntary and that they could withdraw from the study at any time. The teachers gave their consent by completing participant information consent forms. Ethical clearance was given by the Ethical committee of the University of the Witwatersrand.

The purpose of the intervention was explained to the students by the research assistant, who had been trained by the researcher to deliver the intervention programme. The research assistant delivered a 45 minute computer-related ergonomic intervention programme in a power point format. Each learner was given a stretch card and a red dot sticker to take home. The purpose of the red sticker was that it would be taken home by the learner to be placed on their own computer and this serves as a reminder for the learner to check their workstation set up and to do regular stretches. The expert group of four qualified teachers met at a designated meeting point in Johannesburg and the intervention programme was shown to them by way of a power point presentation, delivered by the researcher.

Professors from Boston University, Curtin University and Stellenbosch University agreed to participate in the evaluation of the intervention programme by responding to the email request sent to them. The electronic file of the initial intervention programme was then sent to them along with a detailed explanation of the study and the sample group for the intervention for evaluation in terms of content validity.

The results will be discussed below.

4.8.5 Feasibility and Content Validation of the Participatory Computer-Related Ergonomics Intervention Programme for Grade Eight Learners in the South African School Context

a) Results

The students participated in the activities as prescribed by the intervention and they asked questions following the intervention programme such as: “should they always adjust their workstation before they start to work on it?”, “is it better to use a desk top computer or a laptop?”

The time taken to deliver the intervention programme was 45 minutes, which was longer than originally intended. This was an important consideration for the delivery of the intervention programme in the main study as class times are restricted to 45 minutes and additional time was negotiated with the principals of the intervention school to cater for in the effective delivery of the intervention in the main study.

In terms of the questions asked by the students, and input from the research assistant that delivered the intervention programme, it was suggested that a short post-intervention multiple choice quiz be formulated for the students to enhance the learning experience and reinforce the concepts learnt from the intervention. With the assistance of the four teachers, the researcher developed a short multiple choice quiz that was added to the intervention group for the main study.

Two large wall posters demonstrating correct workstation set up and how to carry a school bag correctly were provided to the computer laboratory at the school. The learners also received a take home stretch card showing all the stretches that they were taught during the course of the intervention programme, a free software download with stretch and rest reminders (http://blogs.bu.edu/kjacobs/) developed by a Professor from the Occupational therapy department at Boston University (permission granted,) as well as a red sticker for their home computer to act as a visual cue for skills learnt from the intervention.

An expert in the field of ergonomic intervention programmes for children, from Boston University (USA) was consulted and her feedback was incorporated into the programme. Feedback included using the word 'discomfort 'rather than 'pain'. The researcher chose to use both words as the students could relate to the word 'pain'as well as 'discomfort'. Using both words allowed for differentiation of the two words along a continuum. Additionally the contents of the programme was found to be suited for the purpose of the study and for grade eight students. However, she did not like the graphic framework around each slide as she was concerned that this may distract learners from the content of the slide. According to Bruner (1967), the different ways of representing concepts in the learning process such as visual, artistic imagery and dynamic colours in visual presentations enhances the learning process. Thus, the researcher chose to use the colourful graphic framework using principles of the learning process, and the fact that the teachers in the expert group felt that the vibrant colours stimulated the learning process. The expert consulted also suggested that the researcher add in a free software download link to the intervention programme to remind learners to do stretches and to check their ergonomic set up.

4.9 CONCLUSION

Testing the feasibility of the ergonomic intervention programme in a school environment prior to the main study was very valuable in terms of catering for extra delivery time for the main study intervention, and in terms of needing to formulate a basic multiple choice questionnaire to test the learners' knowledge after intervention to reinforce the learning process. In addition, testing the content by way of prospective students, teachers and fellow researchers, the contents of the ergonomic intervention programme was validated according to the objectives of increasing learners' awareness of the risk factors such as poor posture and repetitive tasks while working on a computer, for developing musculoskeletal pain. In addition the objectives of teaching the learners to apply ergonomic principles in the school and home environment, as well as to implement workstation adjustments to suit their needs and to perform preventive stretch exercises and frequent work breaks from computing were successfully achieved in the validation process.

All three content experts in the field of ergonomic, occupational health and physiotherapy commented on programme outlay and content as well as process and methodology issues. Under programme issues they recommended using different words such as 'discomfort' rather than 'pain' on its own; and they had different opinions on the graphic outlay of the programme pertaining to the use of colours and distraction of the learners from the content of the programme. This participatory computer-related ergonomics intervention programme forms a foundation for other ergonomic interventions for schools in South Africa, and the recommendations from the content experts have contributed to the validation process.

CHAPTER 5

5. RESULTS OF THE STUDY

5.1 INTRODUCTION

The aim of this study was to determine the effect of a participatory computer-related ergonomics intervention programme on adolescents in a school environment. This chapter presents the results of the main study, Phase one and two: Phase one was primarily concerned with determining the prevalence of musculoskeletal pain among adolescents in a school environment in addition to measuring their posture when using a computer and assessing the ergonomics of the school environment. Phase two of this study assessed the effect of a participatory computer-related ergonomics intervention programme in a school environment on musculoskeletal pain,pain catatsrophising, posture and ergonomic behaviour of the adolescents. The results are therefore presented in two parts with Phase one presenting the prevalence data and phase two presenting the data relating to the effect of the intervention. The flow of the study is given in the consort diagram below.

Figure 5.1 below is a flow diagram of the participants in the RCT using the Consolidated Standards for Reporting Trials (CONSORT) template for flow diagrams recommended for reporting outcomes of trials (Stroup et al., 2000).

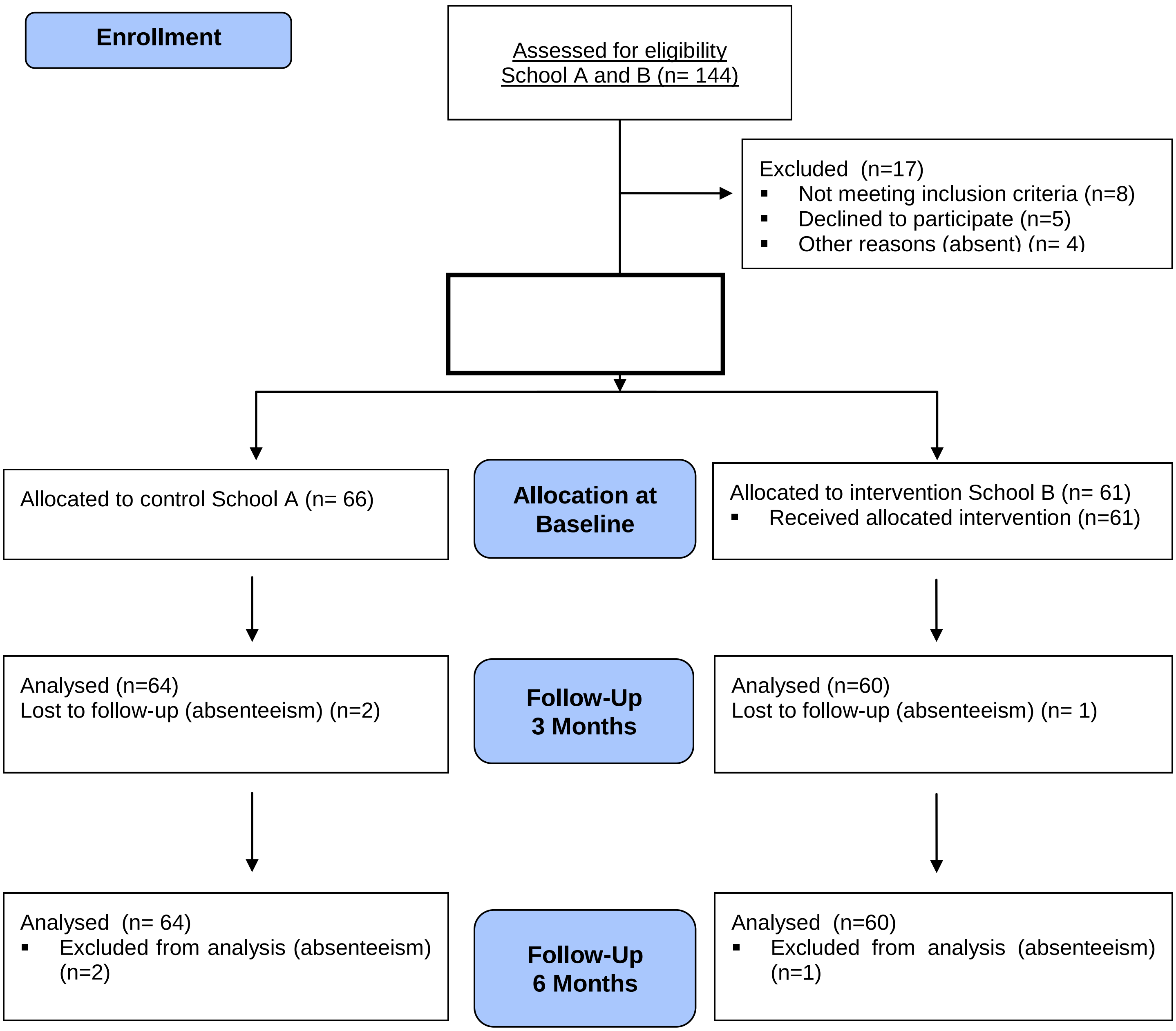

Figure 5.1: Flow of Participants through the Main Study Showing Loss to Follow-Up (n=127)

5.2 DESCRIPTION OF TOTAL LEARNER SAMPLE DEMOGRAPHICS

The demographics of the learner sample from both the control and intervention groups are presented in Table 5.1. This same sample was assessed for prevalence.

Table 5.1: Gender Distribution of Learners (n=127)

	Control group (n=66)	Intervention group (n=61)	Total
Frequency distribution of gender			
	n(%)	**n(%)**	**n(%)**
Male	39(59)	37(61)	76(60)
Female	27(41)	24(39)	51(40)
Total	66(100)	61(100)	127(100)
Descriptive statistics for mean age (years) per gender group (mean ± sd)			
Male	13.5 ± 0.6	13.5 ± 0.7	
Female	13.2 ± 0.4	13.3 ± 0.6	
Total	13.4 ± 0.5	13.4 ± 0.7	

The mean age in years of the total learner sample was 13.3 ± 0.6. There were 39 (59%) males in the control group and 37 (61%) males in the intervention group and 27(41%) females in the control group and 24 (39%)) females in the intervention group.

5.2.1 Distribution of the Body Mass Index of the Learner Sample

The body mass index (BMI) of the learners was calculated according to the paediatric BMI standard formula: learner's weight/height^2 according to a specific age. The BMI-for-age percentile was used to interpret the BMI figure because BMI is both age-and-sex specific for children and adolescents. A summary of the BMI and distribution of the learners is shown in Table 5.2 below.

Table 5.2: Body Mass Index (BMI) of Learners (n=127)

BMI Parameters	Female (Control) (n=27)	Male (Control) (n = 39)	Female (Interven) (n=24)	Male (Interven) (n = 37)
Underweight (< 5th percentile)	7(2%)	0(0%)	5(2%)	0(0%)
Normal BMI (5th to 85th percentile)	26(98%)	27(85%)	21(88%)	28(75%)
Overweight or obese (>85th percentile)	0(0%)	6(15%)	2(8%)	9(25%)

Fifteen percent of the males in the control group and 25% in the intervention group were overweight or obese.

5.2.2 Learners and schoolbag weight

The mean weight of the learners and their schoolbag weight is presented in Table 5.3 below.

Table 5.3: Learners and Schoolbag Weight from Baseline to Six Months (n=127)

	Control group (n=66)			Intervention group (n=61)		
	Baseline	**3 Months**	**6 Months**	**Baseline**	**3 Months**	**6 Months**
Weight (Kg) ±sd	53 ± 12.1	51.8±19	49.3±22.9	56.0±13.8	59.1±14.1	47.2±27.7
School bag weight (Kg) ±sd	6.8 ± 2.5	7.1 ± 3.2	6.7 ± 6.0	7.1 ± 2.0	7.2 ± 2.0	5.4 ± 3.6

The mean weight of the schoolbags of the learners in the control group from baseline to six months reduced from 6.8 ± 2.5kg to 6.7 ± 6.0kg while that for the intervention group reduced from 7.1kg ± 2.0kg to 5.4 ± 3.6kg.

The following sections present results for each objective of the study.

5.3 PREVALENCE OF MUSCULOSKELETAL PAIN

This section presents the results of the following:

- Prevalence data and the risk factors relating to the development of musculoskeletal pain during computer use.

- The body areas that are most commonly affected by pain in adolescents routinely exposed to computers in the school and home environment.

- Risk factors (computer exposure, pain catastrophising and posture while working on a computer) for developing musculoskeletal pain during computer use by adolescents.

5.3.1 The Prevalence of Musculoskeletal Pain among Learners during the Study Period

The prevalence of musculoskeletal pain experienced by the total learner sample in the last month was measured at baseline and is shown in Figure 5.2.

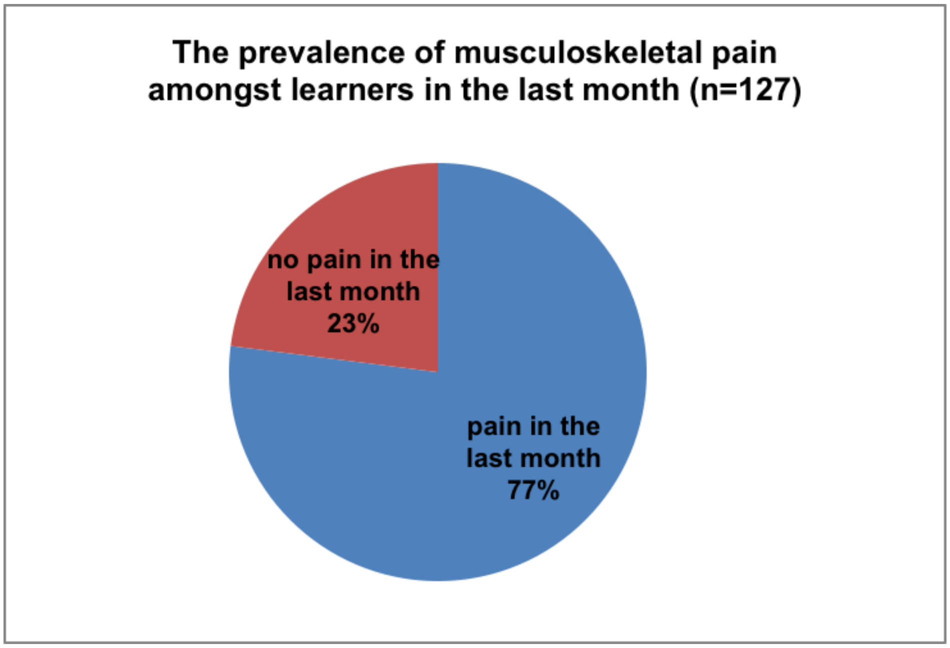

Figure 5.2: The Prevalence of Musculoskeletal Pain amongst the Total Learner Sample in the Last Month (n=127)

At baseline, 77% of the learners indicated that they had experienced musculoskeletal pain in the last month.

The main focus of Phase one study was to establish the prevalence of musculoskeletal pain relating to computer use in learners. Figure 5.3 shows the prevalence of musculoskeletal pain relating to computer use amongst the total learner sample at baseline.

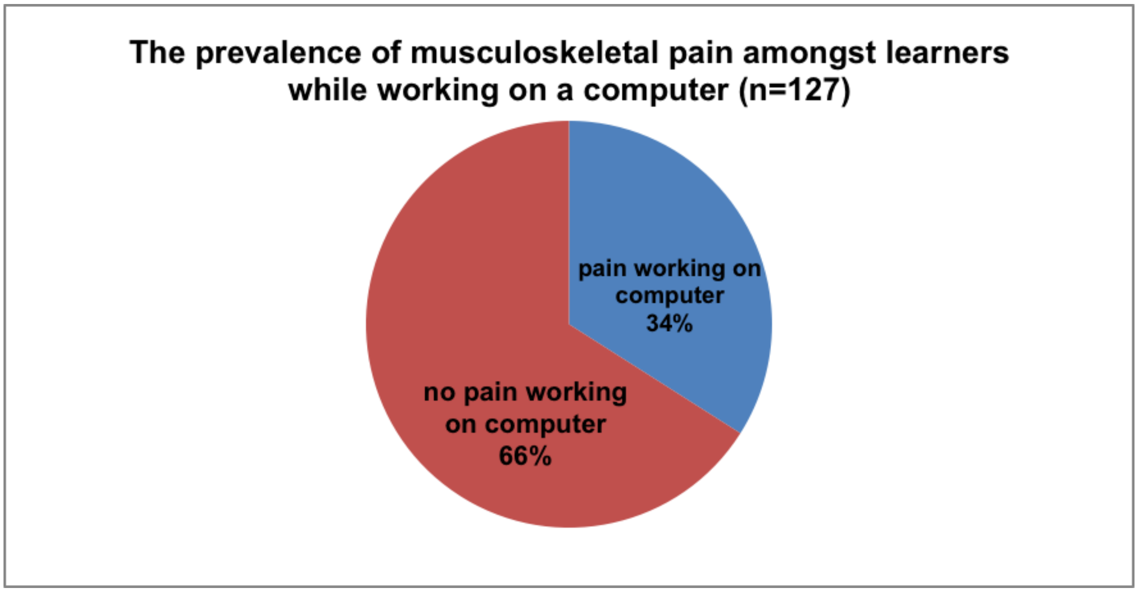

Figure 5.3: The Prevalence of Musculoskeletal Pain amongst Learners while Working on a Computer (n=127)

At baseline 34% of the learners indicated that they had experienced musculoskeletal pain whilst working on a computer in a school environment.

The prevalence of musculoskeletal pain among learners during different activities is shown in Table 5.4.

Table 5.4: Prevalence of Musculoskeletal Pain among Learners during Different Activities (n=127)

Activity	Pain	
	Yes n (%)	No n (%)
Working on computer	43(34)	84(66)
After playing sport	57(45)	70(55)
Writing at a desk	60(47)	67(53)
Lifting	10(8)	117(92)

Other activities that were found to cause pain amongst the learner sample were writing at a desk and playing sport. At baseline 47% of learners indicated that they had felt pain whilst writing at a desk and 45% indicated that they had experienced pain after playing sport.

5.4 BODY AREAS WITH PAIN

The body areas learners felt pain in are shown in Table 5.5. Some of the learners indicted that they experienced pain in more than one area of their bodies.

Table 5.5: Prevalence of Musculoskeletal Pain per Body Area at Baseline (n=127)

Areas of Pain at Baseline	Control Group (n=66)%	Intervention Group (n=61)%	Total (n=127)%
Headaches	5(7.5)	5(8.7)	11(18)
Neck	9(15)	9(15)	18 (30)
Upper back	6(9.4)	5(9.3)	11(18)
Lower Back	5(8.6)	11(18.6)	16(27)
Right shoulder	16 (24.2)	13(21.5)	28 (46)
Left shoulder	12(19.3)	10(16.8)	22(36.1)
Right elbow	2 (3.2)	1(1.6)	3 (4.8)
Left elbow	1(1.6)	2(3.2)	3 (4.8)
Right wrist	8 (13.6)	1(1.6)	9 (15.2)
Left wrist	8(12.1)	3(4.9)	10 (17)

The most common areas of pain experienced while using the computer amongst the total learner sample (n=127), measured at baseline were the shoulders and the neck (46% right shoulder, 36.1%% left shoulder, 30% neck). Shoulder and neck pain were the most prevalent areas of pain in the control group at baseline, compared to right shoulder and lower back pain in the intervention group.

5.4.1 Reported Pain Intensity (Measured with the Numerical Pain Rating Scale) Experienced by Learners per Body Area

The intensity of reported pain was measured on the 10 point numerical pain rating scale (NPRS). Learners reported the intensity of their pain per body area at baseline. The Table 5.6 outlines the mean reported pain intensity per body area as well as the interquartile range of pain intensity recorded at baseline.

Table 5.6: Comparison of Reported Pain Intensity (NPRS) per Body Area between Control and Intervention Groups at Baseline

Level of Pain Intensity per Body Area	Control Group		Intervention Group	
Baseline	**Median**	**InterQuartile Range**	**Median**	**InterQuartile Range**
Head	0.00	(1.00-0.00)	0.00	(1.5-0.00)
Neck	0.00	(0.00-0.00)	1.00	(4.00-0.00)
Upper back	0.00	(3.00-0.00)	0.00	(1.00-0.00)
Lower back	0.00	(0.00-0.00)	0.00	(4.50-0.00)
Right shoulder	0.00	(1.00-0.00)	0.00	(2.00-0.00)
Left Shoulder	0.00	(1.00-0.00)	0.00	(1.50-0.00)
Right elbow	0.00	(0.00-0.00)	0.00	(0.00-0.00)
Left elbow	0.00	(0.00-0.00)	0.00	(0.00-0.00)
Right wrist	0.00	(0.00-0.00)	0.00	(0.00-0.00)
Left Wrist	0.00	(0.00-0.00)	0.00	(0.25-0.00)

The interquartile range of intensity of reported pain amongst learners in the control group that was most present was upper back pain (3.00-0.00) and lower back pain (4.50-0.00) for learners in the intervention group at baseline. The low pain intensity amongst learners is evident throughout both the control and intervention groups.

b) **Pain Catastrophising**

The distribution of the pain catastrophising scores for the total sample of learners at baseline is shown in Table 5.7 below.

Table 5.7: Total Pain Catastrophising Scores at Baseline for Learner Sample (n=127)

Total Pain catastrophising	Baseline n(%)
≤30	93(73.2)
>30	34(26.8)
Total	127(100)
mean ± SD	25.1±8.1

The number of learners found to have clinically significant catastrophising scores (i.e. scores>30(Sullivan et al., 1995)) at baseline were 26.8% , and 73.2% of learners were found to be non- clinically significant catastrophisers.

c) **Posture while Using a Computer**

The postural positions of the adolescents while using a computer during a computer lesson were measured and the results are presented as RULA action levels (Table 5.8 below).

Table 5.8: RULA Action Levels at Baseline for the Total Learner Sample (n =127)

RULA Action Level	Baseline n (%)
AL 1	6 (4.7)
AL 2	53 (42)
AL 3	28 (22)
AL 4	40 (31.5)

Only 4.7% of the total learner sample was in an acceptable postural position (AL 1) at baseline. Thirty one point five percent of learners were found to be in AL 4 – a postural position of high risk and needing urgent investigation.

Descriptive statistics of the RULA grand score and postural scores for wrist and arm position as well as the neck and trunk positions of the learners during a computer lesson at baseline are shown in Table 5.9.

Table 5.9: Descriptive Statistics Relating to RULA Scores Measured at Baseline for the Total Learner Sample (n=127)

	Baseline
	n=127
Grand RULA score Mean(SD)	5.0 (1.82)
RULA final wrist/arm score Mean(SD)	5.0 (1.42)
RULA final neck/trunk/leg score Mean(SD)	4.3 (2.10)

At baseline the postural positions of the learners' wrist and arm positions while working on a computer were found to be poor, scoring an average Grand RULA score of 5.0 on the RULA score sheet and 5.0 and 4.3 for wrist/arm and neck/ trunk/leg positions respectively.

d) **Computer exposure for the learners**

The learners were asked to indicate how many hours they spent on the computer at school per week and if they experienced any musculoskeletal pain. Computer exposure was assessed by looking at a number of factors such as hours spent, venues used and the position of the computer. Learners were also asked to indicate how many years they had been using computers at school. The results are shown in Table 5.10.

Table 5.10: The Distribution of the Number of Hours Learners Spent on the Computer at School per Week and Pain Experienced (n=127)

	Baseline	**Three months**	**Six months**
	n(%)	**n(%)**	**n(%)**
Hours per week working on school computer			
≤2.5 hours	95(76.0)	86(67.7)	91(71.7)
>2.5 hours	32(24.0)	41(32.3)	36(28.3)
Total	127(100)	127(100)	127(100)
Mean ± sd	2.4± 1.4	2.8 ± 1.9	2.5 ± 1.9
Pain while working on school computer			
No	84(66.1)	97(76.4)	100(79)
Yes	43(34)	30(24)	27(21.3)
Total	127(100)	127(100)	127(100)

The average amount of time spent on the computer by the learners at baseline was 2.4 (±1.4 hours) per week. Twenty four percent (n=32/127) of the learners used the computer for more than or equal to 2.5 hours a week at school at baseline compared to 28.3% (n=36/127) after six months. Only 21.3% (27/127) of learners experienced pain while working on a computer after six months compared to 34% (n=43/127) of learners at baseline.

The distribution of the number of years learners had spent using computers at school is shown in Table 5.11.

Table 5.11: Number of Years of Computer use at School in the Control Group and Intervention Group at Baseline

Number of Years of Computer Use	Control n=66; n(%)	Intervention n=61; n(%)	Total n=127; n(%)
<1	7.9(12.1)	5.0(8.2)	12.9(10.2)
1	1.0(1.5)	4.0(6.6)	5.0(3.9)
2	1.9(3)	0(0)	0(0)
3	8.9(13.6)	7.0(11.5)	15.9(12.5)
4	5.0(7.6)	7.9(13.1)	12.9(10.2)
≥ 5	40.9(62.1)	37.0(60.7)	77.9(61.3)

The majority of the learners from the control group and the intervention groups, (62.1% and 60.7%) respectively, indicated that they had been using computers for greater than five years. The distribution of the number of the learners that used computers at home and in the library is shown in Table 5.12.

Table 5.12: Distribution of Computer Exposure at Home and the Library (n=127)

Computer Exposure Home	Frequency n(%)
No	14(11.0)
Yes	113(89.0)
Total	127(100)
Library	
No	110(86.6)
Yes	17(13.4)
Total	127(100)

Most of the learners (89%) used computers at home rather than in a library. The mean number of hours spent using the home computer was found to be 1.7 ±1.2 hours per week for the total learner sample. Learners were asked to indicate where their computer was positioned when using it outside of school for example on their lap or on the floor. The position of the computer when being used is also an important predictor for developing musculoskeletal pain as this relates to the concept of ergonomic behaviour. See Table 5.13.

Table 5.13: A Comparison of the Positions and Type of Computer Usage Over a Period of Six Months (n=127)

Type of Computer use (Baseline)	Control Group n=66(%)	Intervention Group n=61(%)	p-Value
Desktop	54(82)	32(52)	0.02
Laptop	10(15)	25(41)	0.04
Laptop on floor	2(4)	7(6.5)	0.14
Type of computer use (3 Months)			
Desktop	51.4(78)	48.(79)	0.51
Laptop	12(19)	9 (15)	0.58
Laptop on floor	3(4.5)	4(7)	0.63
Type of computer use (6 Months)			
Desktop	45(68)	42.(69)	0.51
Laptop	8(12)	16(26)	0.05
Laptop on floor	14(21)	3(5)	0.04

A greater percentage of learners from both the control and intervention groups used desktop computers rather than laptops. There was a statistically significant difference in the percentage of learners using desktops from the control group compared to the intervention group at baseline (p=0.02). There were more learners from the intervention group (6.5%), who used a laptop on the floor compared to the control group (4%) at baseline. However, this had changed significantly after six months with 21% of learners from the control group using a laptop on the floor compared to 5% of the learners from the intervention group (p=0.04).

On completing the descriptive statistics of all demographic, behavioural and postural data obtained from phase one of the study, their influence, such as, age, gender, height and the level of pain catastrophising, hours spent on the computer at school per week as well as postural positions (RULA), on the development of pain whilst working on the computer was tested for by way of logistic regression analysis.

5.5 RISK FACTORS FOR PAIN

In this section, the results of the logistic regression to establish risk factors for pain are given. The factors that were used for the regression analysis were: age, gender, height, pain catastrophising (TPCS-C ≥30), number of hours a week using a computer (≥2.5hrs), grand RULA score, RULA final wrist/arm and RULA final neck/trunk scores.

The logistic regression was carried out for baseline data. An initial univariate logistic regression was done to identify all the variables that were found to have significance in the prediction of musculoskeletal pain while working on a computer. This was followed by a multivariate analysis-stepwise, (using only those variables significant in the univariate analysis). The dependent variable was pain while using a computer (No/Yes, yes being the reference category), and eight independent variables: total pain catastrophising scale, hours per week using computer, grand RULA score, age, gender, height, RULA final wrist/arm and RULA final neck/trunk scores, which are postural positions relating to wrist/arm position and neck/trunk positions, were considered for developing musculoskeletal pain. The first three variables were categorical variables and the last three were continuous variables.

The results of the logistic regression using adjusted odds ratios are presented in Table 5.14.

Table 5.14: The Factors that were Found to Influence the Development of Musculoskeletal Pain in Learners Working on a Computer at Baseline (n=127) (*significant)

Risk factors at baseline	OR	S.E	UL 95% CI	LL 95%CI	p-value
Gender (Female)	0.4	0.4	0.2	0.8	**0.01***
Hours per week using computer at school (≥ 2.5 hours)	0.4	0.5	0.2	0.9	**0.02***
Grand RULA Score	0.8	0.2	0.6	1.1	0.22
RULA final wrist/arm score	0.9	0.2	0.6	1.3	**0.01***

Being of female gender was found to be a significant risk factor for developing pain while working on a computer at baseline. Those learners that worked on the computer for equal to 2.5 hrs were 40% more likely to develop pain than those that worked for less than 2.5 hours/week. Learner's wrist and arm postural positions were found to increase their risk for developing pain while working on the computer.

5.6 ERGONOMICS OF THE SCHOOL ENVIRONMENT

5.6.1 Design of Computer Workstations in a School Environment

The ergonomic set-up of workstations in the school computer laboratory was assessed using a computer workstation design assessment (CWDA) tool. The tool comprised four sections.

Each section assessed a different aspect of the computer laboratory and workstation:

- Working environment
- Spatial environment
- Visual environment
- Workspace environment including chair, desk, computer screen, keyboard and input device.

The school computer laboratories were assessed using the CWDA form. Table 5.15 below shows the results from the assessment.

Table 5.15: A Description of the Working and Spatial Environments of the Control (C) and Intervention (I) Schools (n=2)

Working environment	**C**	**I**
Classroom climate controlled by air conditioner	*Y	*N
Drafts at level of knees	N	N
Noise level interferes with concentration	N	Y
Spatial environment		
Number of learners in computer lab at a time <= 30	Y	Y
Aisle width between workstations 152 to 183cm	N	N
Adequate space for easy movement between workstations, doorways	Y	Y

*Y = yes, *N = no

The control and intervention schools had non-uniform desks and chairs for use in the computer laboratories, and the space on the desk for the computers in the intervention school was compromised.

The figures below illustrate the computer laboratories at the control and intervention schools:

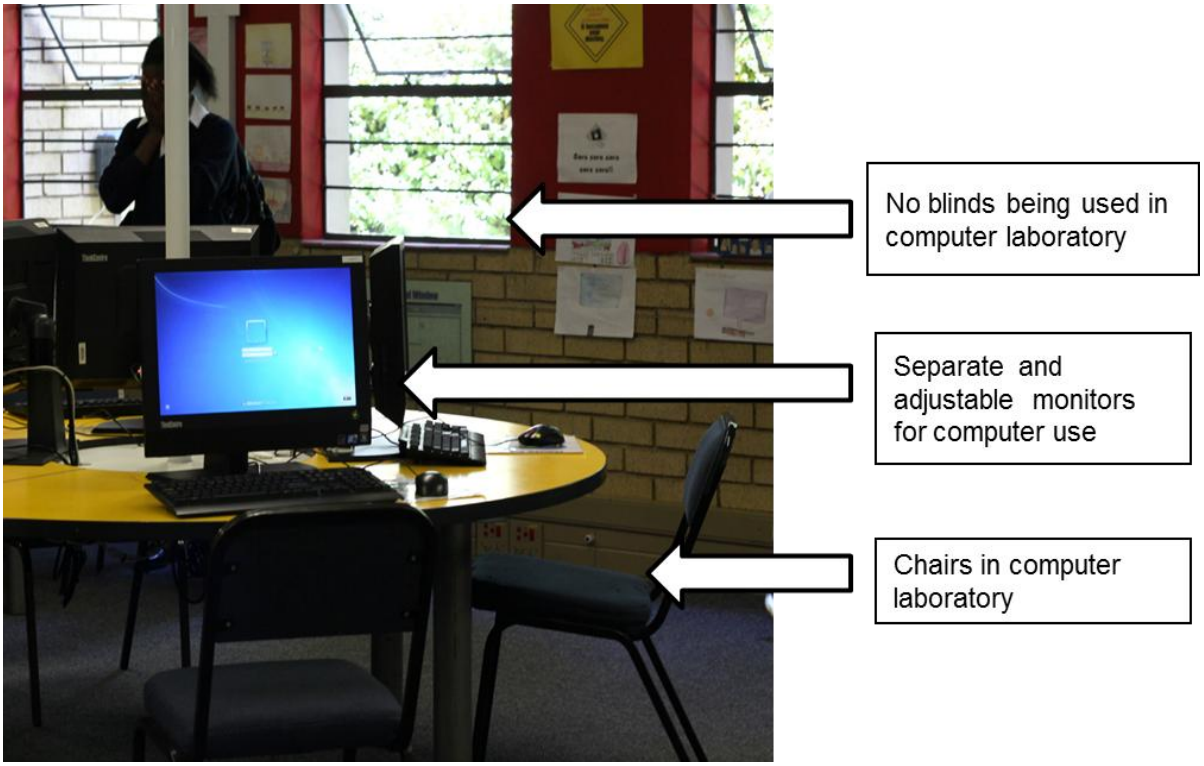

Figure 5.4: Computer Laboratory at Control School

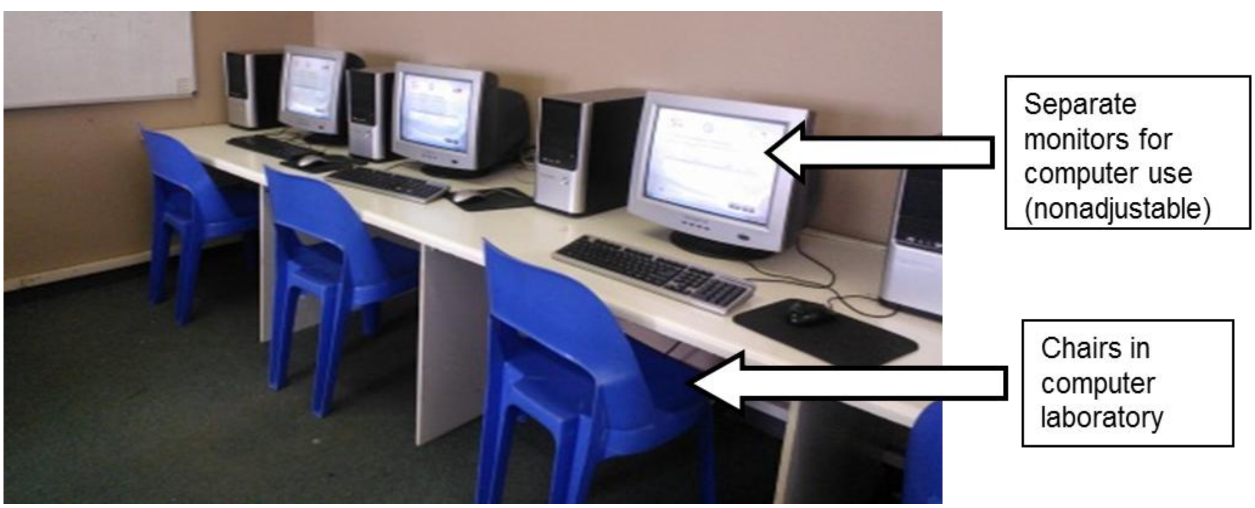

Figure 5.5: Computer Laboratory at Intervention School

Figure 5.6: Computer Laboratory at Intervention School

A description of the visual environment and the desk set up found in the control and intervention schools is shown in Table 5.16 below.

Table 5.16: The Visual Environment and the Desk set up Found in the Computer Laboratories of the Control (C) and Intervention (I) Schools

Visual environment	**C**	**I**
Monitor has adjustable brightness and contrast controls	*Y	Y
Control of glare through use of screens, indirect lighting or equipment positioning	*Y	Y
Desk		
Desk height adjustable	N	N
Desk width 1500mm minimum	Y	Y
Desk depth 900mm	N	N
Leg space under desk when seated 800mm minimum	Y	Y
Depth of space for legs when seated 550mm minimum	Y	Y
Height of space between legs and desk when seated 580mm minimum	Y	Y
Footrest	N	N

*Y = yes, *N = no

There were no curtains/blinds to stop glare (see Figure 5.3 control school) from affecting the computer screens and in turn the learners' eyes in the control school. Curtains were available in the intervention schools (Figure 5.5). Both schools from the sample had dedicated computer laboratories but none of these laboratories had adjustable chairs for computer use.

A description of the computer and the type of input device found in the schools is shown below in Table 5.17.

Table 5.17: A Description of the Computer and the Type of Input Device Found in the Computer Laboratories of the Control (C) and Intervention (I) Schools

Computer Screen **Computer and Input Device**	**C**	**I**
Screen depth 500mm to 750mm	*Y	Y
Screen height from floor to centre of screen 900mm to 1150mm	Y	Y
Screen dimensions	Y	Y
Inclination of viewing monitor is adjustable 88 to 150 degrees from horizontal	*N	N
Document holder	N	N
Keyboard		
Positioned on separate tray	N	N
Height from floor to keyboard is in range of 700mm to 850mm	Y	Y
Height of home row of keyboard to desk level in range of 100mm to 260mm	N	N
Keyboard angle adjustable	N	N
Gel wrist support	N	N
Input device		
Mouse	Y	Y
Adjustable mouse position	Y	Y
Can be used ambidextrously	Y	Y
Mouse pad available and used	Y	Y

*Y=yes, *N=no

Both schools had separate monitors but they were non-adjustable for the height differences of learners (see Figure 5.4 above).

5.6.2 Attitudes and Knowledge of Secondary School Information Technology Teachers and Principals

The knowledge and attitudes of computer ergonomics of teachers involved in information technology and their principals in secondary schools in the Gauteng province were assessed with a computer ergonomics school survey questionnaire developed by Dockrell et al. (2009) for their study in Ireland. The sample consisted of teachers and principals from 27 independent secondary schools in Gauteng.

From the 18 schools that responded in the Gauteng area, a 100% of the grade eight information technology teachers answered the teacher survey and 15 out of the 18 principals responded to the principal survey. The demographics and level of computer skills training among teachers is shown below in Table 5.18.

Table 5.18: Teacher Demographics and Extent of Computer Training of Teachers (n=18)

Sample Description	Male n (%)	Female n (%)	Total n(%)
Computer training	8 (44)	10(55)	18(100)
Ergonomic training	1(5)	2(8)	3 (13)
Satisfied with computer ergonomics	0	0	0
Would like computer ergonomic training	8 (44)	10 (55)	18 (100)

All teachers from the sample had undergone computer skill training at least once a year. Only 13% of the teachers had been trained in ergonomic skills. None of the teachers surveyed were satisfied with computer-related ergonomics.

5.7 PHASE TWO: THE EFFECT OF THE COMPUTER-RELATED PARTICIPATORY ERGONOMIC INTERVENTION PROGRAMME

The main outcome indicators examined for assessing the effect of the ergonomics intervention programme were pain, pain catastrophising and postural changes. These were assessed through the following objectives:

- To determine the effect on musculoskeletal pain in adolescents using a computer in a school environment

- To determine the effect on pain catastrophising in adolescents using a computer at school.

- To determine the effect of the intervention programme on posture in adolescents while using a computer during the duration of their 45 minute computer lesson.

The results will be presented below to answer each of the objectives.

5.7.1 The Effect of the Intervention Programme on Musculoskeletal Pain

To determine if the intervention programme had an effect on learners experiencing musculoskeletal pain with computer use, the two groups were compared using: McNemar's test for significance of probability, the Stuart-Maxwell test for marginal homogeneity and the Generalised Estimated Equations model (GEE) for measuring the overall effect of the intervention on learners with pain while working on the computer over the study period.

a) **A comparison of the prevalence of musculoskeletal pain relating to computer use between the control and intervention groups over six months.**

The percentage of learners who experienced musculoskeletal pain while working on a computer over a period of time from baseline to six months is outlined in Table 5.18.

Table 5.18: Number of Learners Experiencing Musculoskeletal Pain Working on Computer over a Period of Six Months (n=127)

		Control Group n(%)	Intervention Group n(%)	p-Value
Pain working on computer (baseline)	No	49 (74.2)	35 (57.4)	p=0.04
	Yes	17 (25.8)	26 (42.6)	
Pain working on computer (3 months)	No	49 (74.2)	48 (78.7)	p=0.55
	Yes	17 (25.8)	13 (21.3)	
Pain working on computer (6 months)	No	50 (75.8)	50 (82)	p=0.4
	Yes	16 (24.2)	11 (18)	
Total		66 (100)	61(100)	

The number of learners from the control group who experienced musculoskeletal pain while working on a computer at baseline (25.8%) compared to those in the intervention group (42.6%) was different and statistically significant (p=0.04). This could be attributed to sampling bias related to the cluster sampling process. At three months and six months, there was no statistically significant difference in the number of learners with musculoskeletal pain while working on a computer between the control and intervention groups (p=0.55 and p= 0.4 respectively).

b) **Between group analysis of learners experiencing musculoskeletal pain while working on a computer over a period of six months**

A logistic regression analysis was done to determine if there was a difference in the risk of developing pain amongst learners while working on a computer between the control and intervention groups.Table 5.19 shows the findings.

Table 5.19: Musculoskeletal Pain Experienced by the Learners Working on the Computer (n=127)

Pain working on computer (n=127)	OR	z	SE	p-value	95% C.I
Baseline	2.1	0.8	1.97	0.04	(1.01- 4.53)
3 Months	0.7	0.3	0.59	0.55	(0.34-1.78)
6 months	0.7	0.3	-0.85	0.4	(0.29 -1.62)

At baseline there was a significant difference (p=0.04) between the learners for the risk of developing pain while working on a computer. The risk however decreased over the six months as can be seen from the reduction in the odds ratios.

c) **Within group analysis of learners experiencing musculoskeletal pain while working on a computer over a period of six months.**

A test of proportions of learners that shifted from pain to no pain while working on a computer was undertaken using the McNemar's test. The results of the within group analysis are outlined in Table 5.20.

Table 5.20: Distribution of Learners' Pain while Working on a Computer over the Study Period

Baseline-3 Months	Pain to No Pain	No Pain to Pain	OR	95% C.I.	P
Control	7	7	1	(0.2-3.3)	0.9
Intervention	16	3	5.3	(1.5-28.5)	0.001
Baseline-6 Months					
Control	6	10	1.2	(0.3-4.2)	0.9
Intervention	7	4	4.8	(1.5-19.1)	0.001

The results of the McNemar's test for within group changes shows that the intervention resulted in a statistically significant change over a period of six months. Between baseline and three months in the control group, seven learners who started with pain changed to no pain at three months, and seven learners who started with no pain, had pain at three months. In the intervention group, there was a greater likelihood to move from pain to no pain by three months (OR=5.3, 95% C.I.1.5-28.5) as 16 learners started with pain at baseline and by three months had no pain. At six months, the intervention group was 4.8 times more likely to move from pain to no pain (OR=4.8, 95%C.I. 1.5-19.1) compared to the control group (OR=1.2, 95% C.I. 0.3-4.2).

d) **Propensity score matching of the results relating to musculoskeletal pain while working on the computer**

At baseline a difference was noted between the control and experimental groups in terms of the prevalence of pain. This difference could be attributed to sampling bias from the process of cluster randomisation. For this reason, propensity score matching was done to improve homogeneity of the study samples. By matching, an attempt is made to mimic randomisation by creating a sample of units that received the treatment that is comparable on all observed covariates to a sample of units that did not receive the treatment.

A total sample of 66 learners (n=66) was used to run a logistic regression after propensity score matching. A multivariate analysis was done to test the effect of the intervention on this new subgroup. The results are shown in Table 5.21.

Table 5.21: The Factors that Influenced Musculoskeletal Pain in Learners Working on the Computer at Baseline after Propensity Score Matching (n=66)

Pain Working on Computer (n=66)	OR	z	SE	p-value	95% C.I
Baseline	0.9	-0.09	0.4	0.9	(0.37-2.40)
3 Months	0.5	-1.35	0.3	0.2	(0.17-1.61)
6 months	0.4	-1.58	0.2	0.09	(0.12-1.16)

There was a trend towards significance (p=0.09) (amongst the new subgroup that were matched) for factors influencing learners in experiencing pain while working on a computer over the six month study period. There was a 40% risk for learners experiencing pain while working on a computer (OR=0.4, 95% C.I 0.12-1.16) compared to a 70% risk (OR=0.7, 95% C.I. 0.29-1.62) at six months before the sample was matched, which indicates that the intervention had a clinical effect on reducing the risk of learners for developing pain while working on the computer.

A generalised estimated equations (GEE) model was used to estimate the average response over the population. An auto-aggressive 1st order correlation structure was used. The GEE found that the way the learners were at baseline influenced the way they were at three months and in turn this influenced their outcome at six months. The results of the GEE are outlined in Table 5.22.

Table 5.22: Generalised Estimated Equations Model for Pain while Working on the Computer (n=127)

Pain Working on Computer	OR	SE	p-value	95% C.I
Age	1.2	0.4	0.4	(0.72-2.22)
Gender (Female)	2.3	0.8	0.01	(1.18-4.50)
Weight	0.1	0.01	0.04	(0.94-0.18)
TotalPCS	1	0.02	0.01	(1.00-1.18)

The weight of the learners, female gender and total PCS-C scores was found to be significant and predictive of pain among the learners. The heavier the learner, the less likely they were to experience pain while working on a computer.

e) **A comparison of reported pain intensity per body area within the control and intervention groups over the study period**

To determine whether there was a difference within the control and intervention groups in reported pain intensity per body area over the study period, the within group analysis was done using the non-parametric Freidman test of significance as the data were not normally distributed. Table 5.23 outlines the results of the within group analysis for reported pain intensity.

Table 5.23: Reported Pain Intensity (PI) per Body Area within the Control and Intervention Groups Over Time

Body Area	PI(C)							PI(I)						
	B		3M		6M			B		3M		6M		
	Mean	s.d	Mean	s.d	Mean	s.d	p-value	Mean	s.d	Mean	s.d	Mean	s.d	p-value
Head	1.12	2.23	1.15	1.14	1.35	2.33	0.7	1.28	2.45	1.41	2.71	1.33	2.7	0.5
Neck	0.71	1.66	1.59	2.26	1.71	2.44	0.00	2.16	2.76	1.62	2.45	1.66	2.4	0.02
Upper back	0.67	1.76	1.1	2.75	1.56	2.61	0.6	1.33	2.59	1.61	2.6	1.69	2.71	0.9
Lower back	0.71	1.92	1.58	2.38	1.48	2.35	0.2	2.05	2.87	1.72	2.7	1.66	2.67	0.3
Right shoulder	1.18	2.02	1.32	2.24	1.32	2.32	0.9	1.62	2.77	1.56	2.61	1.66	2.7	0.5
Left Shoulder	1.35	2.38	1.17	2.21	1.14	2.18	0.9	1.36	2.6	1.3	2.47	1.33	2.46	0.8
Right elbow	0.09	0.45	0.47	1.15	0.36	0.95	0.1	0.13	0.42	0.28	0.85	0.28	0.85	0.9
Left elbow	0.03	0.24	0.32	0.88	0.38	1.12	0.00	0.13	0.42	0.34	0.94	0.26	0.85	0.6
Right wrist	0.48	1.52	0.95	1.81	0.83	1.61	0.5	0.82	1.64	0.84	1.85	0.84	1.85	0.6
Left Wrist	0.39	1.38	0.8	1.87	0.82	1.88	0.3	0.61	1.52	0.56	1.33	0.52	1.32	0.3

PI(C) = Pain intensity control group   I(I) = Pain intensity Intervention group
B = baseline   3M = 3 Months   6M = 6 Months

The results above show that there were significant differences in reported neck pain ($p<0.01$) and left elbow pain ($p<0.01$) within the control group over six months. In the intervention group, only reported neck pain ($p=0.02$) was found to be significantly different over a period of six months.

f) **A comparison of reported pain intensity per body area between the control and intervention groups over the study period.**

To determine the effect of the intervention on reported pain intensity between groups, the Mann Whitney U statistical test, the non-parametric equivalent of the t-test was used instead of the independent measures t-test as these variables were found to be skewed. Table 5.24 outlines the results of reported pain intensity per body area between the control and intervention groups.

Table 5.24: Reported Pain Intensity per Body Area between the Control and Intervention Groups over the Study Period

Body area	Pain Intensity			Pain Intensity			Pain Intensity		
	Baseline			3 Months			6 Months		
	Mean Difference	Standard Error	p-value	Mean Difference	Standard error	p-value	Mean Difference	Standard error	p-value
Head	-0.1	0.4	0.3	-0.3	0.4	0.8	0.02	0.4	0.6
Neck	-1.4	0.4	0.00	-0.03	0.4	0.8	0.05	0.4	0.1
Upper back	-0.6	0.4	0.04	-0.5	0.4	0.5	-0.1	0.5	0.6
Lower back	-1.3	0.4	0.00	-0.1	0.4	0.9	-0.2	0.4	0.1
Right shoulder	-0.4	0.4	0.5	-0.2	0.4	0.9	-0.3	0.4	0.6
Left Shoulder	-0.01	0.4	0.1	-0.1	0.4	0.1	-0.2	0.4	0.7
Right elbow	-0.04	0.1	0.3	-0.2	0.2	0.3	0.1	0.2	0.7
Left elbow	-0.1	0.1	0.04	-0.02	0.2	0.9	0.1	0.2	0.7
Right wrist	-0.3	0.3	0.1	0.1	0.3	0.4	-0.01	0.3	0.6
Left Wrist	-0.2	0.3	0.3	0.3	0.3	0.5	0.2	0.3	0.3

The results show that at three months and six months, there were no significant differences in reported pain intensity per body area between the control and intervention groups.

5.7.2 To Determine the Effect of the Intervention on Pain Catastrophising Levels amongst Learners

a) **Comparison of pain catastrophising in the control and intervention groups**

The results below show the average Total PCS (TPCS-C) score for the control and intervention groups between 0 and six months. A TPCS-C score of 30/50 refers to the 75 percentile and is clinically relevant in terms of predicting the risk for developing chronic pain.

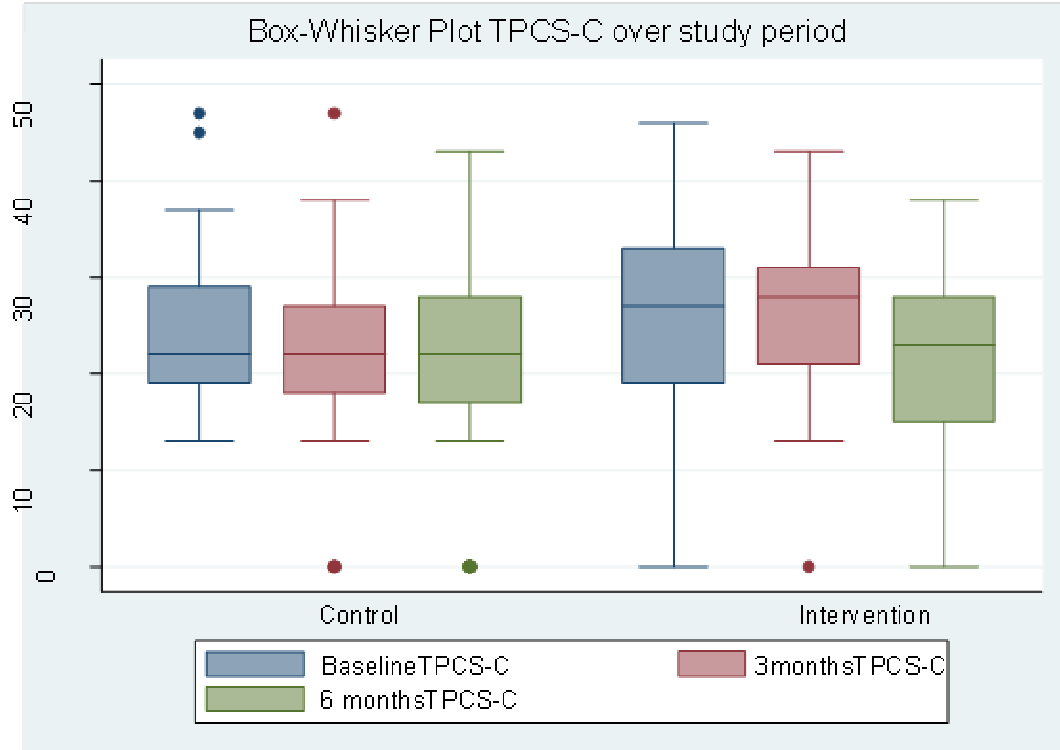

Figure 5.7: Comparison of the TPCS-C between the Control and Intervention Groups over a Period of Time

The results in Figure 5.7 show that the average TPCS-C scores in the control group over a period of six months were similar and that the spread of TPCS-C scores at six months was greater than at baseline in the control group. There were a few outliers observed at baseline and three months amongst the TPCS-C scores in the control group. This was possibly due to the differences at baseline between the control and intervention groups. In contrast, the average TPCS-C in the intervention group at baseline were greater than those in the control group, however at six months, the TPCS-C scores showed a shift to a lower average than at baseline. There were only outliers observed at three months in the intervention group. The box-Whisker plot demonstrates the clinical effect of the intervention as the average TPCS-C scores between the control and intervention groups at six months had reduced compared to the scores at baseline. Therefore, there was a shift in the number of learners with TPCS-C scores from above the 75th percentile in the intervention group to below average at six months post intervention.

b) **A comparison of the TPCS-C scores within and between the control and intervention groups over a period of six months.**

To determine if the intervention programme had an effect on pain catastrophising in learners, pain catastrophising for the two groups was tested using repeated measures ANOVA to test whether within and between group changes were evident.

Table 5.25 below shows the results of the within-group changes measured at six months post-intervention.

Table 5.25: Comparison of TPCS-C Scores within the Control and Intervention Groups over a Period of six months

Time Period	TPCS-C	Control Group		TPCS-C	Intervention Group	
	Mean difference	C.I.	p-value	Mean difference	C.I.	p-value
Baseline - 3 Months	1.43	(-0.79-3.64)	0.2	0.05	(-2.85-2.95)	0.1
3 Months - 6 Months	1.62	(-1.14-4.41)	0.2	6.38	(3.33-9.42)	0.001
Baseline - 6 Months	3.05	(-0.15-5.97)	0.04	6.43	(3.28-9.57)	0.001

The mean difference in the TPCS-C score within the control group increased over a period of six months and the difference was found to be statistically significant ($p=0.04$). The mean difference in the TPCS-C within the intervention group also increased over the 6 month time period with significant differences found at three months($p<0.01$) and six months ($p<0.01$).

Table 5.26 shows the results from the ANOVA (Two sample t-test with equal variances) of the total TPCS-C between the control and intervention groups measured over the 6 month study period.

Table 5.26: A Comparison of TPCS-C Scores between the Control and Intervention Groups over six months

Baseline	**N**	**Mean**	**Std. Err.**	**Std. Dev.**	**C.I**		**p-value**
Control	66	23.9	0.16	8.01	21.9	25.8	
Intervention	61	26.4	1.25	10.2	23.9	28.9	0.9
Total	127	25.1	0.79	9.08	23.5	26.6	
Difference		-2.52	1.58		-5.65	0.62	
3 Months							
Control	66	22.4	1.11	9.04	20.2	24.7	
Intervention	61	26.3	1.04	8.16	24.2	28.4	0.1
Total	127	24.4	0.78	8.81	22.8	25.9	
Difference		-3.89	1.53		-6.92	-0.85	
6 Months							
Control	66	21	1.33	10.8	18.1	23.5	
Intervention	61	20	1.52	11.9	16.9	23.0	0.3
Total	127	20.4	1	11.3	18.4	22.4	
Difference		0.84	2.02		-3.1	4.8	

The results above illustrate that there was no significant differences in TPCS-C scores at baseline (p=0.9) between the control and intervention groups prior to the intervention. At six months post-intervention the results of the Total PCS scores between the control and intervention groups showed that there was no significant difference between the two groups (p=0.3). The mean difference from baseline to six months between the control and intervention groups, showed a positive increase from (-2.52 – 0.84), which could be due to a clinical effect from the intervention.

In terms of the three dimensions of pain catastrophising, it is important to understand whether any of these three dimensions played a significant role in this sample of learners. Pain catastrophising refers to when a subject has an exaggerated negative thought pattern towards pain and it is made of three constructs namely; rumination, magnification and helplessness. Pain catastrophising is clinically significant when an individual scores a TPCS-C > 30 (Sullivan et al., 2001).

Figure 5.4 presents the results for the average rumination scores of both the control and intervention groups over a period of six months.

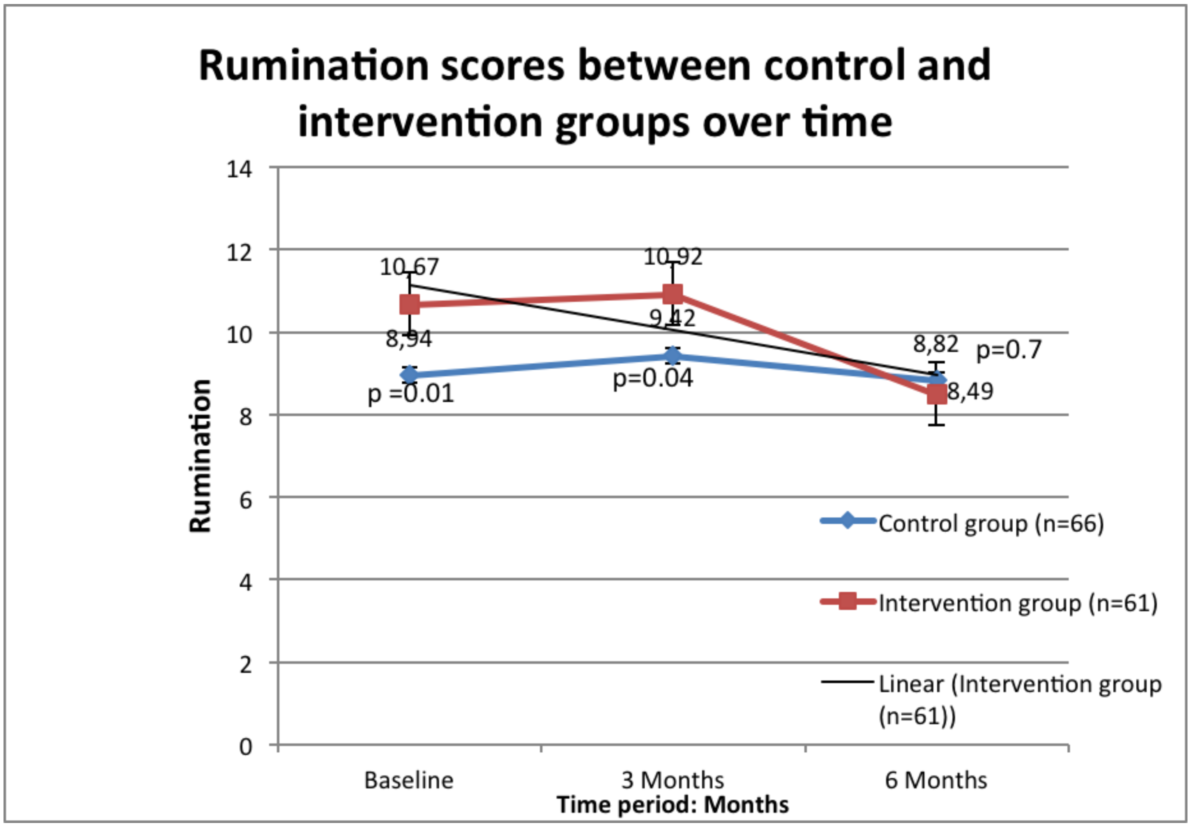

Figure 5.8: Comparison of the Mean Rumination Scores between the Control and Intervention Groups over a Period of time (n=66 Control Group; n=61 intervention group)

The mean rumination scores of the control and intervention groups at baseline, three months and six months were all below a score of 11, which is deemed clinically significant. There was a significant statistical difference in rumination scores at baseline (p=0.01) and three months (p=0.04) between the control and intervention groups. This difference in baseline scores may be attributed to sampling bias during the cluster randomisation process and hence, propensity score matching for the Total PCS-C was done to check that overall effect on the Total PCS-C was not affected by the difference in rumination scores at baseline (see 5.8.2c).

Although there was no significant difference (p=0.07) between the control and intervention groups' rumination scores at six months, it was evident that there was a trend of a declining rumination score, particularly in the intervention group which could indicate a clinical effect had taken place over the 6 month period.

The comparison of the mean magnification scores in learners in the control and intervention groups over a period of six months is shown in Figure 5.5 below.

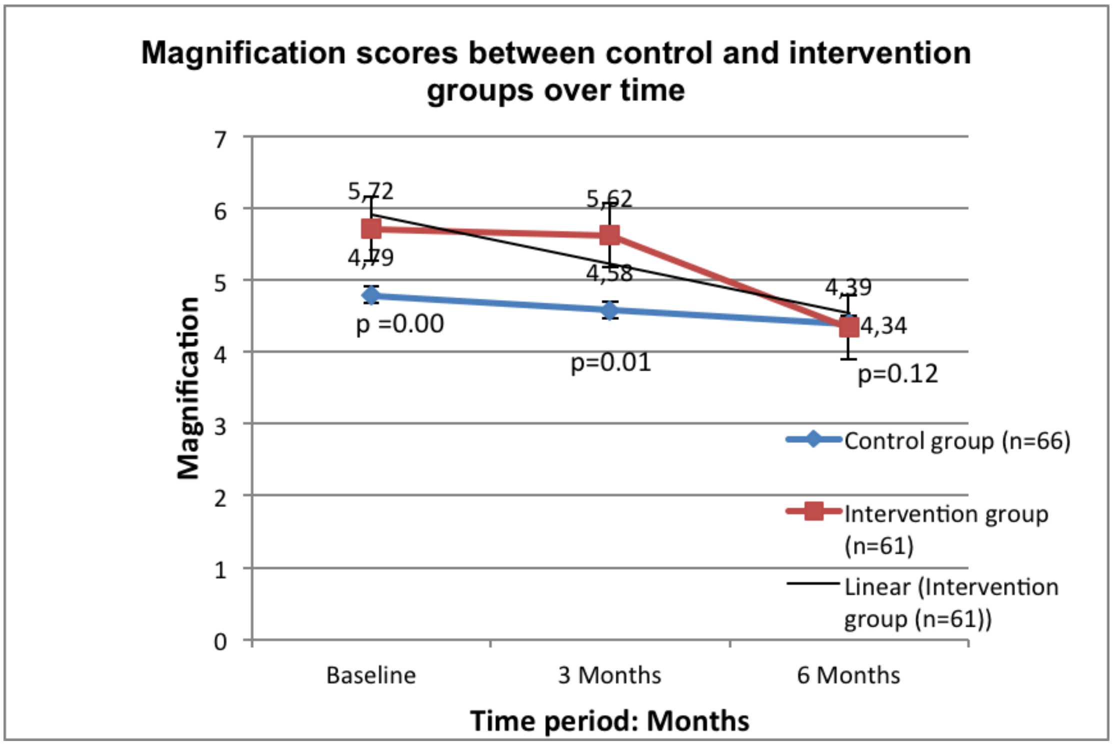

Figure 5.9: Comparison of the Mean Magnification Scores between the Control and Intervention Groups over a Period of Time (n=66 Control Group, n=61 Intervention Group)

The comparison of the mean magnification scores in the control and intervention groups show that at baseline, the mean magnification scores for the control and intervention groups were significantly different (p<0.01) at 4.79 and 5.72 respectively. The differences in the p-values depict the limitation of cluster randomised sampling, which leads to the skewness of the baseline results. Adjustment for the TPCS-C was undertaken to account for the skewedness and the results are shown in 5.8.2c.

At six months, there was no significant difference (p=0.9) between the control and intervention groups as the mean scores of magnification were 4.39 and 4.34 respectively. This demonstrated that the intervention had a clinical effect on reducing the learners' needs to magnify pain over time in the intervention group. In addition the average score of magnification within the intervention group showed a significant change (p<0.011) over a period of six months from an average score of 5.72 at baseline, to a mean score of 4.34 after six months.

The results of the mean helplessness scores between the control and intervention groups over a period of six months are shown below in Figure 5.6.

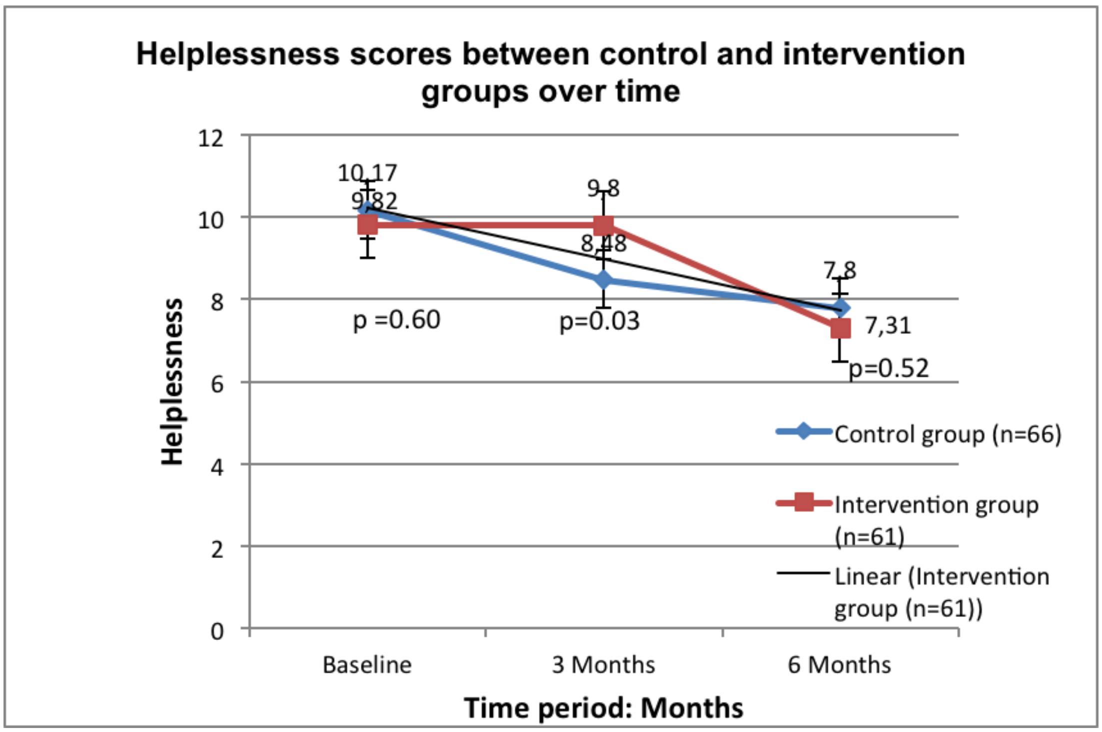

Figure 5.10: Comparison of the Mean Helplessness Scores between the Control and Intervention Groups over a Period of Time (n=66 Control Group, n=61 Intervention Group)

Both groups scored below the 75th percentile for helplessness (score=13), with the control group scoring an average of 10.17 and the intervention group scoring an average of 9.82 at baseline, deemed not statistically significant (p=0.60). The results show that there was a decreasing trend in helplessness scores between both the control and intervention groups at three months and six months.

c) **Propensity score matching of results relating to TPCS-C scores**

As stated previously in 5.8.2a baseline data were skewed possibly resulting from the cluster sampling process. To correct for this, propensity score matching was done to improve homeogenity of the study sample. Matching of a new subgroup (n=66) was used. The Mann-Whitney test and the two-sample t test with equal variances were used to test the effect of the intervention on this new subgroup (n=66) so as to reduce selection bias by equating the groups based on these covariates. The results are shown in Table 5.27.

Table 5.27: Total PCS-C amongst Learners over the Study Period after Propensity Score Matching (n=66)

Total-PCS score	Mean	SE Sd	C.I	p-value
Baseline	26	1.0 9.2	(24.1- 28.4)	0.7
3 Months	25	0.9 7.5	(23.0-26.4)	0.3
6 months	25	0.9 7.8	(23.9-27.6)	0.7

There was no significant difference in the TPCS-C scores between the control and intervention groups for an adjusted sample obtained by the non-parametric tests over the study period. This implies that the differences due to cluster sampling did not impact on the results of the study as there was no significant difference found over the study period. Thus, the propensity matching tests strengthen the results obtained as it suits the design of this study.

5.7.3 The Effect of the Intervention Programme on Posture of Learners while using a Computer

With increasing computer use among children, it is important to assess the impact of that use on their posture as they may be at risk of developing computer-related musculoskeletal pain. Figure 5.7 illustrates a learner sitting at a school computer. See Appendix A for other figures of learners from the control and intervention groups.

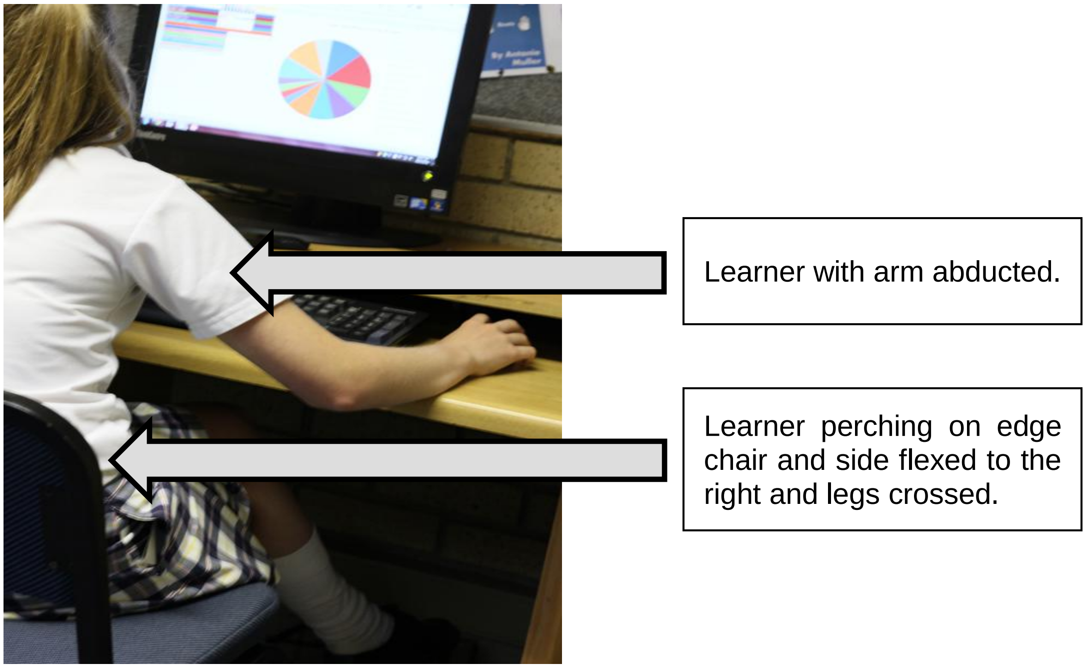

Figure 5.11: Posture of Learner in Control Group

a) **Number of learners in RULA action levels over a period of time between groups and within groups**

Learners from the study sample had their posture measured with the RULA tool over a period of six months at three different intervals, namely: baseline, three months and six months. A numerical score is allocated to an observed posture of different body parts (upper arms, lower arms, wrist, neck, trunk and legs). The posture scores are calculated and combined with a score for static muscle load and force, if appropriate, to give a Grand Score. The Grand Score is then used to identify the action that is indicated for that individual as shown in Table 5.28. A low RULA score is an indication of good posture and a high RULA score, for example 4, is indicative of a very poor posture.

Table 5.28: RULA Levels

Action Level	Grand Score	Indications
1	1 or 2	Posture is acceptable if maintained.
2	3 or 4	Further investigation needed. May need changes.
3	5 or 6	Further investigation and changes needed soon.
4	7 or more	Investigation and changes required immediately.

Following the Chi square test, the Fischer–exact test was used to determine if there was a significance difference in the number of learners in the RULA action levels between the control and intervention groups over the study period. Table 5.29 shows the results.

Table 5.29: A Comparison of the Number of Learners in RULA Action Levels between the Control and Intervention Groups over a Period of Six Months

Action Level Baseline	Control Group (n=66) %	Intervention Group (n=61) %	Fischer-Exact p-Value per Group	p-Value
AL 1	0	6 (4.7)		
AL 2	26.9(40.9)	26.0(42.6)		0.9
AL 3	14.9(22.7)	13.9(21.3)	0.05	0.1
AL 4	24.0(36.4)	20.1(26.2)		0.5
Action level - 3 months				
AL 1	12(18.1)	6 (9.8)		0.6
AL 2	39.0(59.1)	44.0(72.1)	0.3	0.2
AL 3	13.9(21.1)	10.1(18)		0.8
AL 4	1.0 (1.5)	0(0)		
Action level - 6 months				
AL 1	5(7.6)	18(29.5)		0.3
AL 2	21.8(31.8)	34.7(55.7)	0.00	0.07
AL 3	19.0(28.8)	9.0(14.8)		0.4
AL 4	21.8(31.8)	0(0)		

At baseline and six months, there was a significant difference between the number of learners in RULA action levels of the control and intervention groups ($p=0.05$ and $p<0.01$ respectively). The RULA analysis has subscales as shown above in Table 5.29. None of the individual subscales scored at an alpha level of

0.05 or less. Therefore after further consideration of the p values for subscales (where significance was set at 0.01 (0.05/4) there were no differences at a subscale level.

Table 5.30 shows the results of the Stuart-Maxwell test used to test for differences in the number of learners in RULA action levels within the control and intervention groups over a period of six months.

Table 5.30: A Comparison of the Number of Learners in RULA Action Levels within the Control and Intervention Groups over the Study Period

Time Period	Action Level Control			Action Level Intervention		
	Mean Diff.	C.I.	p-Value	Mean Diff.	C.I.	p-Value
Baseline - 3 Months	2.14	(1.53-2.74)	0.001	1.41	(0.96-1.86)	0.00
3 Months - 6 Months	-1.73	(-2.35 - -1.11)	0.001	0.62	(0.46-1.20)	0.01
Baseline - 6 Months	0.41	(-0.25-1.07)	0.2	2.03	(1.28-2.78)	0.00

The marginal homogeneity test – (Stuart-Maxwell) was used as the variables were categorical and discrete. The results showed a significant difference in the number of learners in RULA action levels measured at baseline compared to action levels at three months ($p<0.01$) within the control and intervention groups. The results showed no significant difference in the number of learners in RULA action levels measured at baseline compared to action levels at six months ($p=0.2$) within the control group, and thus there was no significant overall movement of learners in the control group between baseline and six months. However, there was a significant difference ($p<0.01$) in the number of leaners in RULA action levels scores within the intervention group as there was a significant shift in movement of learners between three months and six months($p=0.01$) and baseline and six months($p<0.01$).

b) **Repeated measures ANOVA for wrist/arm and neck/trunk scores over a period of time between control and intervention groups**

To determine the effect of the intervention on the RULA wrist/arm and neck/trunk/leg scores for the two groups, repeated measures ANOVA was used to compare changes. Table 5.31 below shows the results measured over a period of time.

Table 5.31: RULA Final Wrist/Arm Scores between the Control and Intervention Groups over a Period of Time

Time Period	Mean (C)	SD (C)	Mean (I)	SD(I)	p-value
Baseline	5.1	0.9	4.5	1.7	0.03
3 Months	3.4	1.7	3.7	1.3	0.3
6 Months	4.4	1.4	3.0	2.0	0.00

The results showed that there was a significant difference between the wrist/arm scores (RULA) at baseline between the control and intervention groups (p=0.03). The comparison of the RULA wrist/arm scores at three months between the control and intervention groups showed no significant difference between the two groups (p=0.3). However, at six months the results had changed and a significant difference was found between the RULA wrist/arm scores between the control and intervention groups ($p<0.01$).

The results of the Stuart-Maxwell test to test for within group changes are shown below in Table 5.32.

Table 5.32: RULA Final Wrist/Arm Scores within Groups over the Study Period

RULA wrist/arm scores Control group	Mean Diff.	C.I.	p-value
Baseline - 3 months	1.7	(1.23 - 2.17)	0.001
3 Months-6 months	-1.03	(-2.17- -1.23)	0.001
Baseline-6 months	0.7	(0.26 - 1.07)	0.002
RULA wrist/arm scores Intervention group			
Baseline - 3 months	0.8	(0.42 - 1.18)	0.001
3 Months-6 months	1.5	(1.75 - 2.17)	0.02
Baseline-6 months	0.7	(0.10 - 1.22)	0.001

The results showed that there were significant differences in the final wrist/arm scores within both the control ($p<0.012$) and intervention groups ($p<0.011$) between baseline and six months.

Table 5.33 shows the results from the Fischer-exact test for the final neck/trunk/ leg RULA scores between the control and intervention groups at baseline.

Table 5.33: RULA Final Neck/Trunk/Leg Scores between the Control and Intervention Groups over a Period of Time

Time Period	Mean (C)	SD (C)	Mean (I)	SD(I)	p-value
Baseline	4.4	1.1	4.1	2.2	0.03
3 Months	2.1	1.9	2.1	1.5	0.3
6 Months	4.5	2.3	2.2	1.8	0.00

The results show that there was a significant difference between the RULA final neck/trunk/leg scores between the groups at baseline ($p=0.03$). At three months there was no significant difference in the RULA final neck/trunk/leg scores between the two groups.

At six months there was a significant difference in the final neck/trunk/leg scores ($p<0.01$) between the control and intervention groups.

Table 5.34 shows the results obtained from measuring the RULA final neck/trunk/ leg scores within group changes between the control and intervention groups over the study period.

Table 5.34: RULA Final Neck/Trunk/Leg Scores within Groups over the Study Period

RULA Neck/Trunk/Leg Scores Control Group	**Mean Diff.**	**C.I.**	**p-value**
Baseline - 3 months	1.5	(0.78 - 2.13)	0.001
3 Months - 6 months	-1.5	(-2.19 - -0.81)	0.001
Baseline - 6 months	-0.05	(-0.78 – 0.69)	0.9
RULA Neck/Trunk/Leg Scores Intervention Group			
Baseline - 3 months	1.2	(0.62-1.68)	0.001
3 Months - 6 months	0.8	(0.24-1.40)	0.006
Baseline - 6 months	1.1	(1.23-2.71)	0.001

The Stuart-Maxwell test for significance found that there was no significant difference between the RULA final neck/trunk/leg scores between baseline and six months within the control group (p=0.9).However, there was a significant difference in scores within the intervention group between baseline and six months (p<0.011), indicating that the posture of the learners relating to their neck,trunk and leg positions had improved over a period of six months.

c) **Propensity score matching of results for the RULA Final wrist/arm and RULA Final neck/trunk/leg scores**

Propensity score matching of the RULA final wrist/arm and RULA final neck/trunk/leg scores was done accounting for the differences between the groups based on these covariates. The new matched sample of 66 participants (n=66) was tested using the two-sample t -test. The results are shown in Table 5.35.

Table 5.35: Results of the Two-Sample t-Test for RULA Final Wrist/Arm Scores (n=66)

RULA Final Wrist/Arm Scores	Mean	SE	SD	C.I.	p-value
Baseline	5.2	0.18	1.5	(4.36 - 5.08)	0.8
3 Months	4.6	0.18	1.5	(3.33 – 4.06)	0.4
6 months	4.7	0.24	2.0	(3.08 – 4.07)	0.000

The results showed that there was only a significant difference in the final wrist/arm scores after six months which is similar to the results obtained using the non-adjusted sample numbers from the cluster sampling (see Table 5.25).

Table 5.36 shows the results from the propensity score matching of the RULA final neck/trunk/leg scores using the two-sample t-test.

Table 5.36: Results of Two-Sample t-Test for RULA Final Neck/Trunk/Leg Scores (n=66)

RULA Final Neck/Trunk/Leg Scores	Mean	SE	SD	C.I.	p-value
Baseline	4.1	0.4	2.0	(3.34 – 5.30)	0.8
3 Months	3.2	0.2	1.8	(3.79 – 3.64)	0.1
6 months	3.1	0.3	2.4	(2.53 – 4.41)	0.000

The results showed that there was only a significant difference in the RULA final neck/trunk/leg scores after six months with the new adjusted sample which is a similar trend found in the sample obtained from the cluster randomised sampling (Table 5.31) and thus the selection bias did not have an effect on the intervention results.

A generalised estimated equations (GEE) model was used to estimate the average response of the RULA final wrist/arm scores and the RULA final neck/ trunk/leg scores over the population. An auto-aggressive 1st order correlation structure was used (see Tables 5.37 and 5.38).

Table 5.37: Generalised Estimated Equations Model for RULA Final Wrist/ Arm Scores

RULA Final Wrist/Arm Scores	OR	SE	z	p-value	C.I
Age	1.0	0.04	0.7	0.5	(0.94-1.12)
Gender (Female)	1.0	0.05	0.8	0.4	(0.94-1.15)
Weight	0.1	0.002	-0.6	0.6	(0.14-1.00)
Total-PCS	1.0	0.003	0.5	0.6	(0.15-1.00)

The GEE found that the way the learners were at baseline, based on their age, gender, weight and total pain catastrophising scores, influenced the way they were at three months and in turn this influenced their outcome at six months in terms of their wrist and arm position while using a computer. Thus, the GEE strengthens the results obtained as it supports the design used in this study. Learners who were heavier in weight were found to be at a greater risk for developing poor wrist and arm positions while using a computer.

The GEE model for the RULA final neck/trunk/leg scores is shown in Table 5.38.

Table 5.38: Generalised Estimated Equations Model for RULA Final Neck/ Trunk/Leg Scores

RULA Final Neck/Trunk/Leg Scores	OR	SE	Z	p-value	C.I
Age	1.0	0.05	0.9	0.4	(0.94-1.15)
Gender (Female)	1.0	0.06	1.3	0.2	(0.96-1.22)
Weight	0.1	0.002	-1.45	0.1	(0.99-1.00)
Total-PCS	0.1	0.003	- 0.28	0.8	(0.99-1.00)

The GEE model showed that learners with heavier weight and those that had high Total-PCS scores were significantly more vulnerable for developing poor postural positions related to the their neck/trunk/leg positions than other learners.

5.8 CONCLUSION

In conclusion the key findings obtained from the results for Phases 1 and 2 are summarised below:

Phase 1: Prevalence Data

- The prevalence rate of musculoskeletal pain amongst the total learner sample (n=127) in a school environment at baseline was 77%.

- The prevalence rate of musculoskeletal pain related to computer use amongst the total learner sample (n=127) at baseline was 34% and had reduced to 21.3% over a period of six months.

- The body areas most commonly affected by pain in adolescents related to computer use amongst the total learner sample (n=127) were the shoulders, neck and lower back areas with the shoulder and neck pain being more prevalent.

- The learners in the control group(n=66) experienced predominantly shoulder and neck pain over the 6 month study period, whereas the learners from the intervention group (n=61) experienced predominantly shoulder, neck, lower back and wrist pain at different intervals over the 6 month study period.

- Reported pain intensity amongst the majority of learners from this current study are low for all body areas.The median intensity of reported pain amongst learners in the control group that was most present was upper back pain (3.00-0.00), and lower back pain (4.50-0.00) for learners in the intervention group at baseline. The low pain intensity amongst learners is evident throughout both the control and intervention groups and may be attributed to the low weekly use of a computer.

- Risk factors that were found to be significant in influencing the development of musculoskeletal pain amongst learners while working on a computer were: being of female gender, working for ≥2.5hours per week on a computer and the postural position of the learners' wrist and arms during computer use.

- The percentage of learners (n=127) with Total pain catastrophising scores (TPCS-C) that were deemed clinically significant (TPCS-C > 30) at baseline were 26.8% (34/127) compared to 13.4%(17/127) at six months.

- Only 4.7% (6/127) of learners were in an acceptable postural position (AL 1) while working on a computer at baseline compared to 18.1% (23/127) after six months. The majority of learners (42%, 40/127) were in AL 2, a potentially poor postural position at baseline.

- The postural positions of the learners' wrist and arm positions at baseline scored an average of 5.0 on the RULA sheet- considered to be a poor postural postion, compared to 3.7 after six months – indicating an improvement in the wrist/arm positions. Similarly, the learners' neck/trunk/leg positions at baseline scored an average of 4.3 compared to 3.3 after six months and thus indicate some change in their upper torso posturing while working on a computer.

- The computer workstation assessment for both the control and intervention schools showed that neither laboratory had adjustable chairs or adjustable computer monitors for the learners to work on. The risk of glare affecting the learners' eyes and postural positions in the control school was an issue as there were no blinds on the windows of the computer laboratory.

- The knowledge of teachers and principals relating to correct computer-related ergonomics in schools was found to be lacking. However, there was a positive attitude towards furthering their knowledge base on this topic and an interest in being trained in ergonomic skills for both learners and themselves.

Phase 2: The Effect of the Intervention

- There was no statistically significant difference in the number of learners with musculoskeletal pain while working on a computer between the control and intervention groups over a period of six months.

- At six months learners in the intervention group showed a significant propensity for being 4.8 times (OR=4.8, p<0.011) more likely to shift from pain to no pain while working on a computer, compared to the control group (OR=1.2, p=0.9). This suggests that the intervention had a clinical effect on musculoskeletal pain experienced by learners while working on a computer.

- Reported neck pain intensity amongst learners in the intervention group was found to change significantly over the 6 month study period. However, there was no significant difference in reported pain intensity per body area between the learners in the control and intervention group over the 6 month study period.

- Total pain catastrophising scores (TPCS-C) reduced amongst learners in both the control and intervention groups over the 6 month study period. There was a shift (reduction) in the number of learners with TPCS-C >30 (75th percentile) in the intervention group at six months post intervention. The mean difference in TPCS-C scores from baseline to six months increased significantly in both the control and intervention groups, suggesting that the intervention had some clinical effect on the learners' propensity to catastrophise.

- There was a significant difference in the number of learners in each action level (AL) between the control and intervention groups at baseline and six months. Within the control group there was no significant overall movement of learners between action levels from baseline to six months. However, there was a significant shift in movement of learners in the intervention group between action levels from three months to six months (p=0.01) and from baseline to six months (p<0.01) indicating an improvement in posture while working on a computer.

- At six months there was a significant difference (p<0.01) in the RULA Final wrist/arm scores between the control and intervention groups; within the control and intervention groups there were significant differences in the RULA final wrist/arm scores over the 6 month study period.

- At six months there was a significant difference (p<0.01) in the RULA final neck/trunk/leg scores between the learners in the control and intervention groups; there was only a significant difference (p<0.011) in the RULA final neck/trunk/leg scores between baseline and six months in the intervention group.

- Propensity score matching for the covariates: pain while working on the computer, TPCS-C scores and RULA final wrist/arm and neck/trunk/leg scores was done accounting for the differences between the groups at baseline. The results showed that differences due to cluster sampling did not impact on the results of the study.

- A GEE was used to measure the average response of the pain while working on the computer, TPCS-C scores and RULA final wrist/arm and neck/trunk/leg scores over the population. It was found that the way the learners were at baseline influenced the way they were at three months and similarly their state at six months.

In conclusion, the results measuring the effect of the participatory computer-related ergonomic intervention programme on musculoskeletal pain while working on a computer, pain catastrophising and posture amongst learners in a school environment showed no significant effect on the number of learners with musculoskeletal pain, however, there were clinical effects found with regards to the experience of pain by learners in terms of pain catastrophising as well as their behaviour relating to their postural position when working on a computer. The clinical effect was found to be sustained over the period of six months. The findings will be discussed in detail in chapter 6.

CHAPTER 6

6. DISCUSSION

6.1 INTRODUCTION

This chapter begins with a discussion of phase one of the study in which the prevalence of musculoskeletal pain among adolescents in a school environment was investigated, as well as the risk factors which may influence the learner for developing musculoskeletal pain while working on a computer. Five specific objectives were investigated that examined the learner sample in terms of the prevalence of musculoskeletal pain related to computer use: the specific body areas of pain related to computer use, as well as associated risk factors such as computer exposure, postural positions of learners working on a computer; and the ergonomic environment of the schools.

The second part of this chapter will discuss the findings related to assessing the effect of the computer-related ergonomics intervention programme in a school environment on prevalence of musculoskeletal pain, pain catastrophising and posture in grade eight learners over a period of six months.

6.2 THE PREVALENCE OF MUSCULOSKELETAL PAIN IN ADOLESCENTS IN A SCHOOL ENVIRONMENT

The prevalence of musculoskeletal pain in this sample of adolescents was 77%, which is higher than that reported by Smith et al. (2007), who reported a prevalence rate of 74% for musculoskeletal pain in a sample of 1 073 learners in the Western Cape, aged between 14 and 18 years, and that by Jordaan et al. (2005), who reported a prevalence rate of 53% among adolescents in the North Gauteng region. However, Pucktree et al. (2004), reported a higher prevalence rate of 86.9% for musculoskeletal pain in a sample of 176 learners, with a mean age of 12.2 years, in KwaZulu-Natal (Pucktree et al., 2004). The prevalence rate from this study is significantly higher when compared with other African studies such as those done by Bejia et al. (2005) using a sample of Tunisian learners (n=622) and Prista et al. (2004) who used a sample of Mozambican adolescents (n=204), where the prevalence of pain amongst children and adolescents was found to be 28.4% and 13.5% respectively (Bejia et al., 2005; Prista et al., 2004). The reason for this higher prevalence rate amongst the current sample of learners may be attributed to the fact that this population group is based in an urban westernised private school environment with a high exposure and easy access to computers. Furthermore, the South African school curriculum has become more focussed on integrating the use of computer technology into schools without necessarily addressing the lack of ergonomically designed computer-workstations and ergonomic skills training.

In comparison to the international prevalence rates (Straker et al., 2002; Straker et al., 2011b; Burton et al., 1996; Harris et al., 2005; Zapata et al., 2006; Jones et al., 2004; Balague et al., 1999) for musculoskeletal pain among adolescents, which ranged between 40% and 63.5%, the prevalence rate found in this study is higher. With the increasing use of computers in schools and the demand of the school curriculum being predominantly more technologically driven in the past three years, this may have had an impact on the prevalence rate of musculoskeletal pain amongst learners in South Africa and thus a higher prevalence rate of musculoskeletal pain amongst learners in this current study. However, other contributing factors such as playing sport, writing at a desk and carrying heavy schoolbags could also have contributed to the experience of pain besides working on a computer.

Longitudinal studies have shown that there is a rapid increase in back pain early on in adolescence between the ages of 12 and 16 years (Salminen, 1984; Harreby et al., 1999b; Williams, 2002), which is consistent with the prevalence rate found in this study, as the sample of adolescents had a mean age of 13 years. This combination of adolescents' vulnerability to experiencing musculoskeletal pain during the adolescent growth phase and the high prevalence rate of pain is a major concern regarding the long term effects of chronic pain and disability. The results from this study further support the need for identifying risk factors amongst adolescents for developing musculoskeletal pain and looking for solutions and preventive measures to reduce the high pain prevalence rate.

Other characteristics in the study population that were examined, included gender differences and pain experienced while working on a computer. The findings in this study are consistent with local and international findings in that there were a greater number of females (19%) to males (15%) learners who experienced pain while working on a computer in the in the total learner sample measured at baseline. This finding is in accordance with the results obtained from learner samples in terms of gender differences and musculoskeletal pain (Zapata et al., 2006; Hakala et al., 2006; Straker et al., 2011). It has been reported that females sit more upright than males and that they have a reduced kyphosis and increased forward neck flexion compared to males and thus experience more pain than males (Widhe, 2001; Grimmer et al., 2006). In contrast, Prins et al. (2008) found that a greater number of males to females experienced upper quadrant musculoskeletal pain.

The prevalence rate of musculoskeletal pain experienced by learners while working on a computer was found to be 34% for the total learner sample in this study. This is lower than the prevalence rate (69.9%) for musculoskeletal pain while working on a computer in the study by Smith et al. (2007) in the Western Cape. The reason for the lower prevalence rate in this study may be attributed to the fact that the learners spent only an average of 2.5 hours per week on the computer at school compared to 4.8 hours in the study by Smith et al. (2007). Computer exposure amongst children in other studies have been found to be between 2-3.5 hours of computer use per week, which is similar to the average number of hours of computer use found amongst this current learner sample (Harreby et al., 1999; Jacobs and Baker, 2002; Hakala et al., 2006).

Based on the findings of musculoskeletal pain prevalence amongst this learner sample, various factors that have been found to contribute to the increase in the development of musculoskeletal pain were examined such as, pain catastrophising levels and posture.

6.3 BODY AREAS THAT HAD PAIN

Research has shown that children's use of computers is different from adult's use of computers (Breen et al., 2007) and that their spines are not able to withstand similar stresses that adult spines are able to endure (Milanese and Grimmer, 2004). Furthermore, the fast developing spine during puberty and adolescence can put a learner at a greater risk for developing musculoskeletal pain compared to an adult (Hakala et al., 2006; Williams, 2002), and increased computer exposure among children has also been shown to have an impact on their health and development (Harris and Straker., 2000; Jacobs and Baker., 2002; Ramos et al., 2005b; Straker et al., 2006;

Smith and Crouse, 2007; Harris et al., 2010b). Posture, duration and frequency of computer use and force are major parameters of concern. Factors that were found to have a direct effect on computer related musculoskeletal outcomes were age, gender, somatic complaints and computer exposure (Harris et al., 2010a).

In terms of multiple body areas of pain experienced by the learner sample while using the computer, 36% of learners experienced multiple areas of musculoskeletal pain, with bilateral shoulder pain being the most common area of complaint. Watson et al. (2002), Sjolie (2004), and Smith et al. (2007) found that multiple areas of musculoskeletal pain had a greater impact on levels of musculoskeletal pain and disability in computer users This is a concern in terms of users developing chronic pain from adolescence into adulthood (LeResche et al., 2005) as this can lead to central sensitisation pain issues leading to consequent disability within a generation of young adults (Latremoliere and Woolf, 2009).

The findings from this current study found that shoulder and neck pain were the most common areas of pain in the total learner sample at baseline. Forty six percent of the learners indicated that they had right shoulder pain, 36% had left shoulder pain and 30% had neck pain. These prevalence rates for shoulder pain are higher than those reported by Smith et al. (2007), in which shoulder pain was experienced by 12% to 15% of the learner sample. However, in terms of international prevalence rates for shoulder pain, these findings are consistent with the international prevalence rates that range from 11.5% to 40% for shoulder and neck pain (Harris et al., 2010a). An example of one such study is that conducted by Harris. et al. (2010a) who found shoulder and neck pain to be the most common areas of pain in the total learner sample, while using the computer (23.1% right shoulder, 18.2% left shoulder, 15% neck).

The impact of unequal loads on muscle tissue caused by sustained awkward sitting postures of adults and children using computers has been well researched and the resulting pain syndromes are multifactorial in origin (Kumar, 2001; Bongers et al., 2006; Hakala et al., 2006; Harris et al., 2012). In this sample of learners, it was a common occurrence to see learners sitting with their shoulder flexed and abducted when using the mouse due to the fact that the computer workstation was at the incorrect height for the learners' anthropometrics. This may result in increased activity in the Upper

Trapezius muscles, Levator Scapulae, Scalene and Sub-occipital muscles causing pain and discomfort in the neck and shoulder complex (Greig et al., 2005; Straker et al., 2006; Straker et al., 2009).

Headaches only accounted for 18% of a learner's pain compared to 28% in the Smith et al. (2007) study. Lower back pain was experienced by 27% of the learner sample. Thus, in relation to the most prevalent areas for musculoskeletal pain experienced by learners in this current study: shoulder pain, neck pain and then lower back pain; the findings are consistent with international prevalence rates for learner's exposure to computer use (Jacobs and Baker., 2002; Hakala et al., 2006; Straker et al., 2006; Smith and Crouse, 2007; Louw et al., 2007; Harris et al., 2010a; Ismail et al., 2010).

It is clear that musculoskeletal pain remains a problem among adolescents and may cause problems later in life. Understanding the risk factors will contribute to decreasing the incidence of musculoskeletal complaints among adolescents. Factors that were found to be associated with the occurrence of pain in this study were: working on a computer for greater than or equal to 2.5 hours; being of female gender and the learners' wrist and arm position while working on a computer. These will be discussed in 6.3 below.

6.4 RISK FACTORS FOR DEVELOPING MUSCULOSKELETAL PAIN

1. Computer Exposure

The results of the logistic regression using adjusted odds ratios in this current study, found that computer exposure for greater than or equal to 2.5 hours (OR=0.36, p=0.02) per week was a significant risk factor for learners for developing musculoskeletal pain. Several studies have used odds ratios and logistic regression analyses to determine if exposure to computer use is a predictive risk factor for developing musculoskeletal pain (Smith and Crouse., 2007; Hakala, 2006; Jacobs et al., 2006; Burke, 2002; Harreby et al., 1999b; Zapata et al., 2006) and reported some results similar to this study, while others reflect a different picture.

Computer exposure has been found to be predictive for the development of musculoskeletal pain in learners (Harris et al., 2005; Harris et al., 2010b). A large percentage of learners (76%) spent an average of 1.4 hours per week (2.4 ± 1.4 hrs) on a school computer, whereas only a small percentage (24%) of the learners used a computer for greater than 2.5 hours per week at school. A large percentage of learners (61.3%) had used the computer at school for more than five years. Smith et al. (2007) noted in her study that school computer use among South African learners is high because a large portion of the school curriculum is delivered via computers and fewer learners use computers for entertainment compared to international learner samples (Smith and Crouse., 2007).

The numbers of hours learners spend using a home computer has been found to contribute to the development of musculoskeletal pain amongst adolescents (Gillespie, 2006; Smith, 2007; Harris et al., 2010). The mean number of hours of home computer use in this study was found to be 1.73 hours (SD=1.2) a week for the total learner sample, which is lower than findings from international learner samples (Harris et al., 2005; Gillespie, 2006). A small percentage of learners, 13.4% (17/127) indicated that they used a computer at a library and a large percentage, 89% (113/127) used a home computer.

The availability of home computers is influenced by the socio-economic status of the household (Isaacs, 2007) and act as an enabler for the learning process and should be encouraged However, the danger of an increased risk for developing musculoskeletal pain needs to be countered by implementing appropriate stretching techniques and applying ergonomic skills in the home environment. In this current study, the reason such a high percentage of learners (89%) had home computer access was because the learner sample was drawn from a higher socio-economic grouping.

Computer use over a period of time is an associated risk factor for the development of musculoskeletal pain in learners in this sample. These findings are different from those found by a South African study done by Smith et al. (2007) and a Norwegian study by Sjolie (2004), in that they found that computer use of greater than seven and 7.5 hours respectively was predictive of general musculoskeletal pain in their learner sample. The current study’s findings are more consistent with a study by Zapata (2006) as they found computer use for longer than two hours to be positively correlated with developing musculoskeletal pain. A more recent and informative study on computer exposure and musculoskeletal outcomes was undertaken by Harris (2010), that reports that increasing computer exposure both at home and at school was associated with a greater frequency of musculoskeletal pain in children.

In this current study, learners' ergonomic behaviour was assessed by asking them to indicate where their computer was positioned when using it outside of school for example 'on their lap 'or 'on the floor'. Working on a laptop on the floor puts the learner in a less favourable postural position of trunk and neck flexion with hyperextension of the upper cervical spine.A large percentage of learners, 68% (86/127) used a desktop computer and a small percentage, 7% (9/127) used a laptop on the floor. After six months, a significant difference (p=0.04) was found in the number of learners using a laptop on the floor between the control and the intervention group. Fewer learners from the intervention group (5%, 3/61) indicated that they used a laptop on the floor compared to learners from the control group (21%, 14/66) at six months post-intervention. This was a favourable change in behaviour of the elarners in the intervention group.

These results set the scene in terms of measuring the effectiveness of the educational ergonomic intervention programme in changing the behaviour of learners when interacting with different forms of information technology over a period of six months. The current findings are in line with a prior study results by Schwartz and Jacobs (2002) who presented a cognitively-based, 50 minute body mechanics education program to 141 students in grades one to six. A post-test was presented four weeks after the program to test for long-term knowledge retention which they asserted was necessary for changes in behaviour. They found the retention of knowledge was positive, however, their teaching technique involving active hands-on learning and practical learning tasks in the educational programme was found to be the most significant in improving recall in elementary school children. Schwartz and Jacobs (2002) further asserted that although long-term learning is essential for changes in behaviour to occur, the efficacy of the educational program would be best measured by a change in performance, for example, postural positioning and interaction with different forms of IT, rather than knowledge retention. The findings in this current study relating to the intervention group support this concept of change of behaviour in terms of positioning and body mechanics, which suggests that the 45 minute participatory ergonomic intervention program was effective.

Psychosocial risk factors have also been found to be a significant risk factor for developing musculoskeletal pain in children using computers. This current study is the first to incorporate a measure of pain catastrophising amongst the learner sample as part of the assessment of the effect of an ergonomic intervention programme and will be discussed.

2. **Psychosocial Risk Factor – Pain Catastrophising in Children**

This study found the total pain catastrophising scores (TPCS-C) for the total sample of learners to be an average of 25.12 (Mean=25.12, SD=8.1). A TPCS-C score of 30 refers to 75 percentile and is clinically relevant in terms of predicting the risk for developing chronic pain. Over twenty six percent (26.8%) scored in the clinically significant range for pain catastrophising. Logistic regression analysis was done to determine if TPCS-C in the total learner sample at baseline was a risk factor for developing musculoskeletal pain. A total pain catastrophising score (TPCS-C) of greater than or equal to 30 was used for the logistic regression as this is the score that is deemed clinically significant as a risk factor for developing chronic pain (Sullivan et al., 1995). The TPCS-C in learners at baseline (OR=1.28, p=0.57) were not considered predictive for developing chronic pain. These findings are consistent with studies conducted with children in that pain catastrophising has been found in healthy learner samples (Bédard et al., 1997; Chambers et al., 2002; Sullivan et al., 2001) similair to this study's sample of healthy learners.

Since studies have shown that assessing for pain catastrophising in children is important, and that it is associated with heightened pain intensity and negative pain outcomes as well as with lower pain thresholds and higher levels of emotional distress, the findings from this current study are valuable when assessing the effects of a computer-related intervention programme (Vervoort et al., 2008; Crombez et al., 2003; Kashikar-Zuck et al., 2001) as it may impact on the outcome of the intervention programme.

3. **Posture**

In this section, postural positions of the learner sample will be discussed first and then posture as a risk factor will be discussed.

One of the essential components of this study was the use of the RULA assessment tool to measure the learners' posture while working at a computer workstation at school. The RULA results at baseline showed that none of the learners' postures were in an acceptable range while working at a computer. Most of the learners (42%) were found to be in AL 2; 22% in AL 3; and 31.5 % in AL 4. This is a concern, as a high percentage of learners were found in AL4 (31.5%) which indicates that they are in a vulnerable postural position for increasing the risk of developing musculoskeletal pain and urgent attention is needed to change their situation.

Only 4.7%of the learners adopted a posture to qualify for action level 1 (AL1) amongst the total learner sample. These results are similar to those found in the study by Breen et al. (2007) in terms of the percentage of learners in AL 2 however, there was a greater number of learners in AL 4 in this study compared to those in the study by Breen et al. (2007). In contrast, in the study by Dockrell et al. (2010b) on the effects of a school ergonomic intervention on children using computers, the majority of the children at pre-intervention stage were in AL 3 and only 10% were in AL 2. This suggests that a larger percentage of learners from the schools in this study sit in poor postural positions compared to the learners in the Breen et al's and Dockrell et al's studies.

Grand score RULA (OR=0.8, p=0.2) and the RULA final neck/trunk/leg scores (OR=0.84, p=0.07) were not found to be associated with the development of pain while working on a computer when a logistic regression analysis was undertaken. However, the RULA final wrist/arm (OR=8.33, p=0.01) positions of the learners at baseline were predictive of musculoskeletal pain. An incremental RULA score indicates the learners' wrist and arm positions are not in a neutral position when using the computer and this puts them at a higher risk for developing musculoskeletal pain while using a computer, which is consistent with international findings (Breen et al., 2007; Straker et al., 2009a; Kelly et al., 2009; Dockrell et al., 2010a).

These findings are in contrast to those found in a study by Ismail et al. (2010) which found no significant relationship between incremental RULA scores and musculoskeletal pain while working on a computer in their learner sample. However, our sample comprised 127 learners and powered to 80% compared to Ismail et al’s study which only assessed a few learners with RULA rather than all the learner participants. These findings show a variation in the relationship between postural positions and the development of musculoskeletal pain while working on a computer. Furthermore, they highlight the need for educating learners on their wrist/arm positions when using a computer.

In addition to considering risk factors associated with computer use, pain catastrophising and posture, studies have shown that the ergonomics of a school environment are also a risk factor for developing musculoskeletal pain in children using computers (Louw et al., 2007; Harris and Straker, 2000). Other contributing risk factors may have been carrying heavy schoolbags, playing sport and writing at a desk.

6.5 ERGONOMICS OF THE SCHOOL ENVIRONMENT

6.5.1 Design of the Computer Workstations in the Control and Intervention Schools

The results of this study found that the control and intervention schools had non-standardised desks and chairs, in that they were of different varieties, rather than one variety, for use in the computer laboratories. Straker et al. (2001) found that a desk height of 700mm was optimal for providing a work surface close to sitting elbow height and thus reducing the need of the learner to flex and abduct the shoulder. The space on the desk for the computers in the intervention school was compromised and the computers were outdated. In contrast, the control school had desktop computers with separate monitors.

These findings relating to the computer workstations are a concern as they can predispose the learners to the risk of developing musculoskeletal pain while using a computer. Only the control school had computer laboratories with air conditioners, which can have implications on the learners in the intervention school as the computer laboratories can get very hot in the summer months in South Africa. Overheating of the computer environment can cause fatigue and discomfort amongst the learners and affect their sitting posture. The noise level of the intervention school computer laboratories was not well controlled which can add to a learner's stress and impact on their abilities to concentrate.

In terms of the spatial environment, both the control and intervention schools were consistent with the proposed arrangements set out by the Computer workstation design assessment criteria. These findings are similar to those in the Smith et al. (2007) study in Western Cape schools, except that the number of learners in a computer laboratory at one time exceeded 30 in the Smith et al's. (2007) study. The lack of sufficient space in computer laboratories appears to be a world-wide phenomenon according Smith et al. (2007), as similar findings were found in a study in Canadian and Australian schools by Zandvliet and Straker (2001).

The visual environments of both school laboratories scored well on the CWDA form except for the issue of controlling for glare. One of the main issues was the lack of blinds or curtains to stop glare from affecting the computer screens and in turn the learners' eyes. This can have an impact on the learners' posture as they will twist their bodies away from the source of glare, as well as impacting on their eyes and causing fatigue due to the eye strain. The work space environment demonstrated the least adherence to ergonomic guidelines set out by the CWDA criteria as the chairs were of a poor standard in both schools, computer screens were non-adjustable and the brand of computer varied from classroom to classroom. In addition, the layouts of the computer laboratories were not uniform or standard with regards to desks chairs and layout. These findings are similar to those found in the Smith et al's. (2007) and Zandvliet and Straker (2001) study in that the workspace environment was poorly arranged in terms of seating and desk equipment for learners. The workspace environment is the contributor to influencing how learners sit and interact with the computer. Thus, findings from this study with respect to the non-standardised desks and seating in the computer laboratories correlate with the poor postural positions found in the learner sample as the varied anthropometric dimensions of the learners is not supported by the poor workspace environment.

The keyboards in both school computer laboratories were placed on the desk rather than below elbow level. This encouraged an awkward sitting posture with arms flexed and shoulders abducted, thus increasing the upper trapezius activity to stabilise the shoulder position (Straker et al., 2002). This puts the learner at risk for developing neck and shoulder pain. Studies have shown that keyboard placement should be below elbow level and arms supported to reduce the risk of neck and shoulder pain and to increase comfort while using a computer (Gerr et al., 2002; Straker, 2006; Straker et al., 2006; Straker et al., 2010b).

The findings from this current study are consistent with the findings of the Smith et al's. (2007) study in the Western Cape, except that there was uniformity in the types of desks and chairs used in the computer laboratories in the Smith et al's study. Furthermore, the poor ergonomic workstation design such as incorrect desk height, non-standardised, nonadjustable plastic chair and fixed monitors found in this current study, are consistent with international studies that have found similar issues relating to desks, chairs and computers (Oates, 1998b; Zandvliet and Straker, 2001). Given the poor workspace environment and lack of possibility of ergonomic adjustment, the future of ergonomics lies in educating learners about applying ergonomic principles and modifying computer workstation set-ups as best as they can to reduce the risk of developing musculoskeletal pain.

It is not likely that computer laboratories will be designed to suit ergonomic guidelines in South Africa as the cost of this would far exceed the budgets of school governing bodies. In light of cost-effectiveness, teaching ergonomic principles to learners would seem to be a better and more cost-effective solution for reducing musculoskeletal pain related to computer use. However, for this concept to be acceptable among teachers and principals at schools, it is necessary to understand the attitude and knowledge of these stakeholders with regards to ergonomics and ergonomic training in schools.

6.5.2 Attitudes and Knowledge of Teachers and Principals at Independent Schools in Gauteng

Thirteen percent (n=3/18) of the teachers had been trained in ergonomic skills and none of the teachers were satisfied with the computer-related ergonomics at their school. Dockrell et al. (2007)'s study reported that 82.4% of teachers had indicated that they had not had any form of ergonomic training and all of the respondents said that they would like ergonomic training. All (n=18) teachers indicated that they would appreciate ergonomic training from an outside source, which is encouraging in the sense that they will support an ergonomic intervention in their schools which is essential for the successful outcome of such an intervention programme.

The above findings are consistent with international studies that have found evidence of a severe lack of knowledge about ergonomics and computer use among teachers at schools (Dockrell et al., 2007; Legg, 2007). Heyman and Dekel (2006) have successfully incorporated ergonomic training into the curriculum for physical education teachers and found that teachers are accepting of this new knowledge.

The school demographics obtained from the teacher survey, showed that the maximum number of learners at the schools varied from 350 to 840 learners. All the schools had access to computer laboratories. Only 25% of the schools indicated that they had learners using laptops in the classroom and 27% of the schools indicated that learners used iPads during a school lesson. The schools' curriculum was explored as part of the study. Forty five percent of the schools teach the international computer drivers licence (ICDL) module. The ICDL and the information technology curriculum did not deliver an ergonomic component in spite of the ICDL officially having one incorporated.

The lack of ergonomic knowledge and skills training in grade eight information technology teachers in secondary schools in the Gauteng province was therefore evident. This lack of knowledge can contribute to an increased risk for learners developing musculoskeletal pain related to computer use. The literature on teacher or student awareness of the ergonomics of computers is scarce and few studies have been conducted on awareness of health risks associated with computer use by principals and teachers in schools (Straker et al., 2010; Wilson, 1991; Dockrell et al., 2007). However, there is a growing concern of how little knowledge there is of computer ergonomics and installation in the school environment (Shehab and Al-Jarallah, 2005; Bennett, 2000). The findings from this study support the need for implementing ergonomic education in schools for both teachers and learners in South Africa.

6.6 CONCLUSION OF PHASE ONE FINDINGS

The findings from Phase one of this current study, relating to prevalence of musculoskeletal pain and pain catastrophising amongst adolescents in a school environment, and posture of learners and the associated risk factors for developing musculoskeletal pain such as computer exposure and poor sitting posture, support the need for the implementation of a computer-related ergonomics intervention programme in these schools. Learners' exposure to a computer for greater than or equal to 2.5 hours was found to be significantly associated with developing musculoskeletal pain while working on a computer. Furthermore, the ergonomic environment of the control and intervention schools, as well as the lack of ergonomic knowledge among school teachers and principals in Gauteng, highlights the need for teaching learners about correct computer-related ergonomic principles to apply in the school and home environment. A positive outcome of the teacher survey is that there is a favourable attitude towards introducing ergonomic skills training in schools for both learners and teachers.

The findings relating to determining the effects of the computer-related ergonomics intervention programme in a school environment on learners' musculoskeletal pain, pain catastrophising and postural positions while working on a computer, will be discussed in phase 2 below.

6.7 DISCUSSION OF PHASE 2: THE EFFECT OF THE COMPUTER-RELATED ERGONOMIC INTERVENTION PROGRAMME

6.7.1 Introduction

The primary aim of this study was to determine the effect of a participatory computer – related ergonomic intervention programme on adolescents in a school environment. The secondary aims were to determine the effects of the designed intervention programme on variables of pain, pain catastrophising and postural changes. The between group analysis revealed that the number of learners who experienced pain did not show significant differences over the six month study period, however, a specific component of the experience of pain, namely pain catastrophising and elements thereof and posture of learners (RULA) while working on a computer did have significant results. Each of these results will be discussed. These three variables, pain, pain catastrophising and posture were measured and reported on at baseline to determine prevalence and risk factors and have been reported on in the first section of this chapter.

On establishing the prevalence of pain and the posture of learners while working on a computer in the control and intervention groups, the aim of the study was to determine the effects of the ergonomic and education intervention programme on pain, pain catastrophising and posture. Findings would therefore shed light on whether an intervention programme could influence these outcomes and the range of modifiable risk factors established as significantly associated with pain in adolescents. The results may contribute to designing appropriate programmes for inclusion into the school curriculum.
Firstly the sample used in this research consisted of 60% (76/127) male learners and 40% (51/127) female learners in grade eight with an average age of 13.4 years. The ratio of male to female learners in this study is similar to those in other ergonomic intervention studies (Shinn et al., 2002; Jacobs et al., 2006; Saarni et al., 2009; Ismail et al., 2009; Robbins, 2009; Dockrell et al., 2010).The majority of the studies cited above used younger learners with an average age of 8-12 years compared to this study where the focus was on the adolescent age group because of the tendency for spinal growth spurts and the impact that awkward sitting posture while using a computer has on an adolescent spine.

The majority of the learners were within a normal BMI range, except for 25% (n=9/61) of the male learners in the intervention group who were overweight. The mean weight of learners in the control group from baseline to six months reduced from 53kg ± 12.13kg to 49.26kg ± 22.86kg and their schoolbag weight from 6.80kg ± 2.48 to 6.71kg ± 5.97. The mean weight of the learners' schoolbags in relation to their body weight was optimal from baseline over a period of six months. The ideal schoolbag weight taught as part of the ergonomic intervention programme was a weight not greater than 10% of the learner's bodyweight. In the intervention group, the mean weight of the learners reduced from 56.03kg ±13.76 to 47.21kg ± 27.72 and their schoolbag weight reduced from a mean of 7.07kg ± 1.99 to 5.4kg ± 3.62kg. This reduction in schoolbag weight amongst the learners in the intervention group may be the result of the ergonomic intervention programme, as education regarding correct schoolbag weight was taught as part of the programme.

The mean schoolbag weight found in this study compared to other studies is higher, in that the mean schoolbag weight in the study by Ismail et al. (2010) was 4.3kg and 4.8kg amongst 2nd and 5th grade learners in Malaysia; and in a study by Whittfield et al. (2005) the mean schoolbag weight of learners was found to be 6.6kg. The higher schoolbag weight could be attributed to the fact that the learners in this study seldom made use of the locker facilities available at the school. Schoolbag weights which exceed 10% of the learners' bodyweight has been found to increase the risk for developing musculoskeletal pain among schoolchildren and therefore it is essential to include schoolbag weight issues as part of ergonomic intervention programmes (Sheir-Neiss et al., 2003; Whittfield et al., 2005).

The majority of the learners from the control group and the intervention group, 62.1% and 60.7% respectively, indicated that they had been using computers for five years. This is an important consideration as it indicates that the sample is consistent with a high degree of computer exposure in both the control and intervention groups as well as being consistent with international studies and local studies. Studies by Jacobs and Baker, (2002), Harris et al., (2005), Hakala et al.,(2006) Smith et al., (2007), Prins et al., (2008), Dockrell et al.,(2007), Harris et al., (2010) and Straker et al., (2013) have found there to be an association between the number of hours of computer use and musculoskeletal discomfort.

A large epidemiological study by Hakala et al. (2006) found that 2-3hours of computer use per week was a significant risk factor for developing neck/shoulder and lower back pain. Only 24% (32/127) of learners in this study used the computer for ≥ 2.5hrs per week at school and the majority, 89% (113/127) of the learners used a home computer on average for 1.7hrs per week. The trend of computer exposure being predominantly home based is similar to international studies by Hakala et al. (2006), Harris et al. (2010) and Straker et al. (2013), but not local studies such as studies by Smith et al. (2007) and Prins et al. (2008) where computer exposure was found to be greater at school due to socioeconomic reasons and the lack of accessibility to computers at home in the pooper areas of the Western Cape where the studies were both conducted.

The exposure to computer use by learners in this present study are slightly higher than those of local studies by Smith et al. (2007) and Prins et al. (2008), but similar to studies conducted in highly resourced countries, for example, the average number of hours spent on a computer at school was 2.4 hours per week compared to the Smith et al. (2007) study which indicated that learners in the computer group spent an average of 1.55 hours using the school computer per week. The majority of learners, 62.1% from the control group, used a computer twice a week at school compared to 31.1% of learners from the intervention group; and only a small percentage of learners, 10.6% from the control group compared to 32.8% of learners from the intervention group, used a computer three times a week at school. An increase in the number of hours of computer exposure per week has been shown to be associated with an increase in the number of body areas affected by pain (Zapata et al., 2006; Smith et al., 2007).

A larger percentage of learners in the control group at baseline used desktop computers (82%, 54/66) compared to learners in the intervention group (52%, n=32/61). However, a larger percentage of learners from the intervention group at baseline used a laptop (41%, n=25/61) compared to learners in the control group (15%, n=10/66). This may have implications for the number of learners experiencing musculoskeletal pain between the two groups at baseline as 42.6% (n=26/61) of learners in the intervention group experienced pain while working on a computer compared to 25.8% (n=17/66) of learners in the control group. Furthermore, 18.6% (n=11.3/61) of learners in the intervention group experienced lower back pain at baseline which may be influenced by the fact that there were more learners using laptops at baseline and their posture may have increased their risk for developing lower back pain compared to the learners in the control group. The reported pain intensity for headaches and neck pain was high (10/10) for learners in the intervention group at baseline which could also be attributed to the increased lower cervical flexion and upper trapezius muscle activity which is associated with laptop use (Greig et al., 2005; Straker et al., 2006)

6.7.2 The Effect of the Intervention on Musculoskeletal Pain

Results showed a significant difference in the number of learners with pain at baseline. The between-group findings at three and six months showed there to be no statistically significant differences in musculoskeletal pain while working on computers, however, there was a reduction in musculoskeletal pain within the intervention group over the 6 month study period. These results show of a trend towards a reduction in pain post-intervention but not a significant difference in pre-post-test results for musculoskeletal pain between the control and intervention groups. This may be attributed to bias introduced by cluster randomisation and the Hawthorne effect.

Similar results were found from interventions studies by Linton et al. (1994), Cardon et al. (2004), Robbins et al. (2009), Dockrell et al. (2009), Ismail et al. 92010) and Dolphen et al. (2011), where the emphasis was on school-based educational intervention programmes with control and intervention groups as opposed to pure ergonomic furniture interventions alone. The improvement in postural sitting behaviour was found to be the most probable reason for the trend in reducing the prevalence of pain amongst school children in the intervention group in these studies.

A study by Ismail et al. (2010) included two intervention groups, one that received ergonomically designed furniture and ergonomic education, and another that received postural education only. A control group was also used which strengthened the rigour of the study. They found that ergonomically designed furniture in addition to ergonomic education, improved postural scores and comfort amongst the learners, thus supporting the evidence that improvements in the prevalence of pain amongst school children using computers has to include postural education. A study by Dolphen et al. (2011) further supports the trend of reducing pain prevalence amongst learners who have undergone an educational intervention programme relating to posture and back care in this current study and the studies above. Their study measured the long-term effectiveness of a 6-week back education programme among 9-11 year old school children into young adulthood and found that over the 8 year assessment period, the pain prevalence rates were increased in the control group compared to the intervention group (an increase of 22.4% vs. 19.8% over the 8-year time period, respectively) even though there was no statistically significant difference found between the two groups.

Between group results for the experience of musculoskeletal pain showed no differences in this study, however, some interesting results emerged from the within group analysis. The direction of change in terms of the pain experience of learners presented a picture that the author felt had clinical significance. At baseline the learners in the intervention group were more likely to develop pain while working on a computer (OR=2.14) compared to the control group. However, the learners in the intervention group were less likely to develop pain while working on a computer after six months (OR=0.68), indicating the clinical effect of the ergonomic intervention programme.

In addition, using a test of proportions to determine movement within the variable tested namely, musculoskeletal pain while working on a computer (Table 5.22). Within group changes showed that the intervention had a clinical effect over a period of six months as there was a shift of participants within the intervention group from those experiencing pain to no pain between baseline and six months (OR=4.75, p<0.01) compared to the control group (OR=1.16, p=1). The implication is that the computer-related ergonomics intervention programme had a positive sustained effect on reducing musculoskeletal pain while working on a computer as out of those experiencing pain, seven participants shifted to experiencing no pain.

The mechanisms that could have influenced this shift in movement in the intervention group could be due biomechanical, cognitive, behavioural or psychological factors. According to the Child-specific model developed by Harris et al. (2010), children's unique characteristic such as age, gender, computer exposure, TV exposure and psychological factors are essential for understanding the causal mechanisms involved with exposure to computers. The increased knowledge of the learners in terms of applying ergonomic principles (cognitive ability), improved their postural behaviour and being more aware of their postural positions (biomechanical) when working on a computer, as well as feeling in more control relating to their experience of pain (pain catastrophising) are possible factors influenced by this educational ergonomic intervention programme.

These results are further supported by studies by, Linton et al. (1994), Geldof et al. (2006), Dockrell et al. (2010) and Dolphen et al. (2011) where a reduction in pain (clinical effect) was found amongst the participants in the intervention group. Educating adolescent learners in healthy computer skills as a preventive health promotion strategy for reducing the risk of musculoskeletal pain and poor postural habits has been well documented in the literature (Dockrell et al., 2010b; Ismail et al., 2010; Heyman and Dekel, 2009).

According to previous research by Mikkelsson et al. (1997) and Peterson et al. (2006) children may experience musculoskeletal pain in more than one body area (Mikkelsson et al., 1997; Petersen et al., 2006). In both the control and intervention groups, musculoskeletal symptoms in the shoulder area were most prevalent. The results indicated that more than one body area was affected by pain in some of the learners. In the intervention group at baseline, 21.5% of the learners had experienced musculoskeletal symptoms in their right shoulder, 18.6% in their lower back, 16.8% in their left shoulder, 15% in their neck and 9.3% in their upper-mid back area. At six months, right shoulder pain was found to be the most prevalent area of pain amongst learners in both the control and intervention groups, with 24.3% and 21.5% respectively, where as 19.3% of learners in the control group reported left shoulder pain compared to 16.8% of learners in the intervention group. The percentage of learners with lower back pain at six months in the intervention group was slightly higher than that reported at baseline (18.7% and 18.6% respectively) and the percentage of learners with neck pain remained the same at 15% for both the control and intervention groups.

The impact of unequal loads on muscle tissue caused by sustained awkward sitting postures of adults and children using computers has been well researched and the resulting pain syndromes are multifactorial in origin (Kumar, 2001; Bongers et al., 2006; Hakala et al., 2006; Harris et al., 2012). In this sample of learners, it was a common occurrence to see learners sitting with their shoulder flexed and abducted when using the mouse as a result of the computer workstation being at the incorrect height for the learners' anthropometrics. This resulted in increased activity in the Upper Trapezius muscles, Levator Scapulae, Scalene and Sub-occipital muscles causing pain and discomfort in the neck and shoulder complex (Greig et al., 2005; Straker et al., 2006; Straker et al., 2009).

These findings suggest that the ergonomic intervention did not have an effect on the distribution of pain per body area over a period of six months. This may be attributed to the fact that pain intensity levels were low and the amount of computer exposure per week was also low. The prevalence of shoulder pain and lower back pain could be as a result of sitting in an awkward position, usually with the dominant shoulder raised and the trunk laterally flexed. These postural positions were often seen during the RULA observation analysis. These findings are similar to those of studies done by Hakala et al.

(2006), Gillespie et al. (2006), Dockrell et al. (2010) and Ismail et al. (2010) who reported a high prevalence of shoulder, neck and lower back pain. The current study's findings support the child-specific model cited by Harris et al. (2010) whereby individual (genetics, gender, age, BMI), psychosocial (anxiety, socioeconomic status) and computer exposure directly and indirectly affect the potential of learners to develop musculoskeletal pain in the school environment.

Pain intensity per body area between the control and intervention groups over a period of six months was also explored. There were significant differences in pain intensity for the neck ($p<0.01$), upper back ($p=0.04$), lower back ($p<0.01$) and the left elbow ($p=0.04$) at baseline between the control and intervention groups. At six months there were no significant differences in pain intensity per body area between the two groups. The intervention programme therefore had no effect on the level of pain intensity experienced by the learners in the intervention group.

These findings are similar to those obtained by Dockrell et al. (2010) in that body discomfort improved after the ergonomic intervention, but there was no significant difference between the pre and post-intervention scores. This could be attributed to measuring pain intensity by self-report methods (Gillespie et al. 2006), which may not always be truly accurate as each individual may perceive their pain differently and the results of the mean total pain catastrophising scores amongst the two groups were found to be below a clinically significant level, which could further influence the fact that pain intensity was not found to be significantly high amongst the learner sample. In addition, a difference of pain intensity of 1.5 on the numerical pain rating scale was set for comparison to establish if the change in pain intensity per body area over a period of six months was significant.

Linton et al. (1994) and Dockrell et al. (2010) are some of the few school-based ergonomic intervention studies that used the visual analogue scale to measure reported pain intensity as part of their objective outcomes. Only Dockrell et al. (2010) commented on actual reported pain intensity and the maximum and minimum range, which was zero to five (0-5). In comparison to the Dockrell study, this current study's range of pain intensity was much higher for certain body areas, for example the range of reported pain intensity for shoulder pain was zero to nine (0-9) for learners in the intervention group.

Most ergonomic intervention studies have used the “body discomfort chart” to assess pain using a scale of mild, moderate or severe pain rather than an actual pain intensity score.

Understanding which body areas are affected and the intensity of pain experienced by learners may help to define ergonomic effects. Further studies on posture and movement analysis may be carried out to inform intervention programmes with evidence needed to support the implementation of future ergonomic studies in the school environment.

6.7.3 The Effect of the Intervention on Pain Catastrophising in School Children

This study found the total pain catastrophising scores (TPCS-C) for the total sample of learners to be an average of 25.12 (Mean=25.12, ±8.1). In comparison to findings by Crombez et al. (2003), in their study of 818 healthy Flemish school children, the pain catastrophising scores for their learner sample was much lower (M=16.79, ±8.78) than in this current study (M=25.12, ±8.1). Similarly, a study by Vervoort et al. (2008), found the mean pain catastrophising scores in the healthy learner sample of adolescents (n=193) and the clinical sample with chronic and recurrent pain (n=61) to be M=12.24 (±7.55) and M=16.34(±10.31) respectively, which are lower than the mean pain catastrophising scores in this current study.

The reason for this difference in levels of pain catastrophising from other studies using similar healthy learner samples may be attributed to different perceptions of the threat value of pain, cultural differences in the experience of pain, or different levels of anxiety and coping mechanisms relating to eliciting social support and empathy (Bédard et al., 1997). Parenting and different attachment styles of children can also influence their level of pain catastrophising (Tremblay and Sullivan, 2007). A TPCS-C score > 30 refers to 75 percentile and is clinically relevant in terms of predicting the risk for developing chronic pain. Over twenty six percent (26.8%) of the learners in this study scored in the clinically significant range for pain catastrophising, even though they were from a healthy learner sample. However, the TPCS-C scores amongst learners at baseline (OR=1.28, p=0.57) were not considered predictive for developing chronic pain. This finding is consistent with three other studies conducted with children from healthy learner samples (Bédard et al., 1997; Chambers et al., 2002; Sullivan et al., 2001).

Studies have shown that assessing for pain catastrophising in children is important and that it is associated with heightened pain intensity and negative pain outcomes as well as with lower pain thresholds and higher levels of emotional distress (Kashikar-Zuck et al., 2001; Crombez et al., 2003; Vervoort et al., 2008).The findings from this current study are valuable when assessing the effects of a computer-related intervention programme as it may impact on the outcome of the intervention programme.

Key findings resulting from the between group analysis of pain catastrophising did not show a significant difference in the scores between baseline and six months. However, the mean difference of the TPCS-C scores from baseline to six months between the two groups showed an increase from -2.51-0.84, which may be attributed to a clinical effect from the intervention programme (Figure 5.3 Box-Whisker plot TPCS-C). The within-group analysis showed a significant decrease in the TPCS-C score from baseline over a period of six months within each group ($p=0.02$ control and $p<0.01$ intervention). This decrease in the TPCS-C could be attributed to the presence and attention of the researcher over the time period may have influenced how the learners felt with regards to their experience of pain. They may have felt that someone had empathy for their pain and thus felt more supported (Tremblay and Sullivan, 2007; Chambers et al., 2002). This will be further explored when the results of the three constructs of pain catastrophising are discussed.

The mean TPCS-C scores for the control and intervention groups at baseline were below 30, 23.9 and 26.4 respectively. Thus, with the average scores of both groups being below 30, pain catastrophising in this sample of learners was not deemed a high risk factor for developing musculoskeletal pain. There have been no studies thus far that the author is aware of that have investigated the effect of an ergonomic school intervention on pain catastrophising levels amongst school children. Geldof and Cardon et al. (2007) and Dolphens et al. (2011) used the fear-avoidance belief questionnaire to measure this psychological determinant which could affect the behavioural outcome of learners participating in a spinal care intervention program. The researchers found fear-avoidance beliefs of the learners did not affect the impact of the spinal care intervention (Geldhof et al., 2007a; Dolphens et al., 2011).

Pain catastrophising is a multidimensional construct comprising elements of magnification, rumination and helplessness. For the purposes of this study, it was important to understand which aspect of pain catastrophising may be affected by the intervention as pain can interfere with learning, physical activity and social activity (Vervoort et al., 2008).

The intervention group showed a higher tendency for rumination (a constant focus on the threat value of pain) than in the control group. There was a significant difference ($p<0.01$) in the mean rumination score at three months ($p<0.04$) between the control and intervention groups. After six months post-intervention, there was no significant difference between the two groups with regards to the mean rumination scores. However, a reduction was noted in the rumination scores of the intervention group. This could be attributed to a clinical effect from the intervention programme as the learners may have been distracted by the contents and application of the ergonomic intervention programme and less focussed on their pain (Eccleston and Crombez, 1999). This clinical effect was established using a test of proportions (McNemar's) for the within group analysis, which demonstrated a trend/shift in a direction indicating that there was a clincal effect irrespective of there being no statistically significant effect.

The average magnification scores in the control and intervention group at baseline were significantly different ($p<0.00$) with mean scores of 4.79 and 5.72 respectively at baseline. These differences at baseline depict the limitation of cluster randomised sampling, which leads to the skewness of the baseline results. This was adjusted for using propensity of score matching for the total pain catastrophising score (TPCS-C). The intervention group showed a clinically significant average score of 5.72 for magnification at baseline. This score is above the 75 percentile, which is a magnification of five, thus indicating that the learners in the intervention group were at a high risk for developing chronic pain (Sullivan et al., 1995).

At six months, there was no significant difference between the control and intervention groups as the average scores of magnification were 4.39 and 4.34 respectively ($p=0.12$). However, the average score of magnification within the intervention group showed a significant change ($p<0.01$) over a period of six months from an average score of 5.72 at baseline, to an average score of 4.34 after six months, dropping the level of magnification to below a clinically significant level. This could be attributed to the clinical effect of the intervention, in that the threat value of pain was no longer magnified by the learners as it was at baseline prior to the intervention.

In terms of the average scores of helplessness between the control and intervention groups, both groups scored below the 75th percentile for helplessness (score=13), with the control group scoring an average of 10.17 and the intervention group scoring an average of 9.82 at baseline, and was not statistically significant (p=0.6).

There are no intervention studies to the author's knowledge that compare catastrophising constructs as part of the measurement of the effect of an intervention programme, hence no comparisons can be made. There was a significant difference at three months (p=0.03) between the control (8.48) and intervention (9.80) groups. After a period of six months, both the average scores for helplessness for the control and intervention groups had decreased to 7.8 and 7.31 respectively, and there was no significant difference between the two groups (p=0.5).

Certain aspects of the intervention programme which could have resulted in the learners from the intervention group developing better coping strategies and feeling more in control of their pain, hence the lower helplessness scores over the six month period, could be attributed to the stretch exercises given to the learners in the form of a stretch card and the classroom posters showing correct workstation set-up. In addition to these reinforcement tools, the learners were given access to an ergonomic website as a further support tool with demonstrations of correct workstation set-up, muscle stretches and a stretch reminder notification. These aspects of the intervention programme as well as the increased postural awareness amongst learners and their knowledge of ergonomic principles for adjusting a workstation could further enhance their coping abilities and self-efficacy when dealing with pain and thus reduce their sense of helplessness.

The reduction in helplessness scores amongst learners from the control group could be attributed to the consistent presence of the researcher over the study period. This presence could be viewed as a form of attention and support for the learners in the control group, thus enhancing their sense of ability to cope with their pain. Another aspect which may lend itself to improving a learners sense of control and in doing so reducing the effect of feeling helpless, is the conscious awareness that the learner gains from completing the pain catastrophising questionnaire and computer usage questionnaire. This awareness may instil the sense that the learner has more control over his/her pain and that they feel more supported by the researcher in terms of their ability to cope with their pain experience.

Helplessness has been related to secondary appraisal processes where the individuals negatively evaluate their ability to effectively deal with the threat of the pain or painful stimuli (Lazarus and Folkman, 1984; Sullivan et al., 2001). The results from this current study suggest that the intervention programme may have enhanced the learners' ability to effectively deal with their experience of musculoskeletal pain associated with computer use. This demonstrates the value that intervention programs in schools can have in terms of providing learners with better coping mechanisms to manage their pain and in turn this modifies their behaviour and pain expression in the long term.

Dolphens et al. (2011) in their study on the long-term effectiveness of a 6-week back education programme among 9-11 year old school children into young adulthood, investigated self-efficacy (the confidence to successfully change behaviour) as a psychological determinant for attaining sustained health behaviours. They make reference to the fact that self-efficacy is known to affect both the initiation and continuation of health behaviour and they found that the intervention programme did not have an effect on self-efficacy over time (Dolphens et al., 2011).

All three constructs of pain catastrophising in both the control and intervention groups improved over a period of time. This could be attributed to the learners being exposed to the researcher over a prolonged period of time and in doing so their fears relating to musculoskeletal pain and the threat value of pain while working at a computer may have been curtailed as they felt that they were being supported in some way. It could further be surmised that the social context of the school environment by supporting the research process gave the learner participants confidence that they could express their pain without feeling vulnerable and also reason to justify and explain their pain (Eccleston and Crombez, 1999; Sullivan et al., 2001).

No current studies that have looked at the effect of an ergonomic intervention on pain catastrophising levels amongst adolescents in a school environment could be found. Many studies have found strong evidence of psychosocial risk factors such as stress, depression and anxiety as having an effect on the intensity and prevalence of musculoskeletal pain in adolescents (Watson et al., 2002; Jones et al., 2003; Gillespie, 2006; Vervoort et al., 2008).

These findings are different to the findings in the current study, in that pain catastrophising was not found to be associated with the prevalence of pain or pain intensity amongst this learner sample. Furthermore, the pain catastrophising levels did not have a negative impact on the current intervention study. A study by Smith et al. (2007) supports the findings of this current study in that they found that underlying psychosocial issues had no impact or association with the prevalence or intensity of musculoskeletal pain amongst adolescents in the school environment in the Western Cape. The use of the PCS-C tool has been of great value as it provides a foundation for further research in the area of pain expression and behaviour in learners, which if understood and managed may reduce the risk of learners developing chronic pain and disability pain in the long term.

6.7.4 The Effect of the Intervention Programme on Posture

The high number of learners found in poor postural positions while working on a computer in this current study may be attributed to the longer time (1 hour) spent on the computer during the computer lesson compared to the primary school learners (20 minute lesson) in the Breen et al. (2007) and Dockrell et al. (2010) studies that spent less than an hour in a computer lesson. Furthermore the anthropometric mismatch between learners and their computer workstations in this current study may be greater, as well as the effect of different pedagogical cultures worldwide (Geldhof et al., 2007b) on learners’ posture in the classroom, which could encourage poor postures while working at the computer.

The benefits of maintaining a good posture early on in childhood and adolescence, and being aware of the effects of sedentary sitting behaviour when working on a computer has been well documented (Grimmer and Williams, 2000; Cardon and Balague, 2004; Straker et al., 2002, 2005, 2010). Straker et al. (2010) stresses the importance of encouraging learners to change their position regularly during computer use in order to reduce the strain on the adolescent musculoskeletal system.

In the study by Dockrell et al. (2010b) on the effects of a school ergonomic intervention on children using computers, the majority of the children at pre-intervention stage were in AL 3 and only 10% were in AL 2. Post intervention there was a significant shift in the RULA scores such that 91% of the children had shifted to AL 2. Similarly, in the Syawan et al. (2011) study, learners in the intervention group (n=78) were found to have shifted from AL 4 to AL3 and the learners in the control group were found to have a worse posture at the follow-up assessment. These findings are similar to the current study in that there was a shift in the number of learners in the intervention group who moved from AL 4 to AL 2(n=55.7%) and AL 3(n=14.8%) after six months post- intervention. There were no learners in AL 4 in the intervention group at six months. These results show that the ergonomic intervention had an effect on the learners' postural positions and that over time the learners had changed their sitting behaviour when using a computer. In addition, the findings support the hypothesis that ergonomic intervention programmes can modify the risk of developing poor postures and subsequently musculoskeletal pain associated with computer use. This change in postural behaviour could account for the decrease in the number of learners (n=18%) in the intervention group experiencing pain related to computer use at six months post intervention compared to baseline data (n=42.6%).

Learners in the control group in AL 4, an 'unacceptable postural range' was slightly less (n=31.8%) after six months compared to pre-intervention stage (n=36.4%).These results could be the reason for there being no significant change in the number of learners in the control group experiencing pain while working on a computer from baseline (n=25.8%) to six months (n=24.2%).

The between group analysis for the final wrist/arm RULA scores showed that there was a significant difference ($p=0.03$) between the final wrist/arm scores (RULA) at baseline and six months ($p<0.01$) post intervention between the control and intervention group. As mentioned previously between-group differences at baseline may be due to the limitation of cluster randomised sampling.

To counter this methodological limitation, propensity score matching was done to account for the differences between the groups and a similar result was found with a significant difference ($p<0.010$) after six months post-intervention. The improvement in the wrist/arm RULA scores amongst the learners in the intervention group from a mean score of 4.5 at baseline to 3.0 at six months indicates that the ergonomic intervention had an effect on the learner's behaviour with regard to their wrist/arm positioning when using a computer. These results are supported by findings from the Dockrell et al. (2010) study, whereby the upper limb RULA score (mean wrist/arm RULA score) pre-intervention was 4.8 and 3.8 post intervention thus indicating that the educational intervention had a significant effect ($p<0.010$) on reducing poor posture as an ergonomic risk factor amongst school children using computers.

The within-group analysis showed that both the control and intervention groups had significant changes in wrist/arm scores (RULA) between baseline and three months ($p<0.011$) and baseline and six months ($p<0.012$ and $p<0.011$ respectively). The change in the learners' wrist/arm position in the control group could be attributed to the influence of the presence of the researcher, known as the Hawthorne effect (Gale, 2004).

The between-group analysis for the final neck/trunk/leg RULA scores at baseline and six months post-intervention were found to be significantly different ($p=0.03$ and $p<0.01$ respectively) between the two groups. After propensity score matching was done to account for the difference in the baseline data a significant difference was found at six months post-intervention ($p<0.010$). This finding supports the RULA final neck/trunk/leg scores in this current study in that a similar significant difference ($p<0.01$) in scores was found after six months in the original sample ($n=61$). This indicates that the intervention had an effect on the upper body and neck position of the learners in the intervention group. These findings are similar to the reduction in the neck/trunk/leg RULA scores post-intervention in the Dockrell et al. (2010) study. They found a significant reduction in the mean RULA scores pre-intervention (mean=5.7) compared to the mean RULA score (mean=3.9) post – intervention.

Furthermore, within-group analysis showed a significant difference within both the control and intervention groups' final neck/trunk/leg RULA scores between baseline and six months ($p<0.012$ and $p<0.011$ respectively). This suggests that the learners' posture relating to their upper body, in both the groups improved over the study period; however, the final neck/trunk/leg RULA scores for the intervention group (4.5 at baseline to 3.0 at six months) were significantly better than those of the control group (5.1 at baseline to 4.4 at six months) which could be attributed to the clinical effect of the intervention programme.

These findings of RULA Action levels and RULA scores (final arm/wrist and neck/trunk/leg) support an interpretation that the intervention had a positive and sustained effect on the posture of learners over a period of six months. This suggests that the reinforcements from the intervention used during the course of the six months assisted in facilitating a change in the postural behaviour of the learners and reducing the ergonomic risk for developing musculoskeletal pain when using a computer.

The ergonomic intervention studies by Dockrell et al, Ismail et al and Syazwan et al, all implemented a similar type of educational ergonomic intervention programme to this current study, with visual and graphic aids, problem solving strategies for adjusting workstations and stretch exercises. The results reported are consistent to this study for learners in a school environment in that they reported better RULA measurements (Oates et al., 1998; Breen et al., 2007; Dockrell et al., 2010a; Ismail et al., 2010; Syazwan et al., 2011).

In addition to the positive effect of the intervention on the postural behaviour of the learners in this current study, the intervention had a positive effect on encouraging learners to reduce their schoolbag weight over the six month study period. This was noted when learners' schoolbag weight measured at baseline reduced from a mean=7.1kg to 5.4Kg measured at six months post intervention. Similarly, fewer learners from the intervention group (n=5%) spent time using their laptop on the floor after the six month study period compared to the number of learners in the control group (n=21%), thus indicating that intervention had a positive effect on changing the ergonomic behaviour of learners when using a laptop.

6.8 CONCLUSION

The findings from phase two of this study measuring the effects of the computer-related ergonomic intervention programme indicated that the ergonomic intervention programme did not have a significant effect on the prevalence of musculoskeletal pain related to computer use, however, a clinical effect was particularly evident in the intervention groups as a decreasing trend was observed in the number of grade eight learners experiencing pain while working on a computer in a school environment._Similarly, a clinical effect of the intervention programme was observed with the decreasing trend in the pain catastrophising constructs of rumination, magnification and helplessness over the study period of six months. This shows that pain catastrophising amongst learners in this current study did not have a negative effect on the results of the intervention programme. This finding further suggests that an educational ergonomic intervention can modify the perceived threat value of pain by learners and provide them with better coping strategies to reduce their fear of pain in the future, thus reducing the potential of the learners for developing chronic pain and disability in the long-term.

A positive intervention effect was found in terms of modifying the postural and ergonomic behaviour of the learners over a period of six months and thus reducing the ergonomic risk of these learners in a school environment. These clinical and positive effects of this computer related ergonomic intervention programme helps to validate this intervention programme for grade eight learners.

In conclusion, this study's findings demonstrate the importance of an ergonomic intervention programme in a school environment whose effects can be sustainable over a period of six months. It is important that preventive interventions for potential risk factors impacting on the development of musculoskeletal pain should be implemented in a sustainable and cost-effective manner in school environments. Furthermore, the findings from this randomised control trial support the positive outcomes that an effective intervention can have on reducing the development or risk of poor postural and ergonomic behaviour amongst learners exposed to computer use in a school environment.

CHAPTER 7

7. CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

This chapter will discuss the conclusions relating to the current study, as well as the limitations, implication of the findings and recommendations for future research.

7.1 CONCLUSIONS

The prevalence rate of 77.2% for musculoskeletal pain in this learner sample comprising adolescents in grade eight at two secondary schools is high in comparison to local and international studies conducted over the past few years. The prevalence rate of musculoskeletal pain while working on a computer in the intervention group reduced significantly ($p<0.000$) from 42.6% to 18% over a period of six months compared to no statistically significant difference in the control group ($p<0.39$). This suggests that the computer-related ergonomic intervention programme had an effect on musculoskeletal pain in learners in the intervention group. After six months of an ergonomic and education intervention, there was no significant difference in pain prevalence ($p<0.524$) between the control and intervention groups.

With regards to posture, none of the learners from this study adopted a posture to qualify for action level 1 (AL 1), which is a posture that is acceptable if maintained, in either the control or intervention groups. The majority of learners from both groups (40.9% control and 42.6% intervention) were found to be in AL 2 and AL 4 (36.4% for the control and 26.2% for the intervention group) which meant that they were in moderate to high risk postural positions for developing musculoskeletal pain, and investigation and change was essential. A large percentage of learners from the schools in this study were found to sit in awkward postural positions that could put them at risk for developing musculoskeletal pain. These findings are consistent with other studies conducted in Ireland, Australia, the United States of America, Israel and Taiwan to name a few, relating to posture in adolescents. In this current study there was a significant improvement in the number of learners in the intervention group who improved from AL 4 to AL 2 and AL 3. At six months post-intervention, there were no learners in AL 4 and the number of learners in AL 3 had reduced from 26.2% at baseline to 14.8% ($p<0.010$)

at six months. Therefore, this intervention had the effect of reducing ergonomic risk amongst learners in a school environment.

The ergonomic environment in school computer laboratories, assessed in the control and intervention schools as part of this study, proved to be poorly designed in terms of their layout and infrastructure. Furthermore, the knowledge of ergonomic skills among teachers and principals at 18 (66%) of the 27 independent schools in Gauteng (Johannesburg) approached by the researcher was found to be low. However, on a positive note, the teachers indicated that they were interested and willing to participate in ergonomic training at the school if it was provided.

Being of female gender was found to be a significant risk factor for developing musculoskeletal pain amongst learners while working on a computer. Computer exposure of ≥ 2.5 hrs per week was found to increase the risk of learners for developing pain while working on a computer, by 40% as well as learner's wrist and arm positions when working on a computer were found to increase their risk for developing pain while working on a computer.

The intervention programme had a clinically sustained effect on reducing the number of learners with musculoskeletal pain as well as on reducing pain catastrophising levels amongst learners. The findings from this current study found that shoulder and neck pain were the most common areas of pain in the total learner sample at baseline. There was no significant effect on reported pain or pain intensity per body area following the intervention programme. The intervention had a positive sustained effect on improving learners' postural positions while working on a computer as well as modifying their ergonomic behaviour when working on a laptop and carrying a schoolbag. These clinical and sustained positive effects help to validate this computer-related ergonomic intervention programme for grade eight learners.

The results from this study highlight the need for educating all stakeholders in schools on ergonomic principles as well as the need for further longitudinal-ergonomic intervention research in schools.

7.2 STUDY LIMITATIONS

The sample used in this study was limited as it only represented grade eight learners from high fee-paying schools in the Gauteng region of Johannesburg. The reason for this was that the longitudinal design of the study was such that budget, manpower and school term constraints limited this study to grade eight learners from two schools in the Gauteng region. In addition, a further limitation of this study was that it considered only computer related ergonomics as a risk factor for musculoskeletal pain.

In this current study, the rules to avoid selection bias in cluster randomised trials (Kerry et al., 2005; Torgeson, 2012) were implemented so as to protect the validity of the results. The schools were randomised into a control group and an intervention group after baseline measurements were done and all eligible learners were identified. Learner and parent consent for the learners to participate in an ergonomic intervention was obtained before the clusters (schools) were randomised into the control and intervention groups so as to reduce consent bias. Thus, the learners were recruited on the basis that either could get the intervention and every learner that consented was included in the trial and an intention-to-treat analysis was done. This process follows the rules of cluster randomisation so as to reduce the risk of selection bias and ensure comparability of the intervention and control groups, which is essential for the validity of the trial results. However, this process of cluster randomisation brought the limitation of differences in the variables at baseline, which had to be accounted for by propensity score matching.

The computer usage questionnaire (CUQ) was lacking in its identification of pain intensity as only a pain faces scale and body chart were used. Thus, a separate addition in terms of a numerical pain rating analogue scale was included in this study to determine levels of pain intensity. In the future, a numerical pain rating scale included in the CUQ would be recommended.

The teacher survey revealed a poor knowledge of ergonomics in teachers and principals in the school environment, but the sample is not representative of the greater population in the Gauteng region. However, it does highlight the need for further investigation in this area.

7.3 IMPLICATIONS OF FINDINGS

The findings from this current study suggest that prevalence of musculoskeletal pain in learners is of concern and that there is a need for the implementation of ergonomic intervention programmes in schools in South Africa. Furthermore, the actual logistics of implementing such a programme within the school curriculum is possible.

This study had positive effects of reducing the overall prevalence of musculoskeletal pain, improving posture, and modifying pain catastrophising amongst learners in a school environment. It would be useful to test an intervention that included better pain outcome tools and psychological variables in a larger population of learners.

7.4 RECOMMENDATIONS

Future research in this field should consider using a larger sample of learners across all provinces of South Africa to gain a perspective on the need for such an intervention in schools, as well as measuring the effect of the intervention across a broader group of learners from different socio-economic backgrounds. Psychological determinants such as pain catastrophising and fear-avoidance beliefs amongst learners and their impact on the outcome of an ergonomic school intervention should be further explored. Longitudinal studies in this regard should be encouraged in both primary and high-school environments to ensure that the development of musculoskeletal pain in early adulthood is reduced.

Consultation with higher education departments, curriculum developers, parents, teachers and governing bodies on the prevalence of musculoskeletal pain in learners using computers and the need for ergonomic skills, should be encouraged across all provinces in South Africa.

An expert from the physiotherapy department at Curtin University, Australia gave feedback on his evaluation of the intervention programme six months after the first communication request and thus the evaluation came after the intervention had been implemented. Nevertheless, he had some recommendations for the intervention programme such as the fact that as long as the school bag is carried with both shoulder straps on, a slight increase in the school bag weight above 10% could be a good form of exercise rather than having a negative impact on a student’s posture. He also suggested that students should be encouraged to move or change position every 30 minutes and that the visual of the young girl sitting upright in the chair with her arms resting on the desk in the workstation set up graphic, may lead to forearm pain. He also suggested that using an ergo tilt to raise a laptop would not suffice for a tall child and to rather emphasise that a student uses a separate keyboard and mouse and raise the laptop higher.

Lastly, he indicated that he approved of the graphic layout of the intervention programme, which was in direct contrast to the Boston University professor of occupational therapy's evaluation. As such, the acceptance of the graphic layout is subjective and context and preference dependent when designing an intervention programme.

Feedback from an expert at the physiotherapy department at Stellenbosch University, South Africa, was also received too late for any changes to be made to the intervention programme. However, her evaluation and suggestions were and are certainly important when considering future educational interventions. She suggested that a structured document detailing the different sections of the intervention programme and the study itself should accompany the electronic presentation when being emailed to an expert for validation of the intervention programme

She also recommended that each topic should be covered in a separate module. Unfortunately, separating the topics into modules would require too much of the curriculum time at school so this would only be possible if ergonomics formed part of a future curriculum. In terms of the descriptor level, the South African expert was not certain that the programme met the level of grade eight students. The uncertainty may be due to inadequate information on the process provided by the researcher. For example the lecturers of grade eight students had been involved in the design and evaluation of the programme. She also commented on why there was the inclusion of school bags in the ergonomic practice in this computer-related ergonomic intervention programme. The reason school bags were included in the intervention was that a heavy school bag had implications on adolescents working on computers in terms of developing musculoskeletal pain and therefore to negate a confounding variable of carrying heavy school bags, it was decided to include this in the intervention.

Further suggestions from the South African expert included how the students would adjust their workstations at school as the workstations, desks and chairs are not adjustable per se and students are not designated the same workstation each time. In answer to the professor's concerns, the programme specifically refers to teaching the students applied practical modifications to their workstations at school or at home that are economical and user friendly, for example raising their feet onto a file or small box if their feet cannot touch the ground. The principle that is taught throughout the intervention programme is that of modifying the workstation as best as you can to suit your body prior to starting to work on the computer. In some cases even school bags have been used to support feet. It is unrealistic to expect ergonomic furniture to be available at schools, particularly in a developing country like South Africa.

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APPENDIX A

- **PHOTOGRAPHS OF SCHOOL COMPUTER LABORATORIES**

The figure below illustrates the computer laboratories at the control and intervention schools:

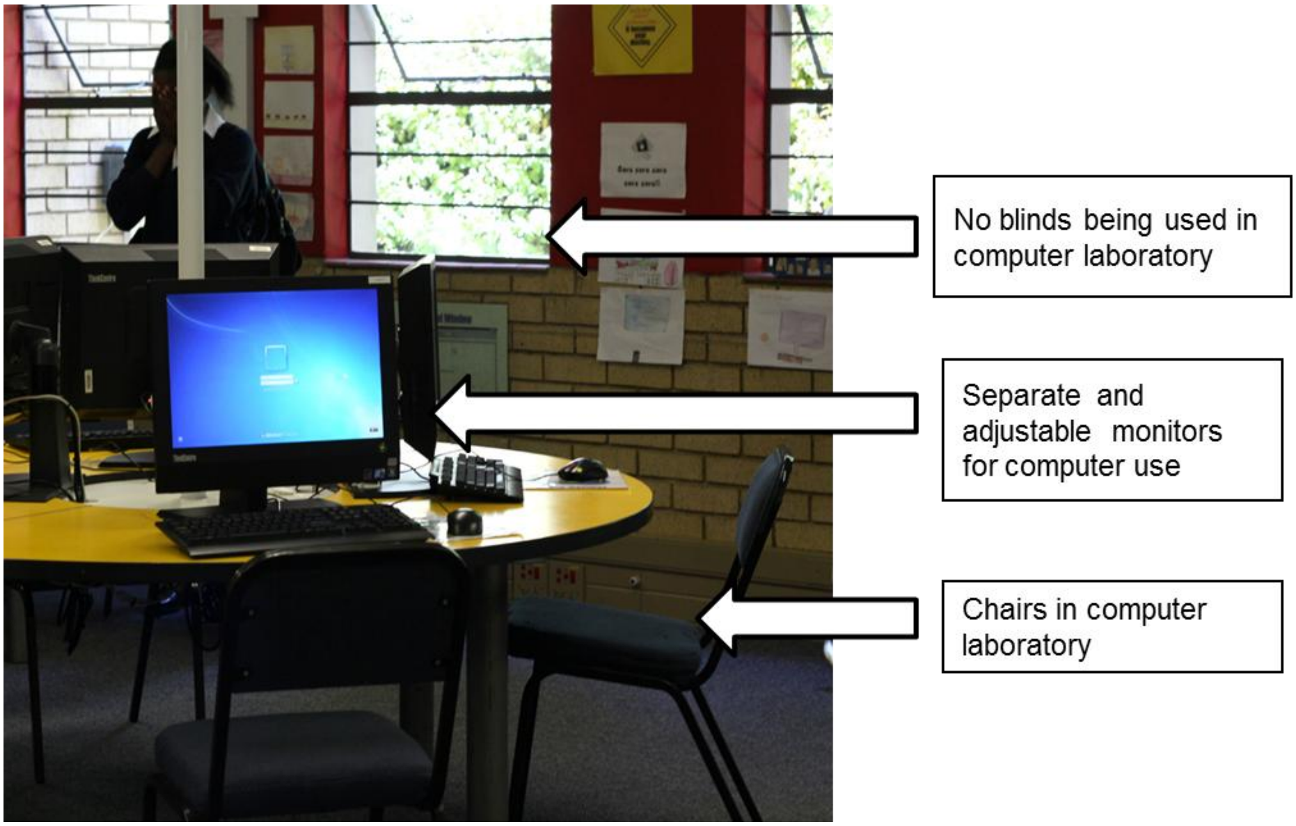


Figure A1: Computer laboratory at control school

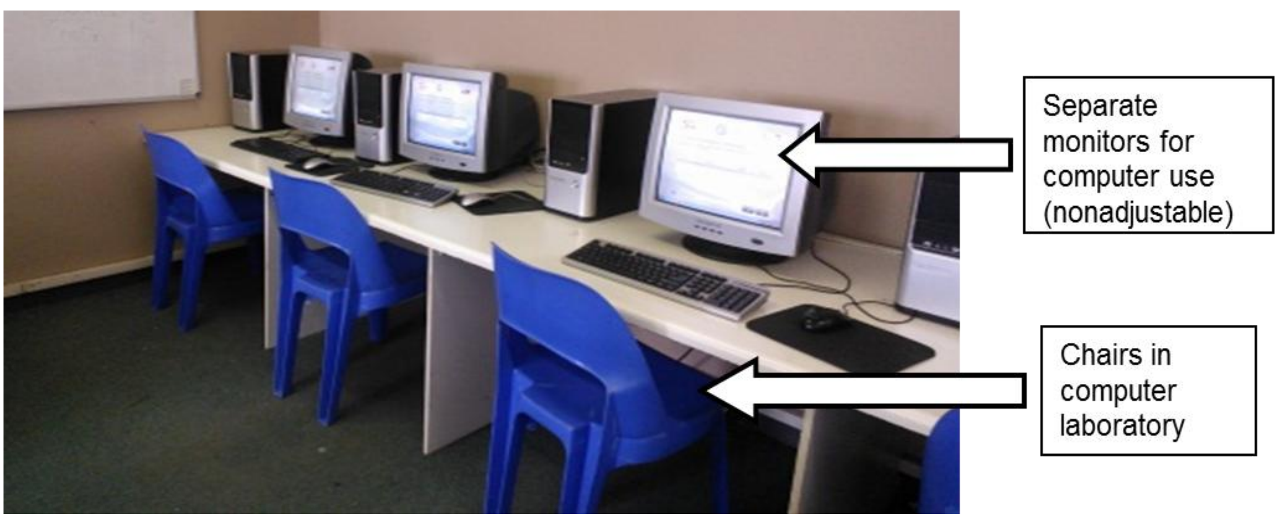


Figure A2: Computer laboratory at intervention school

Postural positions of learners from the control and intervention groups

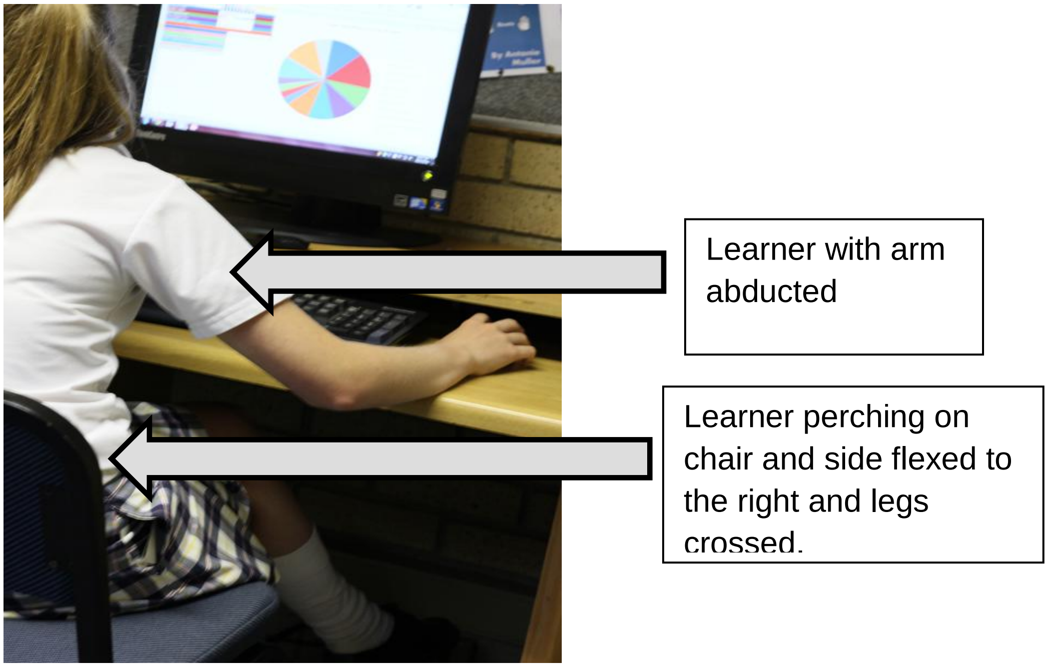


Figure A3: Posture of learner in control group (baseline)

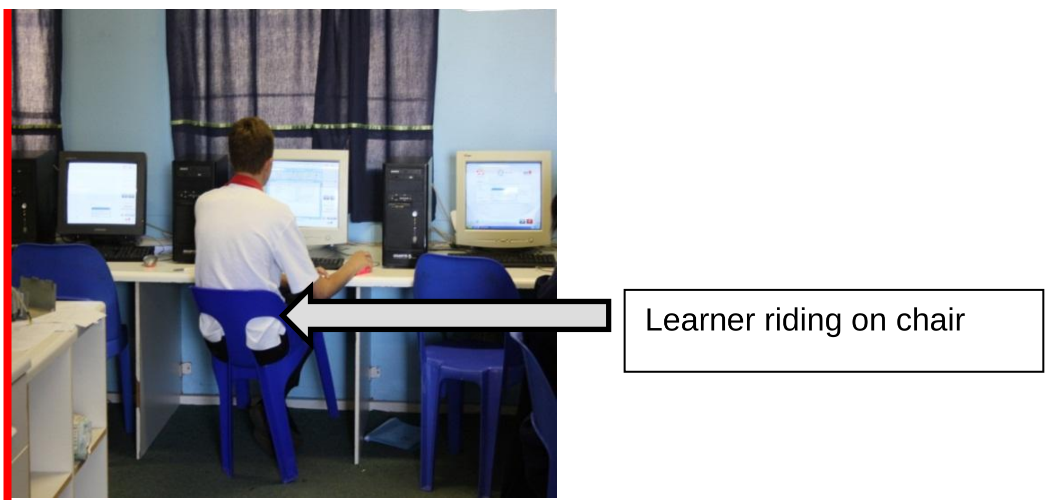


Figure A4: Posture of learner from control group (baseline)

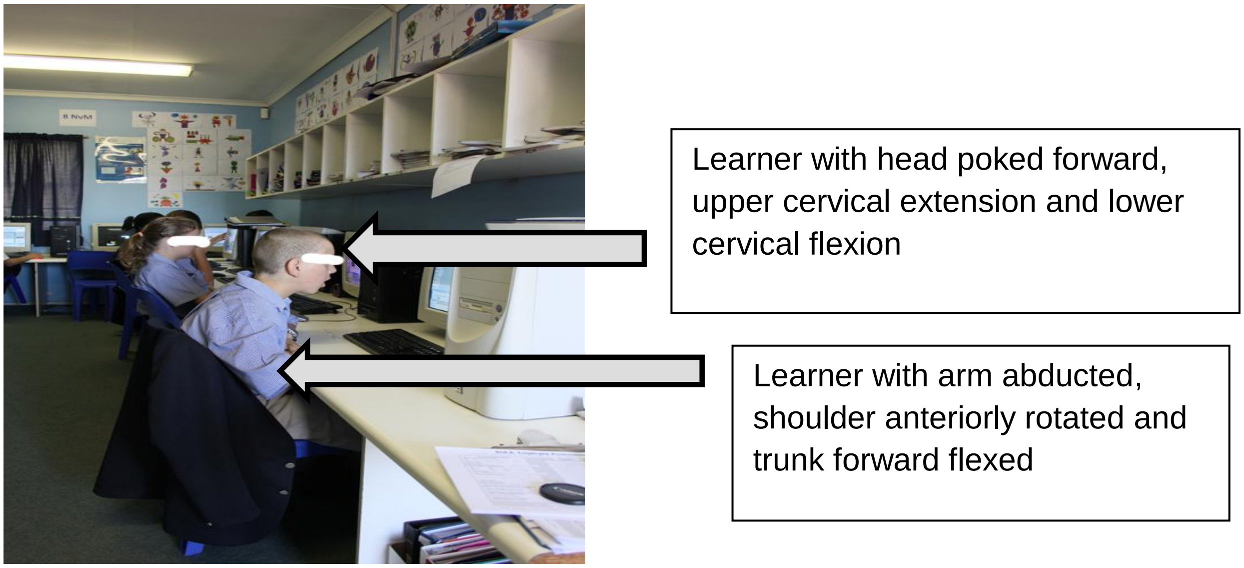
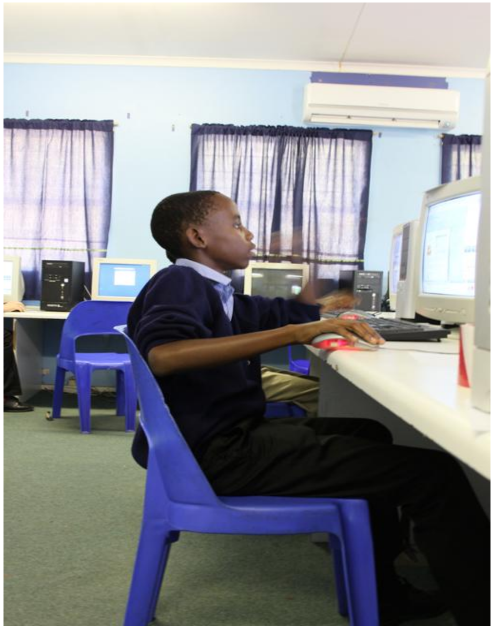


Figure A5: Posture of learner from intervention group (baseline)

Figure A6: Computer laboratory at intervention school



Learner’s arm is abducted and raised as the desk height of the computer laboratory is unsuitable

Figure A7: Posture of learner from intervention group (six months)

APPENDIX B

- **PILOT STUDY**

The pilot study is presented here for clarity. The tools that were used in the main study were piloted and are discussed individually below.

MEASUREMENT TOOLS

1. THE RAPID UPPER LIMB ASSESSMENT (RULA)

1.1 Aim of pilot study

To establish the test re-test reliability of the rapid upper limb assessment (RULA) as a method of assessing children's computing posture.

1.2 Methodology

One randomly selected independent school from Gauteng province was used in this study. The learners were photographed during normal school hours and under normal working conditions to improve external validity. Each student was photographed from the dominant hand side-on position (to observe the use of the mouse hand) and from the rear position from a distance of two metres. A digital Canon camera attached to a tripod, length 1.2m was used to photograph the students. The posture of each learner was observed for two minutes and measured using the RULA analysis tool. This procedure was repeated twice in the same lesson to test the intra-rater reliability of RULA.

The children's faces were blurred in the editing of the images. The researcher then rated each photograph using the RULA assessment tool and the RULA scores were analysed.

1.3 Sample size

Calculations were made by a statistician to establish the required sample size. A sample size of 21 grade eight learners and two photographs per learner was required to achieve a power of 80% and two-sided level of significance ($p<0.05$) to detect an ICC (intraclass-correlation coefficient) of 0.6 or greater, which is a moderate level of reliability.

1.4 Procedure

The school principal and academic head of department were contacted by telephone and a meeting was arranged to discuss the feasibility of doing the study in the school. Following the meeting, the academic head of department was given envelopes containing participant information forms, consent and assent forms (for children older than seven years) for distribution to potential participants. The parents/guardians of the children were requested to return completed consent and assent forms as appropriate to the class teacher. The participants and their parents were aware that the study involved the photographic assessment of their children's computing posture.

1.5 Data collection

Ethical clearance was granted by the University of the Witwatersrand. The main researcher conducted all the measurements. Baseline data, which included height, weight and schoolbag weight of each learner were measured using a standard rigid tape measure and a Tanita scale respectively. Postural analysis began 10 minutes after the start of the computer class. The posture of each learner was observed for two minutes and assessed using the RULA analysis tool. Photographs were taken of each learner from the side of the dominant hand using a Canon 60 D digital camera, following the RULA analysis. This procedure was repeated twice (two minutes per learner) in the same lesson to enable the intra-rater reliability assessment of the of RULA.

1.6 Data analysis

The analysis of the data was performed with Microsoft Excel 2010 and Statistics for Social Sciences (SPSS, v19.0). A significance level of $p \leq 0.05$ was set. Reliability was calculated with intra-class correlation coefficients (ICC). Intra-rater reliability was calculated using the ICC index model (3, 1) with a 95% confidence interval. As a general guideline, an ICC value below 0.50 represents poor reliability and a value ranging from 0.50 to 0.75 indicates moderate reliability. An ICC value above 0.75 represents good reliability(Shrout and Fleiss, 1979) . A strict protocol was adhered to throughout the RULA measurements in an effort to decrease the amount of variable influences on the results.

1.7 Results

The results between the baseline RULA and the repeat RULA scores yielded an ICC of 0.84 (average measures) and an ICC of 0.72 (single measures) for action level and grand scores and was therefore a reliable tool to use on school children aged between 14 and 16 years. This ICC represents the index of consistency for the mixed model case. See table below:

Table B.1: Correlation of RULA (baseline) vs RULA (repeat)

	Intraclass correlation	**95% Confidence interval**		**F test with true value 0**			
	n	Lower bound	Upper bound	Value	df1	df2	Sig
Single measures	0.72	0.43	0.88	6.1	20	20	P<0.001
Average measures	0.84	0.6	0.93	6.1	20	20	P<0.001

The table below shows the ICC value when using the absolute agreement definition index proposed by (McGraw and Wong, 1996). Although the ICC=0.75 average measures and ICC=0.6 single measures are lower than those obtained with the consistency index definition supported by Shrout and Fleiss,1979, the reliability value still indicates that RULA has good intra-rater reliability for postural observation.

Table B.2: Results showing the ICC value for RULA baseline and RULA repeat using the absolute agreement definition index

	Intraclass correlation	**95% Confidence interval**		**F test with true value 0**			
	n	Lower bound	Upper bound	Value	df1	df2	Sig
Single measures	0.6	0.07	0.84	6.11	20	20	0
Average measures	0.75	0.13	0.91	6.11	20	20	0

The results between the baseline RULA (BRULA) and the baseline photographic analysis RULA showed an ICC=0.99 (p<0.01).

1.8 Discussion

The results indicate that RULA (ICC=0.84) is a good reliable tool to use on school children aged between 14 and 16 years. Procedural issues relating to time constraints for individual class times and insufficient manpower for doing baseline measurements, and difficulty accessing the class environment owing to poor classroom design and inadequate spacing between computers were noted as potential impediments to the data collection process.

1.9 Conclusion

It was found that RULA demonstrated good intra-rater reliability for this study, and it will be useful as part of an ergonomic assessment of older children (>7 years) working at computers. The lessons learnt from the pilot study regarding time constraints and issues relating to insufficient manpower for doing the height, weight and schoolbag weight measurements were accommodated by engaging the assistance of a research assistant to do the measurements for the duration of the main study. The school principals were approached and sufficient time was allocated during a computer or life orientation lesson for collecting data during the main study.

2. THE PAIN CATASTROPHISING SCALE FOR CHILDREN (PCS-C)

2.1 Aim

To test the feasibility of the Pain Catastrophising Scale for children (PCS-C) within an independent school environment in South Africa.

2.2 Methodology

This pilot study was school-based and was a feasibility study design. Two grade eight classes from two randomly selected independent schools from the Gauteng region were used in this study.

2.2.1 Sample

One class of grade eight learners from each school formed this sample, n=7 and n=21 respectively, with the total sample (n=28). The grade eight learners were from a multicultural background, but they were all proficient in English and no language barriers were present.

2.2.2 Procedure and data collection

The English version of the PCS-C was handed out to the learners and they were instructed on how to answer the questionnaire by the main researcher. They were given 20 minutes to complete the questionnaire. Each questionnaire was allocated a number so that when the learner was asked to repeat the questionnaire, the same number was allocated to the learner. Following completion of the questionnaire, the learners were asked if they understood the questions and if there were any difficulties filling out the questionnaire. No issues were raised. After a 10 minute rest, the learners were again asked to complete a PCS-C questionnaire. Following the completion of two identical PCS-C questionnaires, the results of the PCS-C questionnaires were captured and analysed for any inconsistencies.

2.3 Data analysis

The scores from the PCS-C questionnaires from round 1 and round 2 were captured onto an excel spreadsheet and then analysed for any differences in the scores obtained for each round. The independent sample *t*-test was used to compare the mean and standard deviations between PCS-C 1 and PCS-C 2 test scores.

2.4 Results and discussion

The results obtained (see table B3 below) suggest that there were no differences between the means or standard deviation of the two PCS-C test scores for the sample group. This indicates that the learners understood the PCS-C and the feasibility of using this tool in the South African context is appropriate for use in the main study, which will evaluate pain catastrophising in adolescents working on computers.

Table B3: Results of the comparison of the of PCS-C 1 and PCS-C 2

PCS-C	**Mean**	**Std. deviation**	**n**
P1 total PCS-C (p<0.112)	33.25	8.427	28
P2 total PCS-C (p<0.112)	33.25	8.427	28

2.5 Conclusion

The results of this feasibility study suggest that with appropriate instruction, the grade eight learners in an independent school environment are able to complete the PCS-C successfully and accurately.

3. COMPUTER USAGE QUESTIONNAIRE (CUQ)

3.1 Aim

To test the intra-rater reliability of the computer usage questionnaire (CUQ).

3.2 Methodology

This pilot study was school-based and was done using a test-retest design. The learners completed the questionnaire during normal school hours and in normal working conditions to improve external validity.

3.3 Procedure

Written informed consent was obtained from the learners and their parents/guardians and the school principal prior to the learner's completion of the CUQ. Ethical clearance was given by the voluntary and that they could withdraw from the study at any time. The purpose of the questionnaire was explained to the learners and the main researcher was available to answer any questions that they may have regarding the questionnaire. The time taken for the learners to complete the questionnaire was documented for guidance of the main study. One day later, the group of learners was asked to complete the questionnaire again. To verify that the same learners completed the questionnaire, each learner was given a number and this was correlated with their names on an excel spreadsheet.

3.4 Data analysis

The data were captured by the main researcher onto an excel spreadsheet and analysed using the test-retest reliability test to establish the reliability of the CUQ using SPSS V19.0.

3.5 Results

The results obtained from the reliability test showed that the repeatability between the first and second questionnaire results were stable and good. The CUQ showed a correlation of 0.99 ($p<0.01$) between the first and second questionnaires for computer usage and hours spent on the computer.

The section of the CUQ that demonstrated poor repeatability was the section on 'where do you experience pain?' and 'how bad are these feelings of discomfort, pain?' This is demonstrated by the ICC; the presence of headaches between the two questionnaires was ICC=0.658 ($p<0.013$). This result could be because there was a one day delay between the first and second CUQ and in that interim the symptoms experienced by the learner could have changed.

4. TEACHER/PRINCIPAL QUESTIONNAIRE

4.1 Aim

To test for content validity, consistency and intra-rater reliability of the teacher/principal questionnaire.

4.2 Methodology

This study was qualitative and a focus group of a panel of experts in the education field, physiotherapy field and occupational therapy field were invited to provide input on the content validity of this questionnaire in terms of the South African context. It was also tested for intra-rater reliability, in that the sample of teachers and principals was asked to fill out the questionnaire twice with an hour in between to check repeatability of the questionnaire.

4.3 Sample selection and size

Two teachers and two principals from different schools were invited to take part in this study (experts in the field of education), one expert in the field of ergonomics, one expert in the field of physiotherapy and one expert in the field of occupational therapy were invited to form part of the focus group.

4.4 Procedure

Consent forms from all participants were obtained prior to the implementation of the study. The teachers and principals completed the questionnaires twice with an hour in between completion of the first questionnaire. A teacher/principal questionnaire was emailed to each participant in the focus group for analysis prior to the focus group meeting one week later. A focus group meeting was held at the researcher’s home and the questionnaire was discussed.

4.5 Results

The teacher/principal questionnaires that were completed twice with an hour in between were compared for differences in the qualitative information on school demographics, ergonomic training and the teachers' attitudes towards and beliefs about ergonomic education. No differences were found between questionnaires one and two. None of the participants had received ergonomic training in computer education and they all indicated that they would like to have more information on computer-related ergonomics.

The comments from the focus group were:

- "The teacher/principal questionnaire is user friendly."
- "The explanation on what ergonomics is all about is well written and easy to understand."
- In the teacher questionnaire, question number 10, "Who provided you with the training?" needed to have the NCTE tutor option changed to ICDL (international computers driver's licence training) to be appropriate for the South African context.
- In the principal questionnaire, question number 3 was amended from 'community/comprehensive school' to 'preparatory school'. In addition, the use of the words 'vocational school' was amended to 'pre-primary school' for the questionnaire to reflect the South African context.

4.6 Conclusion

In conclusion, the repeatability (ICC=0.98, p<0.01) of the teacher/principal questionnaire was found to be good and the results from the focus group were positive.

5. COMPUTER WORKSTATION DESIGN ASSESSMENT (CWDA)

5.1 Aim

To test the appropriateness of using the Computer Workstation Design Assessment form (CWDA) in assessing computer laboratories in the independent schools in Gauteng.

5.2 Methodology

5.2.1 Sample

Two computer laboratories in the two independent schools used for the pilot study in Gauteng were used to test the appropriateness of the CWDA form.

5.2.2 Procedure

The assessment of the computer laboratories at the selected schools took place after school when the laboratories were not in use by learners or educators. All measurements of the computer laboratory and workstations were done by means of one standard rigid steel tape measure and measurements were recorded in millimetres (mm). Each laboratory required 20 minutes for the assessment. The researcher photographed the computer laboratories at each school with prior consent from the principal of the school and the computer teacher. To assess reliability of the researcher's measurements, a second workstation within the same laboratory was assessed.

5.3 Results and discussion

The CWDA form entailed indicating the presence (‘yes‘) or absence (‘no‘) of a specific criterion and each of the four sections was scored using 1 for compliance and 0 for non-compliance. The total score of all four sections came to 40. The measurements were completed successfully, even though the one school (school A) laboratory was designed poorly in terms of accessibility and spatial design layout. Both schools scored poorly in the workspace environment and spatial environment sections of the CWDA, and the scores for the input device and the visual environment section scored best in terms of compliance. School A (23/40, 57% compliance) and school B (19/40,47.5% compliance), demonstrating that both schools had poor ergonomic set-up of computer laboratories and workstations.

The position of the actual computers on the desks in the laboratory differed greatly between the two schools and the furniture used in the computer laboratories were fixed so that the chairs used were non-adjustable and had no arm rests. At the one school, the computer monitor was positioned under the desk and the learners had to look down through a glass pane to see the monitor, encouraging increased cervical and thoracic flexion. At the second school, the monitors were positioned on top of the desk, but there was limited room between computer workstations and poor legroom underneath the desks. Testing the feasibility of the CWDA form for use in independent schools in Gauteng proved successful, but it also highlighted significant risk factors for the development of musculoskeletal pain in learners in a school environment.

Descriptive statistics were used to assess the reliability of the CWDA. The data and probability calculations (odds ratios) were calculated and significant risk was identified by 95% confidence limits around odds ratios where neither 95% confidence limits encompass the value of 1. It was found that the intra-rater reliability of the CWDA form had good reliability and stability.

6. THE COMPUTER-RELATED ERGONOMICS INTERVENTION PROGRAMME

6.1 Aim

To refine and test the content validity of the computer-related ergonomics intervention programme in a school environment

6.2 Methodology

This study was qualitative and one class of grade eight learners formed the experimental and focus group comprising four independent teachers, and two international experts in ergonomics and occupational therapy and physical therapy were asked to evaluate the intervention programme.

6.3 Sample

One grade eight class of eight learners were invited to participate in the evaluation of the computer-related ergonomic intervention programme. A conveniently selected focus group of four independent teachers was invited to evaluate the intervention programme. Two of the teachers were grade eight teachers and another two were trained facilitators and evaluators of training programmes in the education industry.

6.4 Procedure

Written informed consent was obtained from the learners and their parents/guardians and the school principal prior to delivering the computer-related intervention programme to the learners. The teachers gave their assent by completing participant information consent forms. Ethical clearance was given by the University of the Witwatersrand. Learners were informed that their participation in this study was voluntary and that they could withdraw from the study at any time.

The purpose of the intervention was explained to the learners by the lecturer from the University of the Witwatersrand, who had been trained by the researcher to deliver the intervention programme. The lecturer delivered a 45 minute computer-related ergonomic intervention programme in a power point format. Each learner was given a stretch card and a red dot sticker. The purpose of the red sticker was for it to be taken home by the learner and placed on their own home computer to serve as a reminder to check their workstation set up and to do regular stretches. The focus group of four qualified teachers met at a designated meeting point in Johannesburg and the intervention programme was shown to them by way of a power point presentation, delivered by the researcher.

An expert in occupational science and ergonomics from the United States, with experience in research relating to ergonomic intervention programmes in schools, agreed to participate in the evaluation of the intervention programme by responding to an email request sent to her. The electronic file of the intervention programme was then sent to her for evaluation in terms of content validity.

6.5 Results and conclusion

The learners responded with interest and enthusiasm to the ergonomic intervention programme. They participated in the activities as prescribed by the intervention and asked insightful questions following the intervention programme. The time taken to deliver the intervention programme was 45 minutes, which was longer than originally intended. This was an important consideration for the delivery of the intervention in the main study and additional time was catered for in delivery of the intervention in the main study.

In terms of the questions asked by the learners, and input from the lecturer who delivered the intervention programme, it was suggested that a basic post-intervention multiple choice test be formulated for the learners to enhance the learning process and reinforce the concepts learnt from the intervention. Furthermore, two large wall posters demonstrating correct workstation set up and to the correct way to carry a schoolbag were provided to the computer laboratory at the school to serve as a form of reinforcement of the knowledge gained from the ergonomic intervention.

The focus group of the four teachers was invaluable and they too suggested that the learners have a multiple choice test post-intervention to reinforce the learning process.

With the assistance of the four teachers, the researcher developed a short multiple choice questionnaire to be added to the intervention group in the main study.

The professor gave invaluable feedback on the content validity of the computer-related ergonomics intervention programme. She indicated that the word ’discomfort‘ rather than just pain should be added to the programme. She found the contents of the programme to be suited for the purpose of the study and for grade eight learner level. She suggested that the researcher add a free software download link to the intervention programme to remind learners to do stretches and to check their ergonomic set up. The learners were able to download this free software from the internet for use on their home computers, which acted as reinforcement.

APPENDIX C

- **RESEARCH SCHOOLS DIRECTORY**

School	Telephone No	Address
Aurora Private School (Secondary)	011 795 7100	Taurus Road, Sundowner
Beaulieu College	011 468 2114	107 Maple Road, Beaulieu
Bishop Bavin School (College)	011 616 4018	St George's Road, Bedfordview
Dainfern College (Senior Preparatory)	011 469 0635	Broadacres Drive, Dainfern
Deutsche Internationale Schule Johannesburg (Secondary)	011 726 6220	11 Sans Souci Road, Parktown
Helpmekaar Kollege	011 339 2226	Corner Empire and Melle Street, Parktown
King David School Linksfield (Secondary)	011 480 4500	Bedford Street, Linksfield
King David School Victory Park (Secondary)	011 446 7860	Craighall Road, Victory Park
St Martin's School	011 435 0735	114 Victoria Street, Rosettenville
St Peter's College	011 807 5315	Maxwell Drive, Sunninghill
Woodlands International College (Secondary)	011 894 7107	190 Leith Road, Bartlett

APPENDIX D

- **MEASURING INSTRUMENTS**

QUESTIONNAIRE 1

Pain Catastrophising Scale: Children (PCS-C)

Thoughts and feelings during pain

We are interested in what you think and how strong the feelings are when you are in pain. Below are 13 sentences of different thoughts and feelings you can have when you are in pain. Try to show us as clearly as possible what you think and feel by putting a circle around the word under each sentence that best reflects how strongly you have each thought.

1. When I am in pain, I worry all the time about whether the pain will end.
   NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

2. When I am in pain, I feel I can't go on like this much longer.
   NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

3. When I am in pain, it's terrible and I think it's never going to get better.
   NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

4. When I am in pain, it's awful and I feel that it takes over me
   NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

5. When I am in pain, I can't stand it anymore
   NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

6. When I am in pain, I become afraid that the pain will get worse
   NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

7. When I am in pain, I keep thinking of other painful events

NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

8. When I am in pain, I want the pain to go away

NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

9. When I am in pain, I can't keep it out of my mind

NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

10. When I am in pain, I keep thinking about how much it hurts

NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

11. When I am in pain, I keep thinking about how much I want the pain to stop

NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

12. When I am in pain, there is nothing I can do to stop the pain.

NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

13. When I am in pain, I wonder whether something serious may happen

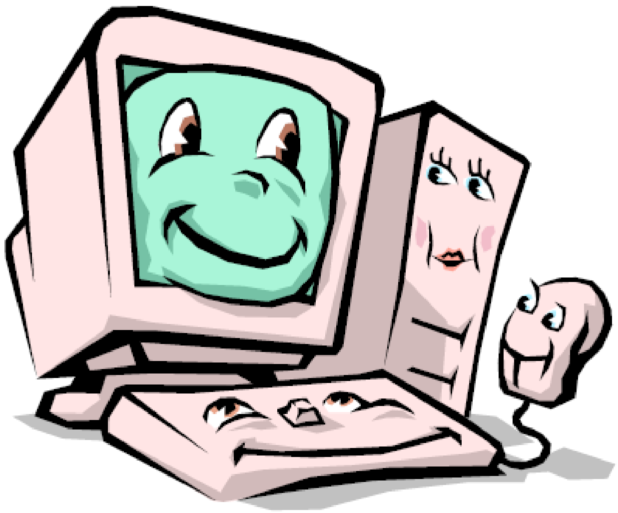
NOT AT ALL MILDLY MODERATELY SEVERELY EXTREMELY

QUESTIONNAIRE 2

Computer Usage Questionnaire for Learners

COMPUTER USAGE QUESTIONNAIRE for

SCHOOL LEARNERS



COMPUTER USE AT SCHOOL.....

*If you **don't** use a computer at **school**, go to **page 3**. Mark your answer with a **cross (X)**.*

1. How long have you been using a computer during **lessons at school**?
   ☐ Less than 1 year ☐ 2 years ☐ 3 years ☐ 4 years or more

2. Do you **use the computer** for any of the following **subjects**? Mark as many as you want.
   ☐ Mathematics ☐ Computer Studies ☐ Languages ☐ Compu-Typing
   ☐ Others, please list:____________________

3. What do you **use** the **computer** for at **school**? Mark as many as you want.
   ☐ Typing ☐ View lessons ☐ Experiments ☐ Internet and e-mail
   ☐ Use educational programmes ☐ Other, please list:______________________________

4. How many **times per week** do you use the **computer at school**?
   ☐ Once or less per week ☐ Twice per week ☐ Three times per week ☐ Four times per week
   ☐ Five times or more per week

5. During **one session** at school, **how long** do you spend using the computer?
   ☐ Less than 30 minutes ☐ About 45 minutes ☐ 1 Hour ☐ 1 ½ Hours ☐ 2 Hours or more

6. How many **hours per week** do you spend working on the **school computer**?
   ☐ About 2 Hours per week ☐ About 4 Hours per week ☐ About 6 Hours per week ☐ 8 Hours or more per week

7. Did you receive any **instruction** on **how to sit** in front of the **computer**?
   ☐ Yes ☐ No

   If "**Yes**", who **instructed** you?________________________________

8. Do you take a **short break** of a few minutes at least **once an hour**, when using the **computer**? (A short computer break, means to stop using your hands at the keyboard/ mouse, e.g. to stand up, stretch out, use the bathroom, etc.)
☐ Yes ☐ No

9. Have you received any information on **stretches/ exercises** you can do during the above-mentioned short breaks?
☐ Yes ☐ No

If **"Yes"**, who provided the information?______________________________
Please describe the type of **stretches** or **exercises** that you do?

____

COMPUTER USE ELSEWHERE....

*If you don't use a computer **outside school**, go to **page 5**. Mark your answer with a **cross (X)**.*

1. **Where** do you use a computer **outside school**? Mark as many as you want.
   ☐ At your home ☐ Internet Café ☐ Relative/ friend's home ☐ Library
   ☐ Elsewhere (state where)________________________________

2. Roughly, **how long** have you been using the computer **outside school**?
   ☐ Less than a year ☐ 2-3 Years ☐ 4 Years ☐ 5 years or more

3. On average, how many **times per week** do you use the computer?
   ☐ Less than once a week ☐ 2 times per week ☐ 3 times per week ☐ 4 times per week
   ☐ Five times or more per week

4. On average, how many **hours per day** do you spend working on the computer **outside of school?**
   ☐ Less than 30 minutes ☐ 1 Hour ☐ 2-3 Hours ☐ 4 Hours or more

5. What **type of computer** do you use most of the time?
☐ Desktop computer ☐ Laptop computer ☐ Both

6. Where is the computer **positioned** when you are using it? Mark as many as you want.
☐ On a desk/ table ☐ On your lap ☐ On the floor ☐ On a chair
☐ Other, please list____

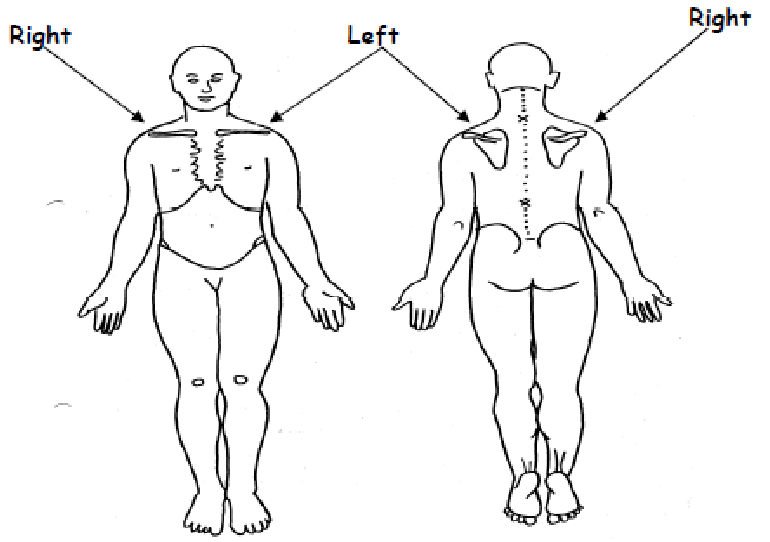
7. Do you participate in any **other activity** whilst simultaneously working on the computer? Mark as many as you want.
☐ Talk to a friend ☐ Listen to music ☐ Talk on the phone ☐ Writing on a page
☐ Other, please list____

TELL US ABOUT YOUR ACHES and PAINS…

*Mark your answer with a **cross (X)**.*

1. Have you experienced any **headaches, discomfort, stiffness, pain,** or **tingling** in your **muscles** or **joints** in the **last month?**
   ☐ Yes ☐ No **If "No", go to page 8.**

2. If **"Yes"**, in which **areas of the body** did you experience these feelings in the last month? Mark the **areas** where you **felt** your **symptoms** with a **"X"**



3. Tell us **how bad** these feelings of **discomfort**, **stiffness**, **pain** or **tingling** has been in the **last month**

If you had **SLIGHT discomfort**, **stiffness**, **pain**, or **tingling**, mark (**X**): .

If you had **A LOT** of **discomfort**, **stiffness**, **pain**, or **tingling**, mark (**X**):

This is an example of how you should do it…

Neck	X	

Body Area	**Slight Discomfort, Pain, etc**	**A lot of discomfort, pain, etc**
Head		
Neck		
Upper Back		
Mid-Back		
Lower Back		
Right Shoulder		
Left Shoulder		
Right Elbow		
Left Elbow		
Right Wrist and Hand		
Left Wrist and Hand		

4. **When** did you feel the **headaches**, **discomfort**, **stiffness**, **pain** or **tingling** of your **muscles and joints**? Mark as many as you want.

- ☐ Sitting in front of your school desk
- ☐ During or after sports.
- ☐ Working on the computer at school.
- ☐ Writing in a book at school desk
- ☐ Working on the computer elsewhere.
- ☐ Other (please list):____

5. Have you ever felt like not using the computer because of **headaches**, **discomfort**, **stiffness**, **pain**, or **tingling** of your **muscles** and **joints**?

☐ Yes ☐ No

6. Have you **stopped** any of the following **activities** because of the **headaches**, **discomfort**, **stiffness**, **pain**, or **tingling** of your **muscles** and **joints** in the **last 3 months**? Mark as many as you want.

- ☐ Playing sports
- ☐ Working on the computer
- ☐ Writing in a book
- ☐ Playing a musical instrument
- ☐ List any other____

7. In the **last month**, have you seen a **Doctor** or any other **medical professional** for any of your muscle and joint **complaints** mentioned above?

☐ Yes ☐ No

HOW DO YOU FEEL?

Tell us how you have ***felt*** *about* ***yourself****, other* ***people*** *and* ***situations*** *in the* ***last month****. Mark each answer with a* ***cross (X)****.*

1. Do you **care** about **other people** and try to be **nice** to them?
   ☐ Always ☐ Sometimes ☐ Never

2. Do you get a lot of **headaches** and **stomach aches**?
   ☐ Always ☐ Sometimes ☐ Never

3. Do you get very **angry** and loose your **temper**?
   ☐ Always ☐ Sometimes ☐ Never

4. Do you feel **sad** and **tearful**?
   ☐ Always ☐ Sometimes ☐ Never

5. Do you **fight** a lot?
   ☐ Always ☐ Sometimes ☐ Never

6. Do you feel **nervous** when meeting **new people** and going to **new places**?
   ☐ Always ☐ Sometimes ☐ Never

7. Do you get **scared** easily?
   ☐ Always ☐ Sometimes ☐ Never

8. Do you make **new friends** easily?
   ☐ Always ☐ Sometimes ☐ Never

YOUR SPORTS and MUSIC....

*Mark your answer with a **cross** (X).*

1. Do you participate in **sports**?
   ☐ Yes ☐ No......... **If "No", go to question 5.**

2. If **"Yes"**, **which sports** do you participate in? Mark as many as you want.
   ☐ Rugby ☐ Soccer ☐ Tennis ☐ Cricket ☐ Netball
   ☐ Athletics ☐ Hockey ☐ Other, please list____

3. How many **times per week** do you participate in your combined sporting activities?
   ☐ Less than once a week ☐ Once a week ☐ Twice a week ☐ Three times or more per week

4. On average, how many **hours per week** do you participate in all your sports?
   ☐ Less than an hour ☐ About 2 Hours ☐ About 4 Hours ☐ 6 Hours or more

5. Do you play a **musical** instrument?
   ☐ Yes ☐ No **If "No", go to page 10.**

6. If **"Yes"**, what **type** of musical instrument/ s do you play?
   ____

7. On average, how many **hours per week** do you play your musical instrument?
   ☐ Less than 1 hour ☐ About 2 Hours ☐ About 4 Hours ☐ Six Hours or more

TELL US ABOUT YOURSELF.... 

1. What is your **school's** name?__________________________________

2. What is **your name**?_______________________________________

3. What is your **date of birth** (day, month, year)?________________________

4. In which **grade** are you?___________________

5. Are you: ☐ A **boy** ☐ A girl

6. Are you: ☐ **Mainly right handed** ☐ **Mainly left handed**

7. Do you wear: ☐ **Spectacles** ☐ **Contact Lenses** ☐ **None**

8. Do you suffer from any **medical condition/s**, e.g. Epilepsy, Diabetes, Asthma?
   ☐ Yes ☐ No **If "No", go to question 10**

9. If **"Yes"**, do you use any **medication** for this condition?
   ☐ Yes ☐ No

10. Have you ever been involved in an **accident or sporting injury** where you injured your **back** or **neck**?
    ☐ Yes ☐ No

11. Have you had any **surgery** involving your **muscles** or **joints** done?
    ☐ Yes ☐ No

If **"Yes"**, please list the **type of surgery** and when it was done.

Year: ______ Surgery: ________________________________

Year: ______ Surgery: ________________________________

Year: ______ Surgery: ________________________________

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE!!!

QUESTIONNAIRE 3

Computer Ergonomics in School Survey

(TEACHER)

The main aim of this study is to establish the current situation with regard to information that teachers have on ergonomics of computer usage. Another aim is to establish the source(s) of that information.

Ergonomics is a science concerned with the relationship between human beings, the machines they use, and the working environment. In the context of this study on the use of computers in school, it relates to factors such as a student's posture as he/she sits at the computer, and the size and position of the various components of the computer workstation relative to the student.

This section deals with any training you might have had in relation to computer use.

Section 1 This section deals with general background information		
		Tick/answer
1. How old are you?	≤ – 25 years	
	26 –35 years	
	36 – 45 years	
	46 – 55 years	
	56 – 65 years	
2. Gender	Female	
	Male	
3. Do you have a computer(s) for use by the students in your school?	Yes – please continue to question 4	
	No – please go to question 8, Section 2	
4. Do you use computers with the students in your school?	Yes	
	No	
5. Do you use the computers?	In a dedicated computer room	
	In the classroom	
	Other, please specify …………………………	
6. How many students would normally be at the same computer at any one time?		
7. How long, on average, would a student spend using a computer per day in school?		

Section 2 This section deals with any training you might have had in relation to computer use.		
8. Have you had any training in the use of computers?	Yes – please continue to question 9	
	No – please go to question 15, Section 3	
9. When did the most recent training take place?	Month	
	Year	
10. Who provided you with the training? Please tick as many as appropriate	NCTE tutor	
	External training company	
	University	
	Colleague	
	Other, please specify …………………………	
11. How long did the training take?	Less than 1 hour	
	1 – 3 hours	
	1 day	
	More than 1 day	
12. Did your training include information on ergonomic issues?	Yes	
	No	
13. If your answer was Yes to question 12, what percentage of the time was given to ergonomic issues? Please indicate on the line provided: 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%		
14. Please tick [✓] if you were given any information on the following:	The position of the keyboard relative to the user	
	The position of the mouse/trackball relative to the user	
	The position of the wrist relative to the keyboard	
	The position of the elbows and forearms relative to the keyboard	
	The height of the monitor relative to the head and neck	
	The distance of the monitor from the eyes	
	The correct sitting posture/position at a computer	

	Adequate leg room under the desk while at the computer	
	How frequently breaks should be taken	
	The effects of lighting (glare, sunlight, etc.)	
	General ergonomic issues (noise, heating)	
	Other, please specify …………………………	
Section 3 This section asks for your opinion on ergonomic issues.		
15. Have you ever considered that there were any ergonomic issues with computers prior to receiving this survey?	Yes	
	No	
16. Do you give any information to the students about ergonomic issues?	Yes	
	No	
17. If you answered 'Yes' in question 16, please specify what information is given.	The position of the keyboard relative to the user	
	The position of the mouse/trackball relative to the user	
	The position of the wrist relative to the keyboard	
	The position of the elbows and forearms relative to the keyboard	
	The height of the monitor relative to the head and neck	
	The distance of the monitor from the eyes	
	The correct sitting posture/position at a computer	
	Adequate leg room under the desk while at the computer	
	How frequently breaks should be taken	
	The effects of lighting (glare, sunlight, etc.)	
	General ergonomic issues (noise, heating)	
	Other, please specify ………………………..	

18. How satisfied are you with your knowledge of computer related ergonomic issues?	Fully satisfied	
	Satisfied	
	Not very satisfied	
	Not at all satisfied	
19. Do you think you need more information on computer related ergonomic issues?	Yes	
	No	
20. If you answered "Yes" in question 19, how would you like to receive information on computer related ergonomics? Please tick as many as appropriate.	During a training session	
	Printed information	
	School visit by an expert	
	Poster for the classroom	
	Video	
	Website	
	CD-rom	
	Other, please specify …………………………	

Thank you for taking the time to complete this questionnaire.

Please return it to the principal in the envelope provided.

Computer ergonomics in school survey (principal)

The main aim of this study is to establish the current situation with regard to information that teachers have on ergonomics of computer usage. A further aim is to establish the source(s) of that information.

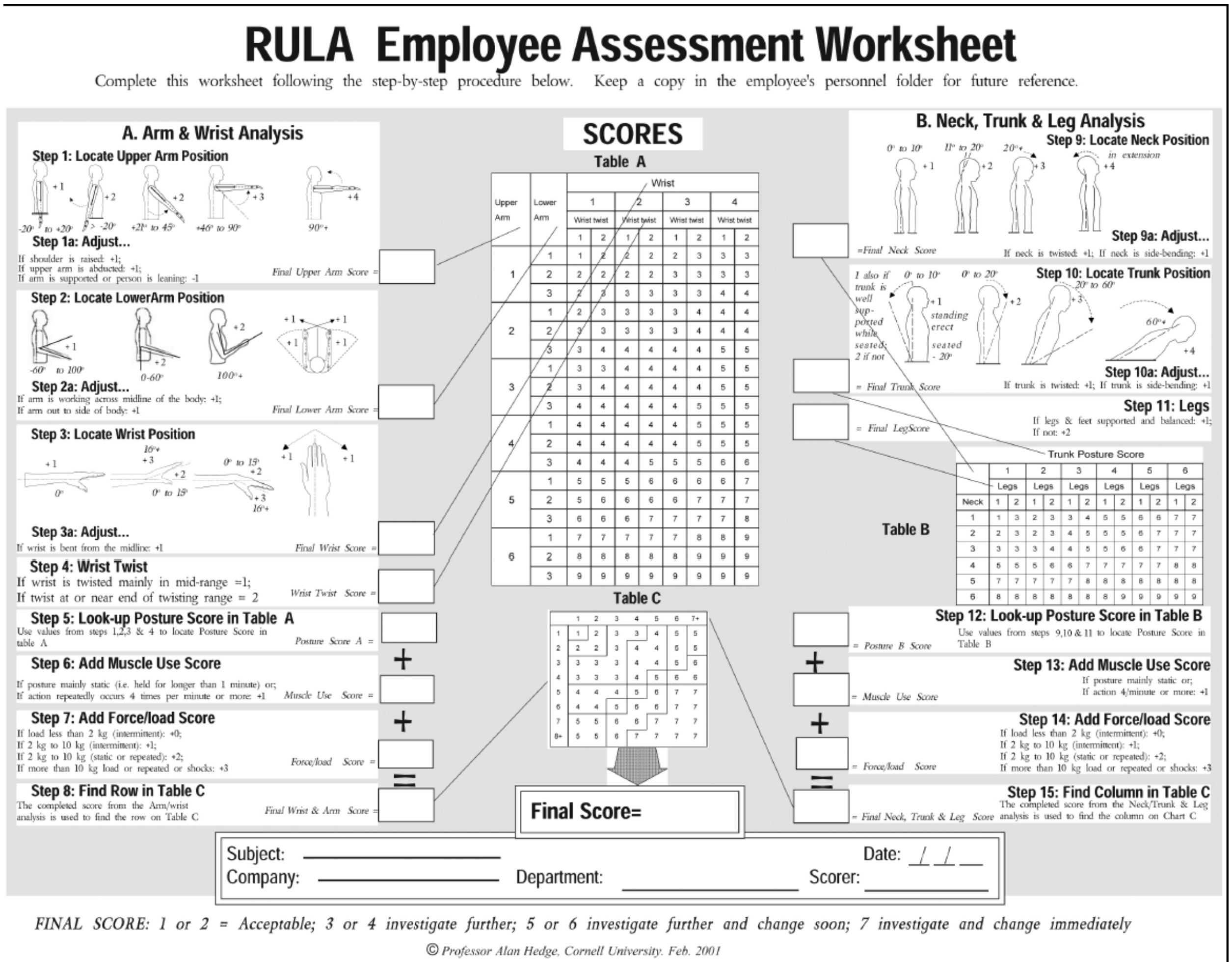
Ergonomics is a science concerned with the relationship between human beings, the machines they use, and the working environment. In the context of this study on the use of computers in school, it relates to factors such as the student's posture as he/she sits at the computer, and the size and position of the various components of the computer workstation relative to the student.

<table>
<tr><td colspan="3"></td><td>Tick</td></tr>
<tr><td colspan="3">1. How many teachers are there in your school?</td><td></td></tr>
<tr><td colspan="3">2. How many students are there in your school?</td><td></td></tr>
<tr><td rowspan="3">3. Is your school</td><td colspan="2">Secondary</td><td></td></tr>
<tr><td colspan="2">Community/comprehensive</td><td></td></tr>
<tr><td colspan="2">Vocational</td><td></td></tr>
<tr><td rowspan="3">4. Is your school</td><td colspan="2">Boys only</td><td></td></tr>
<tr><td colspan="2">Girls only</td><td></td></tr>
<tr><td colspan="2">Mixed</td><td></td></tr>
<tr><td rowspan="3">5. Is your school situated in a</td><td colspan="2">City</td><td></td></tr>
<tr><td colspan="2">Town</td><td></td></tr>
<tr><td colspan="2">Rural area</td><td></td></tr>
<tr><td rowspan="2">6. Do you have a computer(s) for use by the students in your school?</td><td colspan="2">Yes – please continue to question 7</td><td></td></tr>
<tr><td colspan="2">No
Thanks you for taking the time to complete the questionnaire</td><td></td></tr>
<tr><td colspan="4">Please return <u>all</u> completed questionnaires in the addressed envelope provided.</td></tr>
<tr><td rowspan="2">7. What computer equipment is currently in use in your school?</td><td colspan="3">Please tick [✓] as appropriate</td></tr>
<tr><td>Adult size</td><td colspan="2">Child size</td></tr>
<tr><td>Computer desk</td><td></td><td colspan="2"></td></tr>
<tr><td>Computer trolley</td><td></td><td colspan="2"></td></tr>
<tr><td>School desk</td><td></td><td colspan="2"></td></tr>
<tr><td>Adjustable computer chair</td><td></td><td colspan="2"></td></tr>
<tr><td>School chair</td><td></td><td colspan="2"></td></tr>
<tr><td>Keyboard</td><td></td><td colspan="2"></td></tr>
<tr><td>Mouse</td><td></td><td colspan="2"></td></tr>
<tr><td>Trackball</td><td></td><td colspan="2"></td></tr>
<tr><td>Joystick</td><td></td><td colspan="2"></td></tr>
<tr><td>Laptop</td><td></td><td colspan="2"></td></tr>
<tr><td>Footrest</td><td></td><td colspan="2"></td></tr>
<tr><td>Document holder</td><td></td><td colspan="2"></td></tr>
<tr><td>Other, please specify
…………………………..</td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="3">8. Are the computers used?</td><td colspan="2">In a dedicated computer room</td><td></td></tr>
<tr><td colspan="2">In the classroom</td><td></td></tr>
<tr><td colspan="2">Other, please specify
……………………………</td><td></td></tr>
</table>

Thank you for taking the time to complete this questionnaire. Please return <u>all</u> questionnaires to the secretary at the office.

QUESTIONNAIRE 4

The RULA Analysis Instrument



RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

-20° to +20° (+1); > -20° (+2); +21° to 45° (+2); +46° to 90° (+3); 90°+ (+4)

Step 1a: Adjust...

If shoulder is raised: +1;
If upper arm is abducted: +1;
If arm is supported or person is leaning: -1

Final Upper Arm Score =

Step 2: Locate LowerArm Position

-60° to 100° (+1); 0-60° (+2); 100°+ (+2)

Step 2a: Adjust...

If arm is working across midline of the body: +1;
If arm out to side of body: +1

Final Lower Arm Score =

Step 3: Locate Wrist Position

0° (+1); 0° to 15° (+2); 16°+ (+3)

Step 3a: Adjust...

If wrist is bent from the midline: +1

Final Wrist Score =

Step 4: Wrist Twist

If wrist is twisted mainly in mid-range =1;
If twist at or near end of twisting range = 2

Wrist Twist Score =

Step 5: Look-up Posture Score in Table A

Use values from steps 1,2,3 & 4 to locate Posture Score in table A

Posture Score A =

+

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held for longer than 1 minute) or;
If action repeatedly occurs 4 times per minute or more: +1

Muscle Use Score =

+

Step 7: Add Force/load Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Force/load Score =

=

Step 8: Find Row in Table C

The completed score from the Arm/wrist analysis is used to find the row on Table C

Final Wrist & Arm Score =

SCORES

Table A

Upper Arm	Lower Arm	Wrist 1		Wrist 2		Wrist 3		Wrist 4	
		Wrist twist		Wrist twist		Wrist twist		Wrist twist	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	6	6	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C

	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Final Score=

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

0° to 10° (+1); 11° to 20° (+2); 20°+ (+3); in extension (+4)

Step 9a: Adjust...

If neck is twisted: +1; If neck is side-bending: +1

=Final Neck Score

Step 10: Locate Trunk Position

1 also if trunk is well supported while seated; 2 if not

0° to 10° (+1) standing erect, seated - 20°; 0° to 20° (+2); 20° to 60° (+3); 60°+ (+4)

Step 10a: Adjust...

If trunk is twisted: +1; If trunk is side-bending: +1

= Final Trunk Score

Step 11: Legs

If legs & feet supported and balanced: +1;
If not: +2

= Final LegScore

Table B

	Trunk Posture Score 1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
Neck	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B

Use values from steps 9,10 & 11 to locate Posture Score in Table B

= Posture B Score

+

Step 13: Add Muscle Use Score

If posture mainly static or;
If action 4/minute or more: +1

= Muscle Use Score

+

Step 14: Add Force/load Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

= Force/load Score

=

Step 15: Find Column in Table C

The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

= Final Neck, Trunk & Leg Score

Subject: ______________ Date: _/_/__
Company: ______________ Department: ______________ Scorer: ______________

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

QUESTIONNAIRE 5

The Computer Workstation Design Assessment Form

COMPUTER LABORATORY WORKSTATION ASSESSMENT

School Name:

Date:

Number of Labs:

Lab Nr:

Assessed by:

Study Nr:

WORKING ENVIRONMENT	Yes	No
1. Classroom is climate controlled by means of an air conditioner.		
2. Draughts at the level of head and knees.		
3. Noise level interferes with concentration.		

SPATIAL ENVIRONMENT	Yes	No
1. Number of learners in computer laboratory during one lesson/ class, not exceeding 30.		
2. Aisle width between desks or workstations is in the range of 152cm- 183 cm.		
3. Adequate space exists for easy movement among workstations, book cases, shelves and doorways/ exits.		
4. Book cases and shelves are of sufficient size to display and/ or store necessary learning materials.		

WORKSPACE ENVIRONMENT

Chair	Yes	No
1. Chair has movable rolling coasters		
2. Surface of seat to floor in range of 380-510mm		
3. Seat pan depth in the range of 330-430mm		
4. Back support's height is adjustable		
5. Back support's angle is adjustable		
6. Arm supports present		
7. Arm support's height is adjustable		

Desk	Yes	No
1. Desk height is adjustable		
2. Desk width from left to right edge is 1500mm minimum		
3. Desk depth from front to back edge is 900mm minimum		
4. Width of legs space under desk when in seated position 800mm minimum		
5. Depth of space for legs when seated 550mm minimum		
6. Height of space between legs and desk when seated 580mm minimum		
7. Footrest provided		
8. Footrest area: 300x 375mm		
9. Footrest angle is adjustable		

Computer Screen	Yes	No
1. Screen depth (front of screen to table edge): 500-750mm		
2. Screen height measured from floor to centre of screen: 900-1150mm		
3. Screen dimension: ____________________ mm/mm		
4. Inclination of viewing monitor is adjustable : 88°-105° from the horizontal		
5. Usable manuscript holder attached to screen		

Keyboard	Yes	No
1. Keyboard positioned on separate tray		
2. Height from floor to home row of keyboard is in the range of 700-850mm		
3. Height of home row of keyboard to desk level in the range of 100-260mm		
4. Keyboard angle is adjustable		
5. Gel wrist support in use		

Input Device	Yes	No
1. Mouse used as in-put device		
2. Mouse has an adjustable position		
3. Mouse can be used ambidextrously		
4. Mouse pad available and used		

VISUAL ENVIRONMENT	Yes	No
1. Screen image is stable		
2. Monitor has adjustable brightness and contrast controls		
3. Control of glare through the use of screens, indirect lighting sources or equipment positioning		
4.Good quality light with natural or indirect lighting sources		

APPENDIX E

- **ETHICS CERTIFICATE**

.UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Miss Ingrid Sellschop

CLEARANCE CERTIFICATE	M110128
PROJECT	Phase 1 & 2: To Determine the Prevalence of Dysfunction among Adolescents in a School Environment
INVESTIGATORS	Miss Ingrid Sellschop
DEPARTMENT	Department of Physiotherapy
DATE CONSIDERED	28/01/2011
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 28/02/2011 **CHAIRPERSON** ....
(Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Dr Hellen Meyezwa

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX F

- **INFORMED CONSENT FORM FOR LEARNER**

Dear Learner 1/02/2012

My name is Ingrid Sellschop. I am a researcher at the University of the Witwatersrand (Ethics clearance certificate no: M110128M110128).

I would like to invite you to be part of a study that I am doing. The study is about how the use of a computer affects your posture. In the first stage of the study, you will be asked to fill out two questionnaires to help me to understand how much time you spend on a computer and if you experience any pain or discomfort as a result. It will take you 35 minutes in total to fill out both questionnaires. I will also observe how you work on a computer and I will measure you weight, height and the weight of your backpack. The weight measurements will be done in privacy using a screen or a separate room. You will be asked to complete the same questionnaires and measurements of your height, weight and how you work on a computer will be repeated at three months and at six months.

The second stage of the study will involve teaching you how to recognise poor posture and pain behaviour, and how to correct your workstation set up so that you will feel more comfortable when working at your computer. You will also be shown how do some gentle neck, back and arm stretches. This lesson will be 1 hour long. The full details of the study project will be explained to you when I see you at school. There are no dangers or risks involved in this study. Your involvement in this study is voluntary. If you have any questions you are welcome to contact me on my cell-phone 0832122404 or at work 0118079677.

Thank you for volunteering to be part of my study.

Consent

I ……………………………………………….agree to participate in the study on the effects of a participatory ergonomic intervention programme on adolescents in a school environment.
Signature of learner………………Signature of researcher…………… (I. Sellschop)

APPENDIX G

- **PARENTAL/GUARDIAN INFORMED CONSENT**

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM FOR USE BY PARENTS/LEGAL GUARDIANS

TITLE OF THE RESEARCH PROJECT: The effect of a participatory computer-related ergonomics intervention study on adolescents in a school environment.

REFERENCE NUMBER	**:** M110128M110128
PRINCIPAL INVESTIGATOR	**:** Ingrid Sellschop
ADDRESS	**:** P.O. Box 97643; Petervale; 2151
CONTACT NUMBER	**:** 0832122404

Your child *(or ward, if applicable*) is being invited to take part in a research project. Please take some time to read the information presented here, which will explain the details of this project. Please ask the study staff or doctor any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied and that you clearly understand what this research entails and how your child could be involved. Also, your child's participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you or your child negatively in any way whatsoever. You are also free to withdraw him/her from the study at any point, even if you do initially agree to let him/her take part.

This study has been approved by the Committee for Human Research at the University of the Witwatersrand and will be conducted according to the ethical guidelines and principles of the International Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

What is this research study all about?

Aim: To determine the effect of introducing into the school environment a participatory computer-related ergonomics intervention programme on musculoskeletal pain, postural changes and ergonomic behaviour in adolescents.

Procedures: The setting of the study will be the category one co-educational secondary schools in Gauteng. The information needed for this study will be gathered from different source groups, namely: heads of schools and teachers at secondary schools; and grade eight learners in two of the selected independent schools.

Phase one of the study will involve the collection of data from the teachers and learners by way of formally structured questionnaires. The weight and height of the learners will be measured in privacy behind a screen or in a separate room. The learners will then be observed working on their computers during a computer lesson. A video recording of their activity will be made, purely for research purposes. These measurements will be repeated at three and six months during the course of the study.

If your child is in the control school group then they will not go through the intervention phase of this study. If your child is part of the intervention group, then they will go through phase one and phase two of the study. Phase two, the intervention phase of the study will involve teaching the learners how to recognise poor posture and pain behaviour, and how to correct their workstation set-up so that they are more comfortable when working at their computer. Stretches for different muscles will be demonstrated and taught to the learners. This lesson will be 35 minutes in length and will take place during a computer lesson. The study will be conducted over a six month period. Baseline data will be obtained at the start of the study and then data will be collected at three months and at six months again.

Confidentiality: The Information collected will be treated with confidentiality and it will be included in a thesis and publication in a professional journal, without disclosing the identity of participants without their permission.

Why has your child been invited to participate?

Your child has been asked to participate in this study on the effects of a participatory intervention programme on adolescents in a school environment so that the researcher can identify risk factors for developing musculoskeletal pain and poor postural habits when using a computer. In doing so, an intervention programme will be developed that will help reduce pain and poor postural habits and encourage healthy ergonomic behaviour in schools and the home environment.

What will your responsibilities be?

To give consent for your child to participate in this study.

Will your child benefit from taking part in this research?

Possible benefits: The benefits of participating in this study will be that the data collected will contribute to strategic planning and furthering the development of ergonomic intervention programmes.

Are there any risks involved in your child taking part in this research?

There are no risks involved for your child.

If you do not agree to allow your child to take part, what alternatives does your child have?

Voluntary participation/refusal/discontinuation: Participation in this study is voluntary.

Who will have access to your child's medical records?

The information collected will be treated as confidential and protected. If it is used in a publication or thesis, the identity of the participant will remain anonymous. The researchers and university staff in the health sciences department will have access to the data.

Will you or your child be paid to take part in this study and are there any costs involved?

You or your child will not be paid to take part in the study. There will be no costs involved for you if your child does take part.

Is there anything else that you should know or do?

You can contact the Committee for Human Research if you have any concerns or complaints that have not been adequately addressed by the researcher.

You will receive a copy of this information and consent form for your own records.

DECLARATION BY PARENT/LEGAL GUARDIAN

By signing below, I *(name of parent/legal guardian)* …………………………………...……. agree to allow my child (name of child) ……………………………….…. who is ………. years old, to take part in a research study entitled *(insert title of study)*

I declare that:

I have read or had read to me this information and consent form and that it is written in a language with which I am fluent and comfortable.

If my child is older than seven years, he/she must agree to take part in the study and his/her ASSENT must be recorded on this form.

I have had a chance to ask questions and all my questions have been adequately answered.

I understand that taking part in this study is **voluntary** and I have not been pressurised to let my child take part.

I may choose to withdraw my child from the study at any time and my child will not be penalised or prejudiced in any way.

My child may be asked to leave the study before it has finished if the study doctor or researcher feels it is in my child's best interests, or if my child does not follow the study plan as agreed to.

Signed at (*place*) ....…........……………….. on (*date*) …………....……….. 2011

Signature of parent/legal guardian   Signature of witness

………………………………………..   ……………………………………

DECLARATION BY INVESTIGATOR: INGRID SELLSCHOP

I *(name)* ……………………………………………..……… declare that:

I explained the information in this document to …………………………………..

I encouraged him/her to ask questions and took adequate time to answer them.

I am satisfied that he/she adequately understands all aspects of the research, as discussed above

I did/did not use a translator (if a translator is used, then the translator must sign the declaration below).

Signed at (*place*) ....…........……………….. on (*date*) ……………………2011

Signature of investigator   Signature of witness

……………………………………… ………………………………………….

DECLARATION BY TRANSLATOR

I *(name)* ……………………………………………..……… declare that:

I assisted the investigator (*name*) …………..…………………………… to explain the information in this document to (*name of parent/legal guardian*) ……..………………………... using the language medium of Afrikaans/Zulu/Xhosa.

We encouraged him/her to ask questions and took adequate time to answer them.

I conveyed a factually correct version of what was related to me.

I am satisfied that the parent/legal guardian fully understands the content of this informed consent document and has had all his/her questions satisfactorily answered.

Signed at (*place*) ....…........…………….. on (*date*) …………...……….. 2011.

Signature of translator Signature of witness

…………………………….. ………………………………….

APPENDIX H

- **ERGONOMIC MULTIPLE CHOICE (MCQ) FOR INTERVENTION SCHOOL**

1. Posture can be described as

A. the way we hold our bodies

B. sitting up straight

C. exercising a lot

D. being healthy

2. The spine is supported by

A. muscles

B. heart

C. shoulder girdle

D. internal organs

3. Your school bag should weigh

A. no more than 10% of your body weight

B. about the same as you

C. less than 5% of your body weight

D. more than 10% of your body weight

4. If your school bag is too heavy you should

1. carry it on one shoulder
2. discard a few items
3. carry it across your back and both shoulders
4. carry the excess weight in your arms

A. 3 and 4

B. 1 and 2

C. 3 and 1

D. 4 and 2

5. The golden rule for stretching is

A. stretch gently and slowly for at least 20 seconds

B. if it hurts it means its working

C. the stretch period should be proportional to the activity period

D. stretching should be done as quickly as possible

6. If you wanted to stretch muscles in your upper back you could

A. squeeze your shoulder blades together

B. swing your arms around vigorously

C. clasp your hands above your head and reach for the ceiling

D. bend and straighten your knees a few times

7. If you slouch while sitting at a desk or computer, you may get pain in your

A. shoulder

B. stomach

C. thighs

D. arms

8. Poking your chin forward for a prolonged period may cause pain in the

A. shoulder and neck area

B. chin

C. arms

D. jaw

9. How far should you sit from your computer screen

A. an arm's length

B. 30 cm

C. as close as possible

D. a distance equivalent to your height

10. When sitting at your computer your feet should be

A. flat on the floor

B. neatly tucked under your chair

C. crossed under your chair

D. it does not matter as their position will not cause any pain

11. Choose the best position when sitting at a desk

A. sit back and upright in the chair

B. cross your legs

C. tuck your legs under you on the chair

D. lean to the side which is the most comfortable

12. If your feet don't reach the floor when sitting at your desk

A. put a file under your feet to rest on

B. put a sock on so your feet don't get cold

C. cross your legs

D. rather lie on the floor

13. If you use the mouse of the computer and it is too far from your body

A. you may get pain in your neck and shoulder

B. your legs will hurt

C. you will not experience any pain

D. you may make mistakes on your computer

14. Arrange the following in order, from first to last

A. feel it, move it, fix it

B. move it, feel it, fix it

C. feel it, fix it, move it

D. move it, fix it, feel it

APPENDIX I

- **FACILITATORS' MANUAL FOR COMPUTER-RELATED ERGONOMIC INTERVENTION PROGRAMME**

FACILITATORS' MANUAL FOR THE COMPUTER-RELATED ERGONOMIC SCHOOL INTERVENTION PROGRAMME

Introduction

It is important for educators and health professionals to take responsibility for shaping the ergonomic landscape of South Africa so that we, as a community, can encourage the implementation of preventative strategies such as training learners in ergonomic skills to ensure a healthier population.

Musculoskeletal problems reported by school children using computers have often been linked to poor posture and several studies have suggested that children using computers may be at risk of developing problems related to the musculoskeletal system (Dockrell et al., 2010a, Greig et al., 2005, Straker et al., 2009b). Recent studies on the ergonomics of computer use by children have identified potential negative effects of computer use on a child's health and productivity (Harris and Straker, 2000, Straker et al., 2009, Dockrell et al., 2010a). While the use of technology will improve a learner's educational pathways, it also introduces the possibility of exposing young people to poor postural habits and repetitive strain injuries resulting in musculoskeletal pain. Thus it is essential to introduce and implement a health promotion school programme in the area of ergonomics within the school environment.

Aims and benefits of implementing a computer-related ergonomics intervention programme in a school environment

The aim of the intervention programme is to encourage each learner to achieve the following learning objectives:

1. To understand the concept of musculoskeletal pain or discomfort.
2. To identify and describe musculoskeletal pain or discomfort.
3. To identify risk factors for developing musculoskeletal pain related to computer use, prolonged awkward sitting postures, as well as carrying heavy school bags.
4. To apply good ergonomic practice and health computing skills and to rearrange workstation at school and at home to optimize comfort and reduce the risk of developing musculoskeletal pain or discomfort.

5. To explore the importance of rest breaks, visual breaks and doing stretches.

In achieving these objectives, the proposed benefit of the programme is to reduce the occurrence of musculoskeletal pain over a period of time and to prevent any progression of dysfunction at a neuro-musculoskeletal level.

In addition to the above, there are numerous benefits of engaging student involvement in an effort to inspire good ergonomic behaviour, such as:

- enhanced student motivation
- encouraging problem-solving capabilities
- greater acceptance of change
- greater knowledge of the learning and work environment
- empowering the learner
- influencing the individual determinants of health-related behaviour
- prevention and/or reduction of developing musculoskeletal pain and pain.

The involvement of teachers in this process of teaching ergonomic skills to learners is also essential in that it will promote student and teacher self-efficacy, as well as empowering teachers and students to promote a change in behaviour that will benefit them in the long term in terms of implementing healthy computer skills and reducing the risk of developing musculoskeletal pain.

Programme outcomes

By the end of the Ergoskills intervention, learners will be able to:

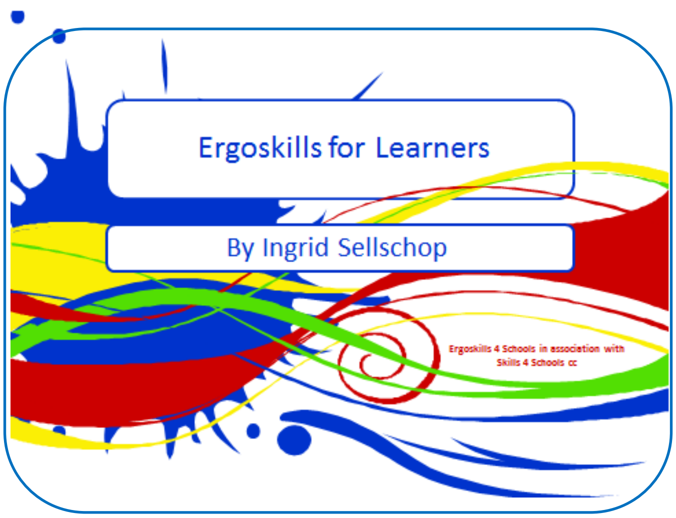
1. identify poor posture in themselves and others and be able to assist in improving posture in themselves and others when sitting at a workstation using a computer
2. calculate the appropriate weight of their school bag
3. apply the basic principles of ergonomics in the classroom and at home when using a computer
4. implement stretching exercises to assist in overcoming discomfort and injury related to poor ergonomics and poor posture
5. Understand the concept of ’feel it, move it, fix it‘ – being proactive and changing their behaviour to benefit their health.

Facilitator approach

This Ergoskills intervention is characterised by its open, friendly and casual approach to ensure participation and to create an accessible learning environment. The facilitator should be casual, yet not too friendly in approach, maintain good discipline and control while allowing for questions and interaction on a personal and group level. The dress code for the facilitator should be non-competitive and non-threatening and allow for movement flexibility when demonstrating stretch exercises. The class teacher and learners will be present during the intervention programme.

The facilitator should introduce his/her self and give a brief biography of who he/she is and what his/her expertise is in terms of being a physiotherapist. Following which put up the first slide (SLIDE 1) and introduce the programme and explain the slide.

Slide 1



1. The approach to the programme will be informal and will involve active participation of the learners both individually and in groups.
2. The intended outcome and benefits of the programme – the reason it is important to implement healthy computing habits both at school and at home.
3. The methodology – facilitation, demonstration, role-modelling and group activities.
4. The content –in the form of a visual presentation that will take approximately 45 minutes.
5. Assessment – there will be a short questionnaire to answer after the lesson to aid the learning process and assess if certain ergonomic and postural principles have been understood.

6. Reinforcement 1 – A stretch card with stretch exercises and a red sticker (which can be applied to the top right hand corner of their home computer screen to act as a reminder to adjust their posture when working at the computer) will be handed out to each learner to take home with them after the lesson.
7. Reinforcement 2 – A poster illustrating correct workstation set-up and correct carrying of a schoolbag will be put up in the classroom after the lesson to aid in reinforcing the principles learnt during the course of the programme.

Following slide 1 and the introduction go onto to SLIDE 2 and ask the class if anyone has any pain or discomfort in their muscles or joints? Give them examples of tension in their neck muscles, headaches or a stiff lower back.

Slide 2

Slide 3

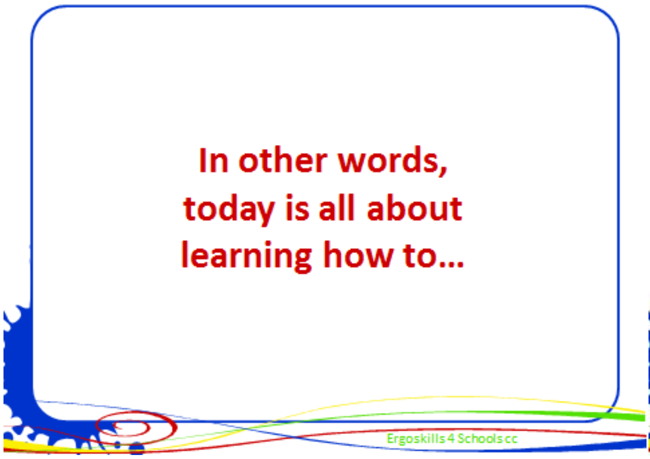
Having introduced the concept of identifying who has muscle pain or discomfort, move to SLIDE 3 and explain what the lesson today is all about.

- The types of activities that can cause pain or discomfort
- How we can learn to move (exercise, stretch) and reposition ourselves and our workstations to help prevent our bodies from feeling pain and stiffness.

Slide 4 and slide 5

SLIDES 4 and 5 represent the introduction of the common theme throughout the programme which is 'Feel it, Move it, Fix it'. You can introduce this theme by saying that, in summary, today is all about learning how to 'feel' if there is a problem in our bodies, learning to 'move' and change position regularly to make ourselves feel more comfortable and to take regular breaks while working at a computer; and learning to 'fix' or adapt our workstations to suit our body's needs and encourage a good comfortable working posture.

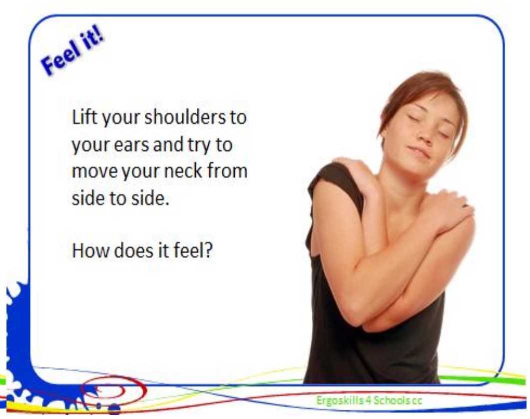
Slide 4 **Slide 5**



Slide 6 and slide 7

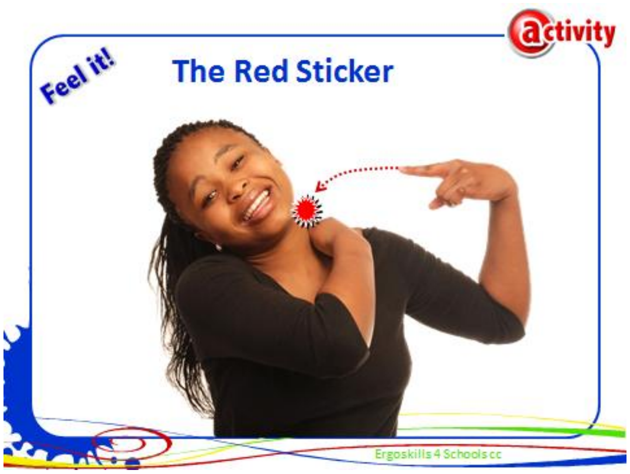
These slides introduce the concept of identifying if you feel discomfort or pain and where on the body you feel it. SLIDE 7 involves an individual activity whereby you as the facilitator demonstrate to the learners how they can feel muscle tension in the neck by pulling their shoulders up towards their ears and feeling the muscles over their shoulder areas – muscle contraction (hunched up shoulders) vs muscle relaxation (shoulders down and relaxed arms). Explain to the learners that this 'hunching up' position of their shoulders commonly occurs when one has been sitting awkwardly at a computer for a prolonged period of time and that this can cause discomfort, pain or headaches.

Slide 6 **Slide 7**



Following on from this individual activity, SLIDE 8 instructs the learners to participate in a class activity.

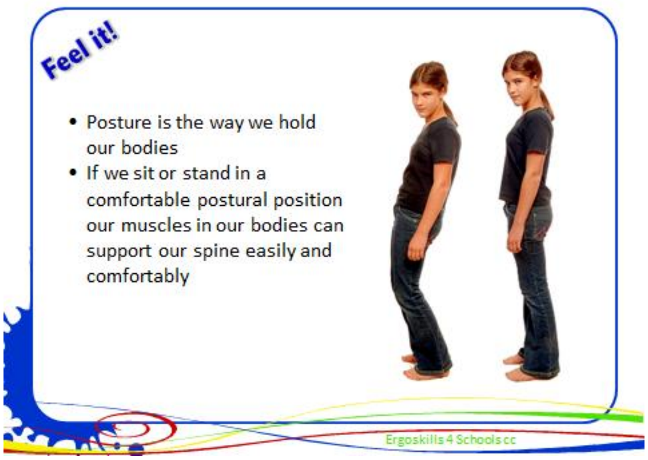
Slide 8



Explain to the class that you would like a person to volunteer to come up to the front of the classroom so that their class mates can come up one at a time and stick a red sticker onto the area that they feel pain or discomfort. This activity demonstrates to the class the numerous areas on the body that learners may be experiencing pain or discomfort. In the past this type of activity has shown that there tends to be a greater percentage of stickers in the neck, shoulder and lower back areas. This activity encompasses the 'feeling' aspect of the educational session. Learners need to be aware of 'feeling' and then identifying and expressing their pain so that they can learn to problem solve in terms of 'moving' (changing their posture) and 'fixing' their workstation.

Slide 9

After completing the class activity for slide 8, follow with SLIDE 9 and introduce the concept of posture – what it is and how it relates to our bodies and that awkward sitting or standing posture can lead to muscle and joint pain or discomfort.



Slides 10, 11, 12 and 13

The next four slides demonstrate the effect of a heavy schoolbag on our posture. This is a class activity. Ask the learners to stand up next to their desks and to hold their school bags out in front of them – 'are they heavy?'. Then ask them to place their school bags on their backs as if they are shoulder bags or to hold them at their sides as if they are carry bags. Ask the learners to look at each other and see how they are standing.

Slide 10

Slide 11

Slide 12 **Slide 13**

Once the class has sat down again, engage the learners by asking three randomly selected learners if they felt that their classmate's school bag was heavy and why? Did it affect their posture? This leads onto SLIDE 14, which asks the class 'How heavy should your school bag be?' Followed by SLIDE 15, which illustrates how to work out what their school bag should weigh. This is an activity in which the learners are asked to work out the correct weight of their bag based on their own body weight.

Slide 14 **Slide 15**

SLIDE 16 then illustrates how learners should carry their shoulder bag if it has shoulder straps. The school bag should sit just above their waist level or belt level so that it does not pull their posture down and backwards.

Slide 16

The next ’feeling‘ activity is for learners to feel what their eyes feel like – are their eyes feeling dry or moist/lubricated? SLIDE 17 illustrates the concept of blinking, breathing and focusing on an object at a distance from where they are sitting.

Slide 17

This is an individual activity that you ask the learners to do while they are sitting at their desks or workstations. It is important for them to remember to ’blink‘ as this helps to lubricate and protect their eyes from becoming dry and tired/painful. Explain to the learners that tired, dry, painful eyes cause them to feel tired in themselves and in doing so this can cause their posture to slump. So they are learning to protect their eyes by lubricating them, exercising their eyes by focusing long-distance (as computer work demands short sighted focus) as well as improving their sitting posture by not slumping, and taking a deep breathe facilitates the circulation to the body and brain.

The above activity ends the teaching of the ’feeling‘ aspect of the intervention programme. SLIDE 18 introduces the concept of ’moving‘ and ’exercising‘.

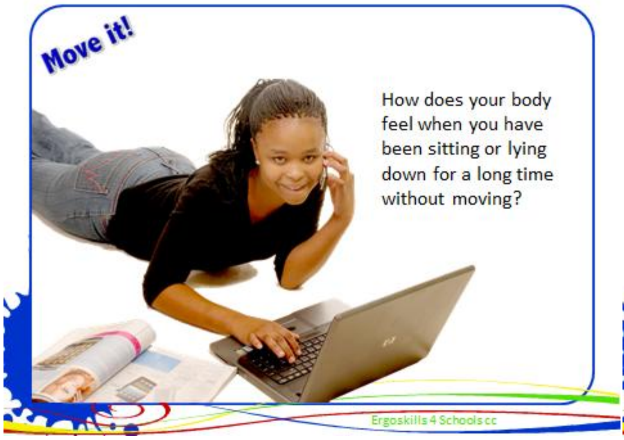
Explain to the class that you will now be teaching them how to apply movement in the form of stretches to their body to help them reduce the risk of developing poor awkward sitting postures that can lead to shortening of different muscles and in turn causing pain or stiffness. SLIDE 19 illustrates and prompts you to ask about who plays sport or a musical instrument or computer games and who actually does some stretching during these activities. Explain briefly the importance of changing position regularly and that stretching a specific muscle, which may get tight while doing a certain activity, is essential to ensuring a healthy body.

Slide 18

Slide 19

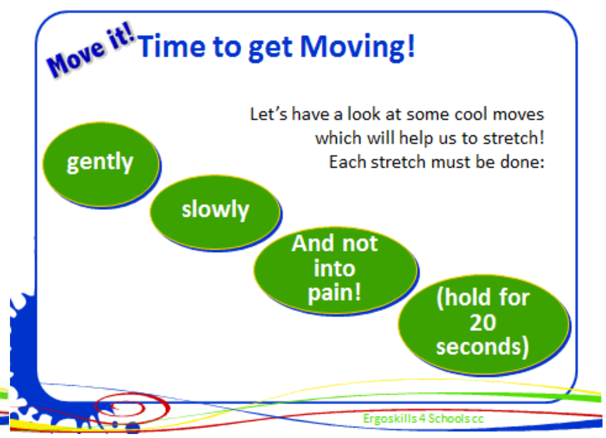
SLIDES 20 and 21 illustrate the concept of a poor postural position while performing an activity – in this case while working on a laptop or a desktop. SLIDE 21 calls for an individual learner to volunteer to demonstrate a slouching posture in front of a workstation. Then ask all the learners to ’feel‘ the slouching posture in their own chairs by engaging in the activity and then to ’move‘ in a way that corrects their poor posture to an appropriate sitting posture. Then reinforce a previous concept learnt relating to ’feeling‘ that teaches the learner to ’move‘ out of a poor posture into a better posture while working at a computer or sitting at a desk.

Slide 20 **Slide 21**



Once the concept of ’move it‘ has been introduced, SLIDE 22 introduces ’goal setting‘ to the learners. It is important to explain to the learners that we change our behaviour by setting a goal and consciously acting on the steps to achieve that goal. In this case the goal is to ’stretch a body area that is vulnerable to becoming stiff or tight while working on a computer or carrying a heavy school bag at least twice a day’. Following this with SLIDE 23 and explain and demonstrate how to stretch and the principle of doing the stretch ’gently, slowly, not into pain, and to hold the stretch position for 20 seconds for it to be effective‘.

Slide 22 **Slide 23**



This introduction reinforces the common theme of ’move it‘ and SLIDE 24 will start with demonstrating the different stretches.

Slides 24 demonstrate the various stretches

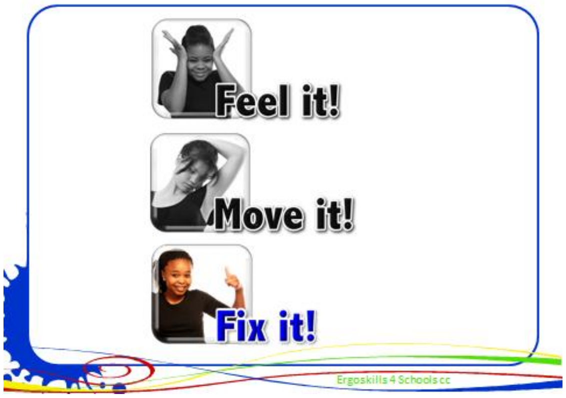
(For example) This slide illustrates the different body areas to be stretched. For each stretch, you, as the facilitator, must demonstrate the stretch to the class and then ask the learners to stand up at their desks and to repeat the stretch activity after your demonstration. While they perform the stretch you can watch that their technique is correct and physically assist a learner that is not doing the stretch correctly to perform it with correct form.

After each stretch has been demonstrated and practiced, SLIDE 36 teaches the learners how to breathe. Explain to learners that consciously taking a deep breath helps to promote a sense of relaxation and helps the muscles in the body to relax. It also assists with enhancing oxygen flow to the brain and muscles. Ask the learners to take three deep breaths while sitting at their desks and then randomly choose three learners and ask each one to provide feedback on how they feel after doing the breathing exercise.

Slide 36

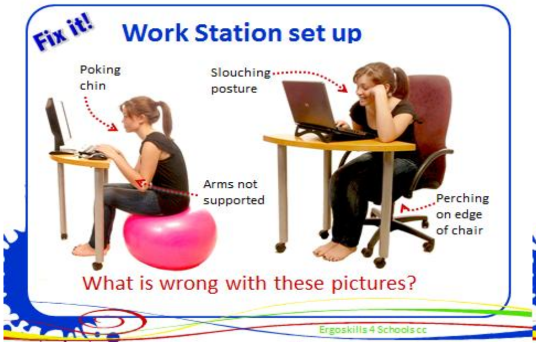
After finishing the breathing activity with the class, introduce SLIDE 37, which summarises the theme of 'Feel it, Move it, Fix it' and highlight the fact that the next concept they will be learning is the concept of 'fix it'. In other words you will be facilitating the process of problem solving with the learners by identifying poor postures and poor workstation set-up and the ways to change them so that they encourage good posture and healthy computing skills.

Slide 37

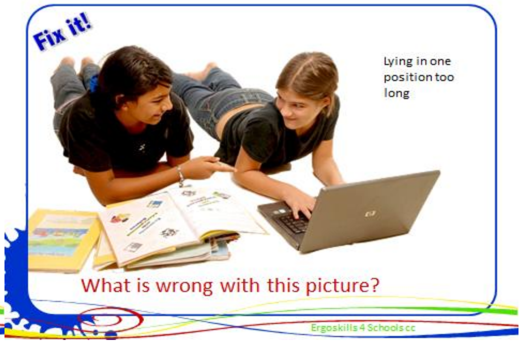


SLIDES 38 and 39 are a problem solving activity to teach learners how to identify a poor postural set-up with regards to a workstation and other activities using a laptop that may put a learner at risk for developing postural strain. Ask the class with each of the SLIDES 38 and 39 to identify what is wrong with each picture and then, as you get feedback from the class, facilitate the answer process by bringing in the answers gradually onto the screen

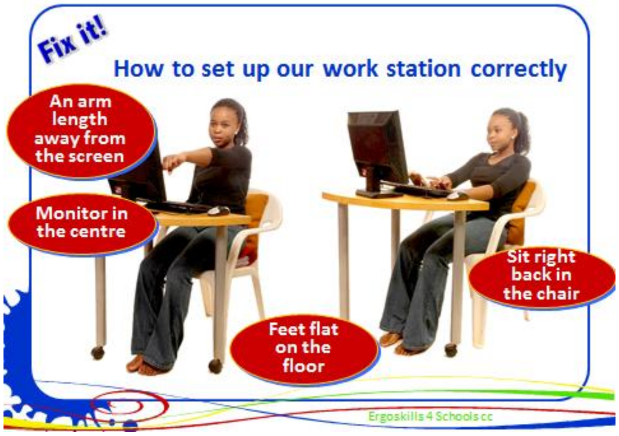
Slide 38



Slide 39



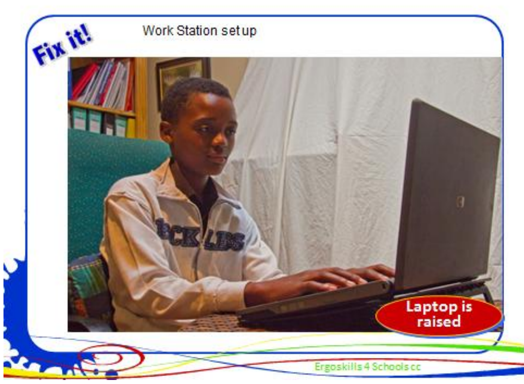
Next introduce **Slide 40**



Explain the concept of 'ergonomics' to the class. The correction of their workstation set-up to fit their body is called 'ergonomics'. Following the slide demonstration and the explanation of 'ergonomics', reinforce the 'fix-it' concept by asking the learners to get into a group of four learners each around a workstation. One learner must be the role model while the other three learners assist in helping the learner to adjust the workstation to optimize the ergonomic set-up. You, as the facilitator, will walk around and check that each group is managing to complete the task correctly. This activity encompasses the 'fix-it' aspect of the educational programme.

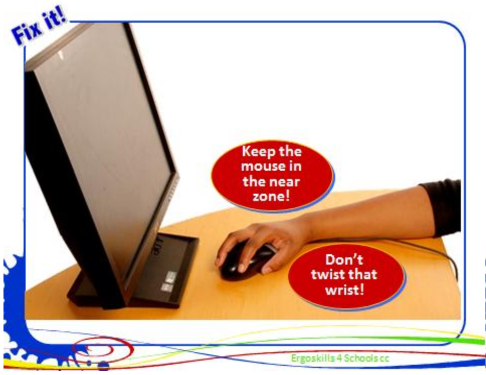
On completing this group activity, reinforce the concept with a summary of the workstation set-up as illustrated in SLIDES 41 – 44. With each slide ask the class what adjustments they would recommend before prompting the red prompts onto the screen.

Slide 41



Slide 42

Slide 43 **Slide 44**



The last four slides act as a summary of what ergonomics is and how the learners can apply it in their school and home environment.

SLIDES 45 and 46 act as a summary of what the learners have learnt today. It is essential that you summarise the concept of 'Feel it, Move it, Fix it' and ask the learners if they have any questions and how their muscles are feeling? Do they feel that their muscles are more relaxed? Are the confident that they can adjust any workstation set-up where ever they are working – at school or at home?

Slide 45 **Slide 46**

The last slide, SLIDE 47, ends the educational presentation by giving learners a website link that they can use to download a complete ergonomic and stretch programme for home computer use. This software has stretch prompts on it to remind you to stretch every 30 minutes, or you can personalize the time intervals for yourself. It also provides images and instructions on how to stretch and also on how to set up a workstation correctly.

Slide 47

After completing the presentation, hand out a short questionnaire to each learner to assess if they have learnt certain concepts during the course of the programme implementation. The questionnaire should take eight minutes to complete (see Appendix H).

Script examples of tasks and activities that can be used to aid the facilitator with the implementation of this ergonomic intervention programme

Introduction

Introduce yourself – Hi my name is Ingrid. I am a physiotherapist and I am here to talk to you about pain and how you can reduce and prevent pain from occurring in the future. The types of activities that can cause pain are: sitting in poor positions or sitting for a prolonged period of time behind a computer, carrying a heavy schoolbag, lifting heavy objects and even texting on your cell phone.

Which of you has got any pain?

Task demo 1: Shoulder tension

Now that you have thought about where you feel pain (discomfort), I want you to put your hands on your shoulders and feel the muscles (Trainer – puts her hands on her shoulders to demonstrate). Now lift your shoulders to your ears and try to move your neck from side to side. How does it feel? Awkward and tight? This can happen to our neck and shoulders when we are writing or typing on a computer and it will eventually cause you to have neck and shoulder pain and even a headache.

Task activity 1:

Who would like to come up to the front of the class to show us with these red stickers where you feel pain? (Learner to stand in front of the class and apply red stickers to areas of pain). Ask other learners in the class to point out areas of pain to stick on the volunteer.

Trainer to follow up with different colour stickers for areas of pain not identified – wrists and jaw. This activity encompasses the FEELING aspect of the educational session. Children need to be made aware of feeling and then expressing their pain.

Causes of pain:

What activities can cause our pain? Earlier I referred to lifting your shoulders up to your ears. This is a position we call poor posture. Posture is the way we hold our bodies and if we sit or stand in a comfortable postural position, the muscles in our bodies can support our spine easily and comfortably without feeling strain.

Task activities 2 and 3:

Bag holding activity: Ask all the learners to stand up and hold their bags out in front of them. See how long you can hold your bag without feeling pain or tired. I am going to time one minute. So how did that feel? Did you notice different areas of your body taking strain? Ask two learners to show you where they felt pain during this activity.

Bag back carrying activity: Those of you that have satchels please put them on your shoulders now and remain standing. Which of you feels that your bag is too heavy or as if it is straining your back or neck?

Did you know that the ideal weight of your schoolbag should be 10% of your body weight? So if Johnny weighs 45 kg, then his bag should not weigh more than 4.5 kg.

Task activity 4: Sitting posture

Ask a learner to come up to the front of the class and sit on a chair (this acts as a mirror to the class). The actor now slouches and the trainer asks the class to mimic the actor. What is starting to hurt?

Okay, now let’s get some ideas from you as the class as to how we can help ’Johnny –actor‘ to correct or fix his posture. How can we help him not to slouch?

Trainer stand behind the actor and facilitates postural correction – sit with your lower back into the back of the chair; feet flat on the floor, shoulders relaxed and no chin poke... balance your head on your neck so that you don’t look like a tortoise.

The way we sit at a desk or while we work on a laptop or read a book, is very important in managing or preventing feelings of muscle or joint pain in the body. Let us now look at how we can optimise our workstation set up in a classroom or home environment.

Demo activity: Slide with picture of a child at a workstation in a poor postural position

Ask the class to identify what is wrong in the picture. Then using a Custom animated slide, talk through a practical solution to correcting the work station set-up.

Feet flat on the floor or put a book/school bag under your feet if you are too short.

The monitor must be central and the monitor height – the top line of writing on a word document must be at eye-level or just below. You may need to raise your chair or raise the monitor onto a book depending on your situation and height.

The keyboard should be close to you and the monitor an arms-length away unless you wear reading glasses.

Keep your elbows relaxed by your side so that your shoulders don’t get tense.

The mouse should be close to you keyboard area so that you don’t have to stretch out your arm too far. We refer to pain in the upper back area when using an outstretched arm with the mouse, as runaway mouse syndrome. Your shoulder is built for mobility (moving) not for stability.

Remember that what you are learning here today you can apply to your workstation at home. If you are using a laptop, then you may need to raise the laptop onto an ergo-tilt (support sloping table) or use a book. IF you use a book then you will need to get a separate keyboard and mouse, otherwise your wrists will be at risk of injury.

The correction of your workstation set up to fit your body is called ERGONOMICS. This is a term that you should become familiar with as it is important in preventing injury in the future.
The above activity encompasses the 'fix-it' aspect of the educational programme.

Now we have identified what can cause pain in the body and how we can fix the environment and our posture to help reduce pain. I am now going to show you how you can stretch your muscles to help reduce pain and prevent poor posture.

Which of you play sport? Which of you play a musical instrument? Which of you dance?
Which activities do you stretch before starting your activity? Why do you stretch? Think of top athletes or dancers – they all stretch before they do their sport so that they can reduce the number of injuries they may get. Stretching gives them flexibility and power.

Which activities can you think of that you don't stretch in? What do you feel when you have been sitting for a long time and you get up to start walking? Stiffness? Pain and discomfort?
Go back to the pain that you felt at the start of today. Rate the pain out of 10. 1/10 being very little and 10 being excruciating. Okay, now I am going to demonstrate some stretches and you are going to copy me. Each stretch must be done gently, slowly and not into pain. You hold the stretch position for 20 seconds.

Demo: Stretches by trainer and on a slide
After doing all the stretches, ask the class how their areas of pain rate now out of 10? Has the pain reduced? Do you feel less stiff? Ask them to raise their hands if their pain feels better?
This exercise demonstrates that movement and stretching are vital activities to get into the habit of using during the course of our lives.

In summary we have learnt how to feel or identify pain: what can cause pain and how we can manage or prevent pain, AND REMEMBER... MOVEMENT IS ESSENTIAL.... so remember the theme…..

FEEL IT, FIX IT, MOVE IT