A BIOMECHANICAL ASSESSMENT OF SELECTED PATIENT TRANSFERS: THE EFFECTS OF INSTRUCTION AND EXPERIENCE FOR IMPROVING THORACOLUMBAR MOTIONS AND ELECTROMYOGRAPHIC MUSCLE ACTIVITIES

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A biomechanical assessment of selected patient transfers: The effects of instruction and experience for improving thoracolumbar motions and electromyographic muscle activities

by

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ABSTRACT

Billions of dollars are being spent each year in North America alone on the treatment and compensation of low back disorders (LBD) related to work processes. Nursing characterizes one of those professions at high risk for the development of LBD. Previous research has identified that patient handling has been the leading cause of occupationally-related LBD for nurses. In response to a need for ergonomic intervention, the Back Injury Prevention Program (BIPP) was introduced in Newfoundland in 1989. While there was some anecdotal evidence that this macro-ergonomic approach was successful in reducing risk of injury, there has been no reported biomechanical evidence that the patient transfer techniques prescribed by BIPP were related to these reductions. The purpose of this study was to examine whether instruction in BIPP transfer techniques is related to beneficial changes in biomechanics metrics thought to be associated with risk for developing LPB. Two comparisons were considered in this model. First, novice subjects were compared prior to and following a standardized BIPP training session, specific to three patient transfer techniques. Secondly, an experienced group of active institutional nurses were measured while performing the same tasks. These transfers were selected based on their history of high incidence of injury and included repositioning a patient to the head of the bed from a side-on position and a position superior to the patient's head and a transfer from a sitting bed position to a wheelchair. Bilateral electromyography (EMG) and a Lumbar Motion Monitor (LMM) were employed to monitor each subject during the execution of a task. Results suggest that BIPP principles for patient transfers reflect sound biomechanical principle, as participant experience increased, the biomechanical demands decreased. Further investigations should consider the administrative controls involved in the implementation of this program in the workplace.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Manual material handling (MMH) has been identified as a major etiological factor for musculoskeletal disorders (Marras, 2000; Marras, Lavender, Leugrans, Fathallah, Ferguson, Allread and Rajulu, 1995). The most common musculoskeletal injury that occurs as a result of manual materials handling activities are low back disorders (Marras, 2000; Marras, 1999; Marras et al., 1995). Professions that sustain the majority of manual materials handling injuries are construction, forestry and laborer as loads are often either heavy or frequently lifted (Orr, 1997; Guo, 2002). It is estimated that the cost of low back injuries is approximately $25.6 billion per year in Canada (Kim, Hayden and Moir, 2004).

The high cost of back injury has lead ergonomists and researchers alike to assess what aspects of manual materials handling tasks are related to musculoskeletal injuries. Low back disorders (LBD) have a complex and mulitfactorial etiology comprised of physical, organizational, psychosocial and individual factors (Karwowski, Jang, Rodrick, Quesada and Cronin, 2005). In order to determine how to address and prevent injuries from happening, ergonomists and researchers have begun to analyze how each factor relates to the overall risk of developing LBD.

Physical and organizational factors possess an obvious relationship to LBD and have been found to be the easiest to mediate towards reducing the overall risk of injury. The physical factors include: static work, posture and technique, load characteristics, handles and coupling, frequency and repetitive handling, asymmetrical handling and non-uniform loads, space confinement and restraints (Jones and Kumar, 2001). Work organization factors include availability of necessary staff and equipment and synchronicity of the tasks required for the job. These factors are related to the task efficiency as well as the physical demands involved in performing tasks. Physical and organizational factors can be optimized to reduce the risk of injury to an operator.

Psychosocial factors are best described as the mental and social stresses of a worker. How psychosocial stress impacts upon an injury is not well understood. There are two theories postulated for potential pathways of how psychosocial stress can manifest into physical injury. The first theory suggests that psychosocial stress will cause an increase in tension in the muscles and therefore increase their susceptibility to injury (Yip, 2001). In combination with this theory is that increased psychosocial stress could cause the worker to be mentally distracted. Lack of attention and focus would inhibit an operator from being able to identify a hazardous situation which otherwise could have been avoided (Yip, 2001).

The second theory regarding the impact of psychosocial factors in injury is that these stresses amplify the sensation of pain. Therefore, an injury that may have already existed with only minor symptoms may become more symptomatic and exaggerated when psychosocial stress is added to the situation (Yip, 2004). Therefore stresses such as job dissatisfaction, monotony of work, limited job control, and lack of social support can be addressed to reduce the risk of injury (Cartledge, 2001; Yip, 2001; Bewick and Gardner, 2000, Retsas and Pinikahana, 2000; Lagerstrom et al., 1998; Cohen-Manfield et al., 1996).

Individual factors have also been reported as impacting the susceptibility of an individual to injury (Smedley et al., 1997). These factors are inherently not easily changed to create a reduction in risk of injury. These factors include age, previous history of back injury, stature and obesity (Smedley et al., 1997). There are but few professions which permit consideration of physical characteristics in the employee selection process. For example, before entering the profession of firefighting an individual must meet a physical fitness standard. However, it is constitutionally unacceptable to consider such criteria in a profession such as nursing.

The profession of nursing is an unexpected profession seen to be ranked next to forestry and construction professions for its high incidence of back injury due to manual materials handling (Yip, 2004, Retsas and Pinikahana, 2000; Marras, Davis, Kirkling and Bertsche, 1999; Smedley, Egger, Cooper and Coggon, 1997; Cohen-Mansfield, Culpepper and Cooper, 1996; Owen and Garg 1991). In Newfoundland and Labrador, health care is ranked the 4th highest sector for workplace injuries, with most of the injuries being musculoskeletal injuries to the low back (WHSCC, 2004). Research has indicated that patient handling is a major contributor to the prevalence of back pain in nurses and other health care professionals (Venning, 1988; Owen & Garg, 1991; Cohen-Mansfield et al., 1996; Hignett, 1996; Orr, 1997; Engkvist, Hagberg, Hjelm, Menckel and Ekenvall, 1998; Marras et al., 1999; Lagerstrom et al., 1998; Bewick & Gardner, 2000; Yip, 2001; Skotte et al., 2002). Nursing has a unique set of challenges with regards to manipulating physical characteristics of manual materials handling tasks. Nurses are faced with the difficulty that they are in fact handling patients and not inanimate objects.

In other professions, ergonomic interventions generally focus on manipulating the load, either changing the dimensions, the handles or the weight of the load and adjusting the positions and distances in which they are moved. However, in the health care setting these loads can not be altered and vary from shift to shift. Workload will depend on the number of transfers and state of well-being of patients being handled. The frequency of lifting and the amount of weight lifted on any particular shift can not be standardized or always controlled. Unfortunately this has left the profession with a limited ability to make ergonomic accommodations to patient handling tasks.

Factors other than patient handling demands also contribute to the nursing profession being at a high risk for injury. The emotional stress associated with nursing, the lack of control that nurses have over their patients and the stress of shiftwork all increase the risk of injury (Cartledge, 2001; Retsas and Pinikahana, 2000; Lagerstrom et al., 1998). The aging workforce in the nursing profession also impacts upon the high risk of injury (Buchan, 2002). Administrative factors such as lack of adequate staff and lack of necessary equipment will also increase a nurse's exposure to risk (Engvist et al., 1998).

Interventions that have been used with some success to reduce the risk of injury attributed to MMH include: mechanical aides, back education, job redesign and employee selection (Veening, 1988). In Newfoundland and Labrador, the Back Injury Prevention Program (BIPP) was developed in 1989 to educate practicing and student nurses on proper transfer and patient handling techniques. The BIPP patient handling techniques were designed on basic biomechanical principles and attempted to reduce the loads acting on the body, particularly the upper extremities. Stinsen (2000) reported that there was, in fact, a decrease in the number of back injuries since the introduction of the BIPP program. Since its introduction, however, the transfers considered in the BIPP have never been assessed for their biomechanical efficacy. In consideration of the predicted shortage of nursing staff by the year 2020 and its obvious impact upon the health care system (Janiszewski, 2003) any program that reduces risk of injury to a person performing a patient handling task will be timely.

The purpose of this study was to investigate whether the BIPP provides sufficient user knowledge regarding body mechanics and movement technique during selected patient transfers to reduce the risk of musculoskeletal injury.

1.2 Hypotheses

This study had two hypotheses. The first hypothesis proposes that the training from the back injury prevention program (BIPP) would not have an effect on thoracolumbar kinematics and selected muscle electromyographical activities between pre- and post-trained novice participants for selected patient transfers.

The second hypothesis proposes there would be no significant difference between the thoraco-lumbar kinematics and selected muscle electromyographical activities recorded from novice participants pre- and post-training results and experienced nurses when performing selected patient transfer tasks.

1.3 Assumptions

Assumptions made in this study include: the effectiveness of BIPP instruction, the reliability of the LMM as a surrogate metric to measure thoracolumbar kinematics and their relation to low back stress. This study also assumed that laboratory atmosphere of the BIPP room of the Miller Center provided sufficient ecological validity for the methodological design. A healthy patient was used in the study in order to protect the health of participants and as well, guard the participants from any unexpected behavior that could occur with a real patient. It is assumed that the model patient behaves in a consistent and realistic manner.

1.4 Limitations

Construct limitations include the possibility for the Hawthorne effect to influence the results. The Hawthorne effect explains the changes to human behavior that occurs as a result of a subject knowingly being observed and consequently modifying the behaviour to more closely satisfy what the subject perceives to be the expectations of the researchers (Muchinsky, 2000).

There are limitations to using EMG activity and LMM values to reasonably predict musculoskeletal loading and therefore risk of low back disorder (LBD). The use of maximum voluntary contractions (MVC) to normalize the EMG data is also a limitation to the accurate description of the participants' muscle activity.

The ethical concerns that human investigation studies must consider often result in methodological limitations. In this study the novice participants are never truly unaware of the proper techniques employed in patient transfers as each viewed a BIPP training video prior to the pre-training testing protocol. This was done in consideration of participant safety as patient handling can be considered a heavy handling task.

CHAPTER 2: REVIEW OF LITERATURE

2.1 Introduction

There is considerable concern regarding the continual increase of reported low back disorders (LBD) in industrial populations (Burton et al., 1997; McCoy et al., 1997). Employers are reported to be spending upwards of $100 billion annually in compensation costs for LBD (Guo, 2002). The high rates of LBD and the resulting economic impact upon society requires further investigation. Research has focused on the multifactoral etiology of LBD and what components of a task or profession contribute to the incidence of pain and discomfort (Karwowski, Jang, Quesada and Cronin, 2005). Studies have also identified nurses amongst the top professions for risk of developing occupational-related LBD (Karwowski et al., 2005). This profession includes a unique number of characteristics unlike other professionals typically examined. This chapter will review the research conducted in the areas of the cost of back injuries, etiology of LBD, and workplace contributors and interventions specific to the nursing profession.

2.2 Cost of Occupational Injury

It has been estimated that 80% of the American population will experience low back pain during their lifetime (Marras, 2000; McCoy et al., 1997). The economic costs of LBD in the workplace can be staggering. According to Marras (1999) LBD have increased by 2700% from 1980 to 1993, with compensation authorities worldwide reporting expenditures somewhere in the range of $5000US to over $60 000US per LBD claim. Even though LBD only account for 26% of all workplace injuries, they represent approximately 30-40% of all injury compensation costs (Marras, 1999; McCoy et al., 1997; Smith, 1997). In Canada alone, costs of musculoskeletal disorders were reported at $25.6 Billion (Kim, Hayden and Moir, 2004).

The cost of a low back disorder claim can be broken down into two accounting factors: direct and indirect costs. Direct costs include the costs associated with medical care, compensation for lost income due to a disability, the management of disability and the potential increases in insurance premiums (Marras, 1999; Cohen-Mansfield, Culpepper and Cooper, 1996). In Canada, the direct costs were reported to be $7.5 billion (Kim et al., 2004).

Each claim will also have related indirect costs. These costs can include, for example, expenses due to absenteeism, loss of production due to overtime, the recruitment of a new hire to replace an injured worker, decreased production while training the new hire and cost of mistakes by new employees (Marras, 1999; Cohen-Mansfield et al., 1996). The indirect costs in Canada were reported by Kim et al. (2004) to be $18.1 Billion. In the United States costs were calculated to be approximately $16 Billion US in 1984 (McCoy et al., 1997). By 1990 the direct costs rose to just over $23.5 Billion US (McCoy et al., 1997). More recent annual estimates reveal that approximately one fifth of all work-related injuries are related to the spine with upwards of US$100 Billion being spent on LBD annually (Marras, 2000; Cohen-Mansfield et al., 1996). Considering that Marras (1999) reports 47% of the population performs physically demanding jobs that place workers at risk for developing LBD, it becomes clear that this issue presents itself as a significant economic and social problem.

2.3 Etiology of Low Back Disorders

2.3.1 Introduction

Investigation of how the LBD occurred is vital when attempting to prevent and control occurrences of future injury. Due to the complex anatomy and physiology of the spine and psychosocial variance of humans, there are many factors that combine to create a situation for an injury to occur. Karwowski et al. (2005) stated that LBD have a mulitfactorial etiology consisting of physical, work organizational, psychosocial, individual and socio-cultural factors.

2.3.2 Physical loads

The most obvious and most researched factors regarding LBD are the characteristics of the load and body posture during the manual materials handling (MMH) event (Marras, 2000; Marras, 1999; Marras, Lavender, Leugrans, Fathallah, Ferguson, Allread and Rajulu , 1995). Spinal loading is related to both internal and external forces acting on the system. An external load is a force that acts on the body (Marras, 2000). An internal load is described as the magnitude of forces created by the muscles, tendons, ligaments and skeletal structures. The mass of the external load, the distance at which this load is located from the articulation and the velocity at which this load must travel will impact the amount of internal load that is required to effect the task (Marras, 2000; Marras, 1999).

2.3.3 Types of loading

Occupational-related back injury occurs when the biophysical tolerance of the soft tissues is exceeded and can be related to the compression, torsion and shear forces acting upon the system. Much research has been conducted to determine the magnitude of forces in each plane that will result in a musculoskeletal injury (Marras, 2000; Marras, 1999; Waters, Putz-Anderson and Garg, 1994).

Compression forces acting on the trunk due to a MMH activity can result in trauma to muscles, ligaments, tendons, discs and endplates located in the spinal column. An injury will occur if the absolute or cumulative forces exceed the soft tissue tolerance. Previous research from the National Institute of Occupational Safety and Health (NIOSH, 1981) identified maximal compression forces that can be tolerated by the spine. An average limit of 3400 N was determined to be tolerable before vertebral endplate damage is likely to occur (NIOSH, 1981). Since the vertebral endplate is responsible for facilitating nutrient flow to the disc, trauma to these structures can result in atrophy and degeneration of the disc (Marras, 1999). The NIOSH compression limit became widely accepted as the action limit, or the allowable limit of disc compression for a job to be considered safe. The maximum permissible limit indicated was 6400 N of compression, at which jobs requiring exertions above this limit would be considered hazardous

(Marras et al., 1995; Waters et al., 1994). Subsequent research has revealed that repetitive loading appears to reduce the loading tolerance of involved tissues. While static models may provide a means of initial evaluation of a task, it is not a valid approach to understanding the etiology of chronic LBD due to more dynamic MMH activities (Marras, 2000).

2.3.4 Injury pathway

Injuries may be classified as either acute or chronic. An acute injury is generally a result of a single accident or trauma (Pengal, Herbert, Maher and Refshauge, 2003). Clinical evidence in the UK has concluded that approximately 90% of persons suffering from acute back injuries make a medical recovery within 6 weeks (Pengel et al., 2003). Acute back injury cases, with no previous history of injury, will have less scar tissue and patients can be rehabilitated more quickly than a chronic injury case. Chronic injury is typically a result of untreated acute injuries, cumulative loading and/or long-term exposure (Marras, 2000; Marras, 1999).

Recently, Marras (2000) postulated a pathway that is believed to represent the sequence of events that precede the occurrence of LBD. Excessive or repetitive loading as a result of the internal and external forces cause microfractures to the vertebral end plates. When these microfractures occur the individual will typically feel no pain as few pain receptors are located in the disc fibers. Of greater concern are end plate micro-fractures, as scar tissue begins to form. End plates are responsible for transporting nutrients to the disc fibers. Since scar tissue is denser than normal tissue it will impede the nutrient flow to the disc. When this occurs the discs will atrophy and weaken, resulting in degeneration. This is the mechanism that has been thought to be responsible for the lowered tolerance of the spine after cumulative loading (Marras, 2000).

Kumar and Jones (2001) indicated that repeated exposure to stress creates hysteresis in the collagenous materials due to its viscoelastic properties. Hysteresis is a tissue property described as the difference in the amount of relaxation that occurs in tendon and ligament tissue during the loading phase compared to the unloading phase. Even repeated exposures to minimal loads can lead to permanent elongation of the collagen structures of ligaments and tendons, otherwise known as creep. As a result of the stretch, capillaries in the muscle may become compressed and this may cause ischemia, tearing of muscle fibers and inflammation. To compound the issue further the body needs to compensate for the lack of stability sustained from lax ligaments and tendons and therefore will need to use active mechanisms not normally required to perform a movement. The fatigue of the active mechanisms will eventually result in instability, thus creating higher risk for overexertion injuries to occur (Jones and Kumar, 2001).

Since it is evident that research has not yet agreed on the exact pathway that leads to the development of a LBD, the ability to provide post trauma care is limited at best. Research must be focused on the factors that precede injuries, and of those factors, what can be controlled to prevent the injury from even occurring.

2.4 Factors Related to Occupational LBD

2.4.1 Introduction

Research on workplace prevention strategies has focused on identifying task- and operator-related factors most associated with risk of LBD. It has become clear to ergonomists that some professions are at higher risk for developing LBD than others. From these professions, the physical demands of the job have been analyzed and conclusions drawn on which physical factors likely contribute to the incidence of LBD. Personal characteristics and psychosocial stresses have also been identified as being contributors to LBD. Thus, a holistic approach to studying the problem may be necessary (Yip, 2004; Carledge, 2001; Skotte, Essendrop, Hansen and Schibye, 2002; Yip, 2001; Bewick and Gardner, 2000; Caboor, Verlinden, Zinzen, Van Roy, Van Riel and Clarys, 2000; Marras, 2000; Owen and Garg, 1991; Owen, 2000; Retsas and Pinikahana, 2000; Marras, Davis, Kirkling and Bertsche, 1999; Josephson and Vingard, 1998; Lagerstrom, Hansson and Hagberg, 1998; Burton et al.,1997; Smedley, Egger, Cooper and Coggon, 1997; McCoy et al., 1997; Cohen-Mansfield et al., 1996).

2.4.2 Personal Factors

Personal physical factors involved in the risk of developing a LBD are variables such as age, previous history of back injury, stature and obesity (Smedley et al., 1997). Other variables that have been reported to have potential correlation with LBD are smoking and low income status (Marras, 2000). Ferguson and Marras (1997) reviewed 57 industry-base surveillance studies that indicated that personal factors were the most frequently investigated risk factor of LBD. This review identified several personal factors that had a significant relationship to LBD (Ferguson and Marras, 1997). These factors were previous history of LBD (87%), household income/unemployment (66%), smoking (44%) and intelligence/education level (40%). This study also reported an interaction between age and gender with regards to prevalence of LBD. The risk for men reportedly peaks at approximately 40 years of age, whereas risk for women has been reported to be between 50-60 years of age (Ferguson and Marras, 1997).

Anthropometric measures were related to LBD (Ferguson and Marras, 1997). This study indicated that sitting height and obesity were the only measures that have been associated with greater risk of LBD (Ferguson and Marras, 1997). However, Smedley et al.. (1997) indicated in a review of the prevalence of back pain for nurses, that neither weight nor height could be considered to have a strong enough correlation to LBD for these factors to be considered as exclusion criteria for employment.

Another associated factor that has been studied is strength, in particular isometric strength (Marras, 2000). Although no evidence has directly linked isometric strength with LBD, it has been suggested that when matched with job requirements, it is an indicator of risk (Marras, 2000). Similar considerations were made for muscular endurance (Marras, 2000).

There is evidence that mood and lack of physical activity are risk factors for psychosocial stress and therefore LBD (Yip, 2001; Marras, 2000). By increasing the amount of physical activity an individual engages, typically morale and perception of the external environment becomes more positive. With a more positive outlook, the psychosocial stresses may seem less daunting to an individual and will not create as much internal stress and tension (Yip 2004). Despite the efforts of previous research, Marras (2000) concluded that personal factors only have a modest correlation with the incidence of LBD and therefore can only be considered as compounding factors involved in the development of LBD.

2.4.3 Occupation-Related Factors

The major factor for the development of a LBD is often acknowledged as task-related (Guo, 2002; Marras, 2000; Marras et al., 1995, Marras et al., 1993). In particular, professions with heavy MMH tasks tend to be strongly correlated with the incidence of low back pain. MMH occupations include heavy and/or repetitive lifting, pushing, pulling, whole body vibration, awkward postures or movements, and prolonged static postures. All of these factors have been correlated with the presence of LBD (Yip, 2004; Marras, 2000; Karwowski and Marras, 1999; Marras et al., 1999; Smith, Ayoub and McDaniel, 1992). According to Marras (2000) critical reviews of the literature have strongly supported the association of LBD risk with lifting and forceful movements, bending and twisting movements and whole body vibrations. However, the magnitude of force and at what frequency that force is applied for an injury to occur still requires further study (Marras, 2000).

Jones and Kumar (2001) categorized risk factors for LBD injury into four categories: genetic traits, morphological traits, psychosocial traits and biomechanical aspects of the job. Genetic and morphological characteristics are fixed and employee morphology may not fit the physical demands of the job. However, employee selection based on these traits is only marginally acceptable for certain occupations (eg. firefighters). Psychosocial aspects of an occupation, for example the level of emotional stress, relationships with coworkers/supervisors, are difficult to adjust and tend not to be addressed by ergonomists. However, the biomechanical aspects of the job are able to be altered and have been the primary focus of ergonomic intervention strategies (Jones and Kumar, 2001).

The following is a list of the occupational risk factors as reviewed by Jones and Kumar (2001): static work, posture and technique, load characteristics, handles and coupling, frequency and repetitive handling, asymmetrical handling and non-uniform loads, space confinement and restraints, work environment, work duration, work organization. These are the biomechanical factors that can be reviewed in the workplace to provide a safe and healthy work environment for all employees.

Lifting postures and technique for safe lifting have been generally misunderstood according to Jones and Kumar (2001). Physical restrictions imposed by the work space will generally dictate the posture adopted by the worker. Therefore, the concept of the "safest technique" for lifting needed to be considered (Jones and Kumar, 2001).

Mital (1997) provides guidelines regarding lifting techniques in a variety of situations. Moderate weight should be handled between the knees and lifting infrequently, a squat posture is appropriate. When the load cannot fit between the knees and requires frequent handling, the load should only be lifted with the help of another person or a mechanical aid. When two people are required to lift an object, they should be matched for height and coordinate the lift through verbal communication. Mital (1997) also recommended avoiding the following when lifting: movement to the extreme of ranges of motion, twisting and jerky motions and statically loaded postures. Lifting above shoulder height or below the knees should be avoided. Twisting alone can reduce the tensile strength of the muscle by approximately 50% due to the alignment of the fibers of the annulus fibrosus within which each vertebral disc lies (Mital, 1997).

The characteristics of the load should be controlled to allow for safer lifting. The load should be rigid and uniform in shape and no larger than 50 cm in depth. If the load is required to be carried for any distance, then the line of sight should be unobstructed by the dimension of the load. Depending on the frequency, load size and the complexity of the lift, the magnitude of the mass should be adjusted. Frequency should also be limited to a maximum of 10 lifts per minute in an 8 hour shift, and should not exceed 12 lifts per minute for the durations greater than 2 hours (Mital, 1997).

The coupling of the load is another characteristic that must be considered to avoid risk of injury due to lifting. Mital (1997) specifies that handles should be 11.5 cm long and 2.5-3.8 cm wide and if the handles are cylindrical, 3-5 cm of clearance around the entire handle. These handles should be placed at diagonally opposite ends providing stability about the horizontal and vertical planes. If the load does not have handles then the mass of the load should be reduced by 15% to avoid injury. The symmetry of the load will impact the magnitude of shear forces acting on the spine. If a load is asymmetrical the shear forces about the spine will increase. A reduction in load by 15% is recommended if the load is require to be lifted 90° in the saggital plane from its original position. The space in which the lift must occur may also become a risk factor if it restricts the operator from adopting a safe lifting posture (Mital, 1997). Although these recommendations alleviate the biomechanical risk factors involved with lifting, they may be too ideal to be prescribed for all workplaces.

2.4.4 Psychosocial Occupation- Related Factors

Psychosocial factors are the mental and social stresses involved with work such as job dissatisfaction, monotony of work, limited job control, and lack of social support (Cartledge, 2001; Yip, 2001; Bewick and Gardner, 2000, Retsas and Pinikahana, 2000; Lagerstrom et al., 1998; Cohen-Manfield et al., 1996) and have been associated with the incidence of LBD. Carayon and Lim (1999) identified eight psychosocial factors that may contribute to stress. Job demands comprise the quantitative workload, the monotony of the workload, the pressure to work and the cognitive demands. All of these factors can influence the amount of psychosocial stress that an individual will experience at the workplace. Job content was the second factor to be considered, which included issues regarding the amount of repetition the job requires, the challenge of the job and whether the skill set of the individual is being used. The third factor was job control. This involves the level of instrumentation of the task, the control the individual has over the task, involvement in decision making and organization of work. The control over the physical environment, pace of work and resources available will also impact the perceptions of psychosocial stress of a worker (Carayon and Lim, 1999). The level of social interaction was the fourth factor considered. This factor includes social support from supervisors and colleagues and having to deal with difficult clients. The fifth factor was regarding roles, specifically if the role of the individual is clearly defined, and therefore no ambiguity or conflict will arise. Job security and future job prospects comprised the sixth factor (Carayon and Lim, 1999).

Carayon and Lim (1999) list work organization and management issues as a contributor to psychosocial stresses. Management style and the amount of input the employee is allowed will dictate perceptions of the workplace. If the employee perceives the workplace to be repressive and lacks support, psychosocial stress may contribute to an increase risk of injury.

All of these factors can have an impact on an employee's overall perception of their workplace and their own position within that workplace. When support systems are not available to reduce that amount of psychosocial stress that an individual will encounter, then employee perceptions of work become negative. Psychosocial stresses are thought to interact with the physical demands to create a biomechanical situation in which an injury will occur, such as lack of awareness of an appropriate lifting posture. Psychological stress at work or at home can also increase musculoskeletal tension, increasing the potential of an injury occurring (Yip, 2001). Increased psychosocial stresses may also affect a person's attention to work detail, reducing a person's ability to recognize hazardous situations or influencing judgment about how tasks should be completed.

Yip (2004) suggested that injury will result in psychosocial stress which in turn may even intensify the sensation of pain , exasperating or perhaps exaggerating the seriousness of the injury (Yip, 2004). Regardless of whether the stress came first or last, it is still impacting the duration and cost of the rehabilitation of the injury, and therefore cannot be ignored. While some may perceive the relationship of psychosocial factors to LBD as a statistical association rather than a clinical one, there is a growing consensus that these factors have a more direct effect on how a person physically performs a task and thus psychophysical factors must be considered in every ergonomics intervention strategy.

2.4.5 Assessment and Determining Occupational Guidelines

Given what is known about the mechanisms of LBD, the physical environment of the workplace and the physical demands upon the operator should be modified by ergonomists to provide a safer and healthier workplace. Workstations should be designed to ensure that force, repetition, awkward and static postures of physical tasks are within safe and allowable limits relative for the population performing the task (Yip 2004; Marras, 2000; Smedley et al., 1997).

A variety of models have been applied to assess physical demands, including biomechanical, physiological, psychophysical and epidemiological approaches. Due to the diversity of these approaches and of the tasks they are analyzing, no universal guidelines have emerged (Kumar and Mital, 1992). Laboratory experimentation to accurately determine the safe and allowable limits of occupational physical work are limited. The attempt to extrapolate participant responses from short experimental collection periods to a whole work day has obvious limitations.

Dempsey (1998) reported that psychophysical data established from short collection periods, less than 25 minute, are valid for low frequency lifting tasks, but may not be appropriate for tasks that employ lighter loads handled more frequently.

Buckle et al. (1992) reported that they seldom found direct application of published guidelines to be satisfactory. They recommended that each specific task should be systematically examined to assess the interaction of all relevant variables. Snook and Ciriello (1991) expressed the opinion that the best protective guidelines would be for the operator to understand his or her physical, physiological and psychological limits and to work within them. However, the reality remains that employees are not likely to be able to select what loads and at what frequencies to handle in an occupational setting. This is particularly true in a health care setting.

2.5 Occupational Factors Specific to the Nursing Profession

2.5.1 Introduction

Nurses have been reported to be among the highest at risk professions for incidence for LBD (Yip, 2004, Retsas and Pinikahana, 2000; Marras et al., 1999; Smedley et al., 1997; Cohen-Mansfield et al., 1996; Owen and Garg 1991). Cohen-Mansfield et al.. (1996) reported that nursing was the third leading profession for LBD and workplace injury. Typically, nurses have a number of personal, physical and psychosocial characteristics that place them in the high risk category for developing LBD. However, patient handling is the most frequently reported factor related to LBD (Carteledge, 2001; Yip, 2001; Retsas and Pinikahana, 2000; Marras et al., 1999; Engvist et al., 1998; Josephson et al., 1998; Lagerstrom et al., 1998; Cohen-Mansfield, 1997; Owen and Garg, 1991).

2.5.2 Nursing Shortage

Worldwide, the labour market is experiencing the effects of a cohort of retiring baby boomers. This vast number of retirees has left many occupational sectors, particularly the nursing profession, with a lack of experienced workers (Buchan, 2002). Vacancy rates, staff turnover rates, extended use of temporary staff and the amount of overtime only compounds the physical and mental demands placed upon health care workers. New diseases and infections such as SARS and HIV/AIDS are also related to the increased work demands of health professionals (Buchan, 2002).

Since the 1980's nurses have been changing orientations within or have left the profession altogether as a result of overexertion injuries (Owen, 2000). In a study conducted by Hemsley-Brown and Foskett (1999), youth are generally "aiming higher" than nursing, viewing the pay, conditions and required personality characteristics as undesirable. The attention on the nursing shortage has only fueled the continuing need for injury prevention in order to maintain the health and wellness of the nurses that are currently in the workforce.

2.5.3 Nursing and Personal Factors

A cohort study conducted by Smedley et al. (1997) reported that there was no relation between age, mass or body mass index (BMI) and reported musculoskeletal injury. Yip (2004) investigated whether level of leisure activity outside the workplace would have an impact on incidence a low back injury. The suggestion was that the effects exercise can have on mood, anxiety, spine mobility and relaxation would positively impact the tolerance of the nurse to perform work duties with reduced risk for injury (Yip, 2004). However, this study reported that factors such as being comparatively new on the ward, bending frequently during work and having poor relationships with colleagues were independent predictors of LBD; while the level of exercise outside the workplace was not (Yip, 2004).

O'Brien-Pallas et al. (2004) investigated the contributing factors leading to injury claims by Canadian nurses. The study investigated workload and staffing data, the nurses' lost time injury claims data, organizational factors and individual nursing characteristics. One of the findings of this study was that even though Canadian nurses response to questions regarding their level of health was overwhelmingly positive (97% reporting excellent, very good or good health), other experimental results suggested otherwise (O'Brien-Pallas, 2004). When data regarding frequency of health related absenteeism, pain in the back, buttock, neck and shoulder and burnout were considered, 44% reported having one or more occasions of being absent due to these reasons in the previous three months leading to the questionnaire collection (O'Brien-Pallas et al., 2004). Sixteen percent reported back or buttock pain and 17% reported neck or shoulder pain in the previous week. Twenty five percent reported working with musculoskeletal pain for most of or all of the time (O'Brien-Pallas et al., 2004). O'Brien-Pallas et al. (2004) mentioned that nurses may compare their level of health to the patients which they care for, therefore resulting in a more positive outlook on their own health. However, it seems clear that nurses therefore may not recognize the importance of their perceptions of health as precursors to injury.

2.5.4 Nursing and Physical Loads

The most commonly reported physical demands of nursing that likely contribute to the development of a LBD are lifting, pushing/pulling, transferring patients (Skotte, et al. 2002; Retsas and Pinikahana, 2000; Marras et al., 1999; Engvist et al.,1998; Lagerstrom et al., 1998; Cohen-Mansfield et al., 1997; Smedley et al., 1997), repetition of patient handling tasks (Yip 2004, Cohen-Mansfield et al., 1996), inadequate space to perform patient handling tasks (Bewick and Gardener, 2000; Cohen-Mansfield et al., 1996), poor work posture (Yip 2004; Engvist et al., 1998; Lagerstrom et al., 1998; Smedley et al., 1997; Cohen- Mansfield et al., 1996), lack of proper technique during patient handling (Bewick and Gardner, 2000; Engvist et al., 1998; Cohen-Mansfield et al., 1996), inadequate staff (Engvist et al., 1998; Cohen-Mansfield et al.,1996) and inadequate rest (Beynon et al., 2000).

According to Engvist et al. (1998) there are twenty-two identified factors related to the risk of injury and that these factors can be grouped into five categories. These factors have been summarized in the Table 2.1.

Table 2.1: Summary of the twenty-two factors involved in the injury process according to Engvist et al. (1998).

Category	**Risks**
Work Organization	lack of adequate staff
	lack of information on the patients condition that day
	nurses felt stresses or rushed
	nurses performing transfer alone
	lack of training regarding technique or lost grip during transfer
Workplace factors	risks inherent in the environment
	no proper transfer devices
	nurses assuming awkward postures due to space constraint
Nurses	assuming an awkward posture on own accord
	lack of communication between nurse and patient regarding transfer
	Nurse making a sudden movement
Patients	Mass greater than 80kg
	sudden loss of balance or resistive to being moved
Specific Transfers	moving a patient in the bed
	moving the patient to or from the bed
	moving the patient to or from the toilet
	moving the patient from floor level
	moving patient from a stretcher or x-ray table

Yip (2001) supports Engvist et al.. (1998) with similar findings regarding risk involved in patient transfers between beds and chairs, onto trolleys, repositioning in bed, and assistance during ambulation or walking exercises resulting in the highest reports of injury. Another major contributor that Yip (2001) recognized is the relationship of repetition of patient handling tasks and risk of injury.

Studies have identified specific units within the hospital that most injuries have occurred and include: geriatric (Cohen-Mansfield, 1997), surgical and medical wards (Engvist et al., 1998). The Health Care Corporation of St. John's, NL reported in 2000 that the continuing care unit, followed by the critical care unit as the location of the most injuries (Stinsen, 2000). These are units that involve a high volume of patient handling.

2.5.5 Patients as a risk factor

The potential to automate a task involving the transfer of a live human being can be limited. Referring to Mital (1997), the load that nurses lift does not comply with any of the traditional manual materials handling guidelines. Patients that nurses are responsible for transferring are not rigid bodies, are asymmetrical with respect to load distribution and impose awkward coupling. Nurses do not have the ability to control the magnitude or the shape of the load handled, nor the ability to predict the movement of the load or the pattern of lifting that will be present during a shift. The number, mass and dependency level of the patients that will be under a nurse's care for any particular shift cannot always be predicted or standardized. Furthermore, the patient themselves can be unpredictable. The patient may or may not be compliant when being transferred. Depending on the condition of the patient, the nurse may become unexpectedly loaded if the patient suddenly loses balance or consciousness. The end result being that the patients themselves can not be administratively controlled to the benefit of the nurse. Thus, related research has focused more on the adaptations the nurses can make to transfer techniques and the surrounding environment.

Kjellberg, Lagerstrom and Hagberg (2004) assessed the comfort of the patient during handling and transfer tasks. These authors found a moderate correlation between the comfort of the patient (r=0.23) and the self reported evaluation of the nurses' own work technique for both tasks analyzed (r=0.21), concluding that safe transfers with regards to the nurses' musculoskeletal health are also the transfers that are most comfortable and secure for the patient (Kjelberg et al., 2001). Mannion, Adams and Dolan (2000) reported that sudden and unexpected loading can substantially increase the compressive load on the spine and that eliminating such events are recommended. If the patient is more confident that the transfer will be performed in a safe and secure manner, it could be postulated that safe transfer methods could reduce the factors of resistance to transferring, such as combative behavior, thus reducing the chances of unexpected loading events. The inherent issues involved with manipulating the patient in a safe and efficient manner has lead to important research regarding safe transfer skills and other intervention strategies to prevent injury for nurses.

2.5.6 Patient handling

According to research conducted over the past ten or so years, the following are considered the most prevalent patient handling maneuvers that lead to injury: repositioning/ adjusting patient in bed (Skotte, Essendrop, Hansen and Schibye, 2002; Yip, 2001; Marras et al., 1999; Engvist et al., 1998), transferring patient from bed to chair and chair to bed (Marras et al., 1999; Smedley et al., 1997; Owen and Garg, 1991), transferring patient from chair to commode and commode to chair (Smedley et al., 1997; Owen and Garg, 1991; Marras et al., 1991), assisting a patient while walking (Yip 2001; Engvist et al., 1998) and assisting patient stand from a sitting position (Skotte et al., 2002). A prevalent theme emerging from this body of research was that there was not adequate training in proper technique to prevent over-exertion injuries (Bewick and Gardner, 2000; Engvist et al., 1998; Cohen-Mansfield et al., 1996). Nurses are now being provided with education programs, mechanical lifts, and other tools to aid in transferring and handling patients. However, Hignett (1996) believes that back education alone will not solve the high injury incidence of nurses.

2.5.7 Psychosocial stresses of nursing

Psychosocial stress has been identified as a contributing factor related to the occurrence of LBD. The stresses in the workplace that nurses have to compete with are mainly the stress of being responsible for ill or dying people (Cartledge, 2001; Retsas and Pinikahana, 2000), lack of authority (Lagerstrom et al., 1998), lack of social support (Cartledge, 2001; Retsas and Pinikahana, 2000; Lagerstrom et al., 1998), lack of job desirability (Cohen-Mansfield et al., 1996), and the effects of shiftwork (Cartledge, 2001; Retsas and Pinikahana, 2000; Josephson et al., 1998; Lagerstrom et al., 1998). According to Josephson et al. (1998) the most influential psychosocial stress for nurses is shift work. The sleep disturbances that often accompany shift work can lead to "low control" in planning a patient transfer task, easily leading to mistake and injury (Josephson, 1998).

The lack of job desirability has also become a recent issue. With the retirement of the baby boomers and the tendency for high turnover of nurses in particularly heavy patient handling units, there is now a shortage of nurses able to work.

2.6 Ergonomic Interventions Related to the Nursing Profession

2.6.1 Introduction

A number of interventions have been employed in attempt to decrease the threats to job-related injuries. These have included tools to aide transfers, mechanical lifts, back education and practical application of specific transfer training (Collins, Wolf, Bell and Evanoff, 2004; Finch, Guthrie, Westphal, Dahlman, Berg, Behnam and Ferrell, 2004; Keir and MacDonell, 2004; Li, Wolf and Evanoff, 2004; McCannon, Miller and Elfessi, 2004; Johnsson, Carlsson and Lagerstrom, 2002; Caboor et al., 2000; Zhuang, Stobbe, Hsiao, Collins and Hobbs, 1999; Burton, Symonds, Zinzen, Tillotson, Caboor , Van Roy and Clarys, 1997;Goodridg and Laurila, 1997; Charney, Zimmerman and Walara, 1991;

Owen and Garg, 1991; Venning, 1988). Each intervention has been reviewed to assess which are the most effective for reducing overexertion injuries for nurses.

2.6.2 Back education and transfer instruction

Guthrie et al. (2004) reported that back education alone has not been effective in changing work related injuries for nurses. The primary reason for the lack of success with solely implementing a back education program is that most back education programs are not directly applicable to specific patient handling tasks, therefore most of the standard rules for body mechanics under load cannot be employed by nurses (Guthrie et al., 2004). Ergonomic interventions for nurses combining back education with practical training of safe transfer methods and /or the designation of lifting teams have been more successful.

Practical training in transfer techniques have been recognized to reduce poor postures and other risk factors that typically result in injury. McCannon et al. (2003) compared the differences between a control group (had no previous patient handling experience), a basic body mechanics training group and a job site training group. Two transfers were assessed, the one person pivot transfer and repositioning a patient up in bed. The results of this study indicated that job site training (ie specific patient transfer training) is the most effective intervention in producing safe postures as opposed to back education alone (McCannon et al., 2003).

Another concept that has been introduced as an intervention strategy against injury is for nurses to lift in teams. Charney et al. (1991) found that a lifting team approach was able to reduce lost time injuries by 95%. The lifting team are professional patient handlers that have had specialized training on the unique characteristics of patient transferring and understand the system's complexity (Guthrie et al., 2004). By having a lift team that will be screened, trained, equipped and then dispatched to perform the patient transfer tasks, the nurses are relieved from this work and can focus on patient care (Guthrie et al., 2004). Charney (1992) found that the implementation of a lifting team reduced the number of total injuries related directly to patient handling, those with and without lost time by 69%. Not only will a lifting team provide a reduction in the physical related risks for back injury of nurses, Charney et al. (1991) also reported greater nursing morale, recruiting nurses was much easier when lifting teams existed. Therefore, there are psychosocial benefits to a lifting team approach. The team lifting approach does have some negative aspects which have therefore prevented it from becoming a universally accepted approach. The primary reason for lack of adaptation of this approach by other countries is that the increased cost of employing a specialized team to perform only these duties. The return on investment however will offset these costs, as injury rates has shown to dramatically decrease as a result of this approach.

2.6.3 Tools and mechanical aides

Owen (1988) and Bell (1984) reported that employing mechanical devices during patient transfers could take up to 17 times longer compared to a more traditional manual transfer technique. The majority of this time is taken by having to position the patient in an appropriate manner in order to secure them within the device. Owen and Garg (1991) found that two out of the three mechanical devices that they used for patient transfer were perceived by those using the device to have as high or higher physical stress level than a manual transfer. Although previous literature indicates that transfer devices, if used, would provide a reduction in injury, nurses still are not using them as much as expected (Owen and Garg, 1991). The reasons that nurses often provide for not using the transfer aides is that too much time is involved in using the device, that the staff lacked experience in the usage or there was lack in availability of the device at the time of need (Owen and Garg, 1991).

Owen (2000) commented on the lack of use of assistive transfer devices. Nurses indicated that the reasons they were not using them was because the device required was unavailable; the device took too much time, the device was unstable or otherwise unsafe and that the patients were not comfortable with the devices being used. Nurses' perceptions of the assistive devices in this study were changed when they were properly trained on how to use then, when there were appropriate numbers of devices and were supported by management to use the device (Owen, 2000). A more recent study conducted by Zhunag et al. (2004) reported on the use of a basket sling or an overhead lift used to aid a resident into a standing position and/ or transferring into a chair. Zhunag et al. (2004) found that the manual transfer without employing a mechanical aid would result in 3454 N of compression, a value exceeding the 3400N NIOSH recommendation, in comparison to the 2698 to 2951 N range of compression predicted when using an overhead or basket sling lift. The range was a result of the differences between those nurses who pushed the patient to their side (2698 N) rather than pulling to roll the patient to their side in bed (2951 N). Li et al.. (2004) also reported similar findings, stating that the implementation of the mechanical lifts reduced the reported musculoskeletal symptoms, injury rates and lost day injury rates. Li et al. (2004) noted that mechanical lift usage compliance gradually decreased during the six month trial period, thus strategies must be developed to encourage future usage of transfer devices.

Since nurses perceived mechanical lifts as more stressful then manual transfers, Keir and MacDonell (2004) assessed the electromyography (EMG) activities of primary movers (bilateral upper and lower erector spinae, bilateral latissimus dorsi, bilateral trapezius) in experienced nurses. They hypothesized that experience has an impact on the reduction of EMG measured during the use of mechanical lifts and manual transfers. Initially, it appeared that the manual transfer would result in the greatest amount of muscle activation. However, when the EMG of each manual and mechanical transfer method were integrated over the time it took to complete the transfer, they found that the manual transfer took much less time than the mechanical lifts and therefore had the lowest level of integrated EMG (Keir and MacDonell, 2004). With empirical evidence such as this, the anecdotal reports from nurses that manual transfers are more efficient and less stressful than a mechanical lift may seem valid.

In summary, transfer aides can be effective but often are unavailable or underutilized (Finch Guthrie et al., 2004). Furthermore, empirical evidence supports the allocation of resources to develop manual transfer methods and educational approaches to reduce the risk of LBD in nurses.

2.6.4 Back Injury Prevention Program (BIPP)

A focus on manual transfers led the Occupational Health Services Department of the Health Science Center in St. John's, Newfoundland and Labrador to develop the Back Injury Prevention Program (BIPP) (Bouchier, 1996). The BIPP was designed to teach professional and student nurses patient transfer techniques which adhere to proper biomechanical principles. Those principles are out lined as "the ME rules". These rules are a used as a reminder to the nurses to protect themselves ("ME"), when performing patient handling tasks. Those rules are:

> "(1) Test the weight of the object. Be certain I can lift without injury risk. (2) Hold object/person close to my body and in front of me. (3) Feet wide apart to lower my center of gravity and to weight-shift. (4) Trunk upright and stabilized on the pelvis. (5) Shoulders stabilized, elbows close to sides, wrists straight. (6) Don't twist, move symmetrically. (7) Use my legs to make any movements not my trunk. (8) Move smoothly, do not jerk."

The program provides instruction on how to perform various patient handling tasks while applying these biomechanical principles. The nurses are taught what questions to ask themselves to aid in selecting an appropriate transfer for the patient and their condition. In other words, nurses are conditioned to perform a risk analysis prior to attempting a patient transfer. The nurses that continue to work with the Health Care Corporation of St. John's, NL are retrained every few years to ensure they are still applying the principles of BIPP. Since the implementation of the BIPP the Health Care Corporation of St. John's, NL has seen a decrease in the number of back injuries in most departments (Stinsen, 2000).

Jensen (1990) reported that back education programs provide little evidence to support their efficacy for reduction in overexertion injuries. However, Jenson (1990) does state that back education in conjunction with other ergonomics interventions, such as identifying the tasks with greatest amount of risk of injury and modifying these tasks to incorporate mechanical aides should negate some of these risks. While this approach may have high elements of content validity, not all hospitals have the financial resources to install a mechanical lift in needed rooms. The BIPP requires little equipment, therefore if its instruction can provide reasonable protection against injury, then its implementation can be a cost effective method hospitals can employ to protect their employees.

CHAPTER 3: METHODOLOGY

3.1 Introduction

There were two data collection periods for this study. The first data collection period, Phase 1, considered novice participants who had no previous experience with patient handling. Volunteers who were not female, reported previous back injury, were pregnant or were not of consenting age were excluded from this study. This collection period occurred over two consecutive days. The first day was to examine the muscle activity and lumbar motions of participants before being taught the BIPP (Back Injury Prevention Program) method of patient handling. The second day consisted of instruction according to the BIPP methods and subsequent re-examination of the novice subjects performing the same patient handling tasks.

The second data collection period, Phase 2, assessed experienced, active nurses performing the same patient handling tasks as Phase 1. No instruction was provided regarding handling techniques to the experienced nurses prior to data collection. Thus, subjects in Phase 2 were only sampled once. The study protocol was approved by the Human Investigations Committee of Memorial University.

3.2 Dependent Measures

3.2.1 Electromyography

Five muscles, measured bilaterally, were selected for analysis during the patient transfers. These included the trapezius, posterior deltoid, external oblique, erector spinae and rectus femoris muscles. Prior to electrode placement, the skin was shaved, abraded and cleaned with rubbing alcohol to help increase the transfer of the signal from the muscle to the electrode. Surface electrodes (Kendall ® Medi-trace 100 series) were used in a bipolar configuration and were placed at the midbelly of each muscle. A ground electrode for each bipolar arrangement was placed within 10cm of the recording site. The

ME3000P (Mega Electronics Ltd. Kuopio, Finland) unit was used to collect the EMG profiles. The external unit was connected to the communications port of a personal computer via an optical cable to collect the data in real-time. Each of the eight channels was sampled at 1000 Hz, band-pass filter between 20 Hz and 500 Hz amplified (differential amplifier , common mode rejection ratio ≥ 130 dB, gain x 1000, noise ≤ 1μV) and analogue to digitally converted (12-bit) and stored on a personal computer for later analysis. Table 3.1 outlines the muscles that were assessed for each patient handling task.

Table 3.1: Selected EMG Collection Sites Based on Patient Transfer

Patient Handling Task	Muscles Assessed				
	Erector Spinae	Trapezius	Deltoid	External Obliques	Rectus Femoris
Repositioning up in bed: head	X	X	X	X	
Repositioning up in bed: side	X	X	X	X	
Bed to Chair	X	X		X	X

3.2.2 Lumbar Motion Monitor

A Lumbar Motion Monitor (LMM) was employed to measure the subject's thoraco- lumbar displacements in three dimensions. The data from the LMM were collected at 60 Hz, converted to a digital record and stored on a computer for further reduction and analyses. The LMM was attached to the subject by a backpack harness system using a chest and pelvis straps (Figure 3.1).

Figure 3.1: Placement of LMM harness and backpack on participant.

3.3 Patient Handling Tasks:

Three patient handling tasks were considered in this study:

(1) The patient was reposition towards the head of the bed using a draw sheet. This is a two person transfer, both positioned at the **side** of the bed (Figure 3.2, 3.3. In reference to this study, this will be called "Transfer 1".

(2) The patient was reposition towards the head of the bed using a draw sheet. This is a two person transfer, both positioned at the **head** of the bed (Figure 3.4, 3.5). In reference to this study, this will be called "Transfer 2".

(3) The patient was transferred from a bed to a wheelchair. This is a one person transfer and employs a transfer belt (Figure 3.6. In reference to this study, this will be called "Transfer 3".

3.3.1 *Repositioning up in bed using a draw sheet while positioned at side of the bed (Transfer 1)*

For reposition up in bed positioned at the side of the bed the participants begin the transfer at the side of the bed with their center of mass in line with the pelvis of the patient. With feet and arms parallel, palms facing upward and arms bent between 90-100° of flexion, the participant grasped the draw sheet tight between their hands and the patient's body. The participant will start with all of their weight on the leg closest to the foot of the bed. The patient will be displaced up in bed as the participant transfers their weight from this leg to the other leg, while keeping their elbows braced at their sides and knuckles staying in contact with the bed (Figure 3.2a &b).

Figure 3.2 a: Repositioning up in bed from side: position at the start of the transfer.

Figure 3.2 b: Repositioning up in bed from side: position at the end of the transfer.

3.3.2 Repositioning up in bed using a draw sheet while positioned at head of bed (Transfer 2)

When repositioning a patient up in bed, positioned at the head of the bed the participant would begin the movement by kneeling on the corner of the bed with their navel in line with the corner of the footboard diagonal from them (Figure 3.3 a &b), The participant, ensured that their knee was positioned such that the patient's shoulder would clear from obstruction when repositioned up in bed. The participant would stand tall on the kneeling knee, grasping the draw sheet tight with palms facing up. While bracing their elbows at their sides, the participant transferred weight by sitting down on their heel, effectively transferring the patient to the head of the bed.

Figure 3.3 a: Repositioning up in bed from head: position at the start of the transfer.

Figure 3.3 b: Repositioning up in bed from the head: position at the end of the transfer.

3.3.3 Bed to Chair using one person pivot method (Transfer 3)

For assisting the patient from bed to chair using the one person pivot technique (refer to Figure 3.4), the participant began the lift by applying the transfer belt to the patient's waist and then grabbed the handles located on the back of the belt with the participant's hips square with those of the patient. To clear the patient from the bed three rocking motions were used to gain enough momentum to clear the patient from the bed. The participant's legs were positioned on either side of the patient's legs to ensure control over the patient. The wheelchair was located at a 45 degree angle to the bed. Once the patient was clear from the bed the participant pivoted at the feet, not at the trunk, and lowered the patient slowly by bending the legs.

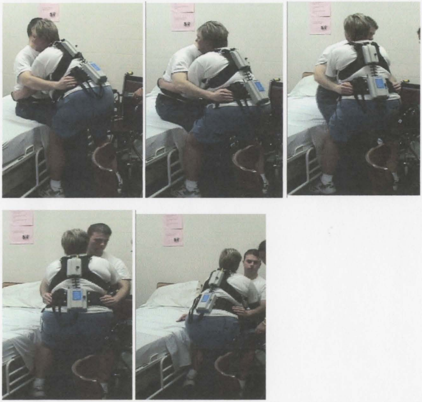

Figure 3.4: Transferring from bed to chair using the one person pivot technique: sequence of movement events.

3.3.4 Successful Transfer Criteria

A criterion was established to identify a successfully completed transfer. For Transfers 1 and 2 (reposition up in bed), successful completion required the patient to be repositioned to at least 6 cm from the head of the bed. For Transfer 3 (transferring patient from bed to chair), successful completion required that the patient be effectively relocated to the chair.

3.3.5 Patient Level of Dependency

For each of these patient handling tasks, a healthy surrogate patient was used. This "patient" was recruited to participate in all the patient handling tasks for the entirety of the experiment. The patient was requested to maintain a consistent level of dependency throughout the experiment. During Transfers 1 and 2 (reposition up in bed) the patient was completely passive. According to the BIPP requirements to employ a one person pivot from bed to chair, a patient must be able to follow verbal instructions and able to bear his own weight, but not necessarily be able to go from a sitting to standing position unassisted. Thus, the surrogate patient was asked to act in this manner. To ensure inter-trial consistency by the surrogate patient a familiarization session with a qualified BIPP instructor was implemented. The one person pivot transfer was performed until the instructor was confident that the patient was bearing an equal amount of weight for each practice transfer.

3.3.6 The Second Patient Handler

Two people were required to complete Transfers 1 and 2 according to BIPP protocol. The same person performed this task consistently throughout all trials. To ensure this consistency the person had completed two BIPP training sessions and BIPP instructors confirmed that this aide completed the transfers properly.

3.4 Experimental Protocol

3.4.1 Phase 1: Novice Participant Pre and Post- training

Subjects

Twelve female participants (stature of 1661 ± 6 mm; mass of 65 ± 12.2 kg; age of 23.7 ± 1.4 years) volunteered to participate in the study. These subjects had no previous training in patient handling procedures.

Session 1:

Participants were required to attend three experimental sessions for Phase 1 of the study. The experimental protocol was explained and written and verbal consent obtained during the first session. The participant's mass and stature were recorded. Surface EMG electrodes were placed on the left and right trapezius (TRAP), left and right deltoid (DELT), left and right erector spinae (ES), left and right external oblique (EO) and left and right rectus femoris (RF). Maximum voluntary contractions (MVC's) were then collected. For collection of the MVC's the participant was positioned and resistance was provided while verbal encouragement was given to the participant to exert a maximal voluntary effort. For the trapezius MVC's the participant's hand was held and gripped at the wrist by a research assistant to provide enough resistance against a isometric shoulder elevation activation. Right and left trapezius were collected separately. For the deltoid MVC's, the participant was positioned next to a wall with her elbow flexed at a 90 degree angle and performed and isometric shoulder abduction activation. Right and left deltoids were collected separately. Both left and right erector spinae MVC's were collected simultaneously while the participant flexed forward at the hip onto a bed while two research assistants were positioned to provide resistance against the right and left scapula while the participant performed an isometric lumbar extension activation. For the external oblique MVC's, the participant stood with their back against a wall and were instructed to rotate medially about the longitudinal axis. A research assistant provided enough resistance against the anterior aspect of the participant's shoulder to ensure an isometric activation was performed. The rectus femoris MVC's were collected while participant sat in a chair with her knee flexed at 90 degrees. A cuff was secured to the back two legs of a chair and the subject's ankle to provide the resistance against an isometric knee extension activation. Right and left legs were collected separately. All activations were held for 5 seconds and two repeated measures for each muscle were collected. The largest activation for each muscle was selected for normalization purposes.

The participants then viewed a 3 minute video of the three transfers considered in this study. No further instruction was give to participants. The LMM was then calibrated and mounted on the subject employing manufacturer's suggested guidelines. At this time, the subject was ready to begin data collection. The three transfers were randomly assigned to each subject. Data integrity was monitored during collection and the recorded raw data were verified before proceeding to the next trial. Each transfer was repeated three consecutive times.

Session 2:

The participants attended a 2 hour BIPP instruction session. During this session the participant was provided standardized instruction of the biomechanical principles of the BIPP and practiced the transfers. The technique was critiqued and corrected by a BIPP instructor during this session.

Session 3:

The participant then repeated the first session protocol, only without viewing the video. Again, the transfers were assigned in a random order to the subjects. Refer to Figure 3.5 for chronological sequence of events for Phase 1 of the study.

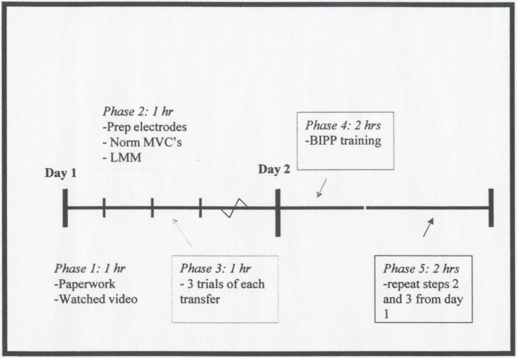

Figure 3.5: Chronological sequence of three sessions in Phase 1 completed by novice participants.

3.4.2 Phase 2: Experienced Nurses

Subjects

Ten female participants (stature of 1599 ± 59.9 mm; mass of 73 ± 19.5 kg; age of 41.6 ± 10.2 years) volunteered to participate in this study. These participants were experienced nurses (14.3 ± 9.5 years of employment) from the Health Care Corporation of Newfoundland. The dependent measures and patient handling tasks were similar to those described in Phase 1 of the methodology.

The experienced nurses were required to attend one experimental session as their requirement to participate in the study. The experiment was explained and written and verbal consent obtained at this time. The participant's mass and stature were recorded. The same procedures were employed as Phase 1 to collect MVC's for the experienced nurse participants. The LMM was then calibrated and mounted on the subject employing manufacturer's suggested guidelines. At this time, the subject was ready to begin data collection.

The experienced nurse was then informed of what transfers she was required to complete. The three transfers were randomly assigned to each subject. Data integrity was monitored during collection and the recorded data were verified before proceeding to the next trial. Each transfer was repeated three consecutive times.

3.5 Statistical Analysis

In Phase 1 a paired t-test was used to compare the pre- and post-training values calculated from the EMG- and LMM-time histories. Significant differences were identified using a 95% confidence interval. In Phase 2 an analysis of variance (ANOVA) test was used to compare the pre- and post-training novice participants to the experienced nurse participants. Significant differences were identified using a 95% confidence interval. A Least Squared Difference (LSD) Post Hoc test was employed in those cases where the ANOVA identified significant inter-group differences.

CHAPTER 4: RESULTS

4.1 Introduction

The EMG and LMM data were collected, reduced and analyzed in a similar manner for both Phases 1 and 2 of the study. The EMG and LMM data were synchronized in time using the proprietary software purchased with these devices. The start of each transfer movement was clearly indicated on both the EMG- and LMM-time histories which allowed for easy synchronization of the data sets.

The EMG data were normalized in magnitude in reference to the largest mean MVC value sampled during the middle three seconds of the isometric activation. Normalization values were always collected prior to the collection of patient transfer tasks and are experimental session specific. For each trial the maximum and average EMG value were determined for each muscle. The means of these three repeated measures data were then calculated and used in subsequent statistical analyses.

The LMM collected displacement-time series data in the sagittal, lateral and twisting planes. The LMM software (Ballet 2.1, BIOMEC Inc.) was employed to derive the velocity -time histories in all three planes of movement using a finite differences approach. For each trial the mean displaced position in both directions of the three movement planes were determined and then a mean was calculated across the three trials. For each trial the maximum and average LMM velocity values were determined for each movement plane. The mean of these data were then calculated and used in subsequent statistical analyses.

4.2 Comparative analysis of pre- and post-training novice participant's results

Repeated measures t-tests were employed to analyze the pre- and post- training results from the novice participants. The following section will describe the results of this comparison.

4.2.1 Transfer 1: Repositioning up in bed, positioned at the side of the bed for novice participants pre- and post-training

The mean EMG values for the repositioning up in bed, while positioned at the side of the bed demonstrated significant decreases in the left trapezius ($p< 0.005$) and left ($p<0.005$) and right ($p<0.025$) erector spinae (Figure 4.1). The maximum EMG values showed similar decreases in activities for these muscles during the post-training session (Figure 4.2). While not statistically significant, there were also decreasing trends in both the mean and maximum EMG data for the right trapezius, as well as the left and right deltoid.

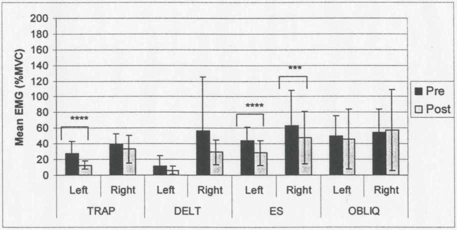

Figure 4.1: Mean EMG data for novice participants during transfer 1: reposition up in bed, positioned at the side of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005*

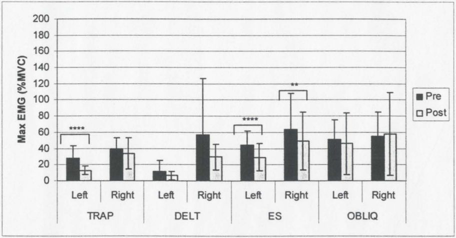

Figure 4.2: Maximum EMG data for novice participants during transfer 1: reposition up in bed, positioned at the side of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

The LMM ranges and velocities in three planes of motion (lateral, sagittal and twist) were compared between the pre- and post-training test sessions. The repositioning up in bed when positioned at the side of the bed resulted in two significant differences in the LMM data. There was a reduction in the maximum amount of extension recorded ($p<0.025$) and the maximum amount of flexion recorded ($p<0.005$) for the novice participants (Figure 4.3). There were not significant differences between the pre and post-training novice results with regards to thoracolumbar velocity (Figure 4.4).

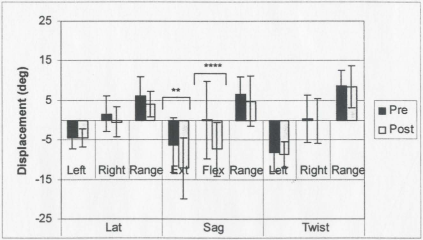

Figure 4.3: Mean LMM displacement in novice participants performing transfer 1: reposition up in bed, positioned at the side of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

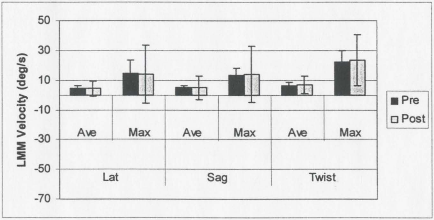

Figure 4.4: Mean and maximum LMM velocity in novice participants performing transfer 1: reposition up in bed, positioned at the side of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

4.2.2 Transfer 2: Repositioning up in bed, positioned at the head of the bed

Significant decreases were found in the mean muscle activity for the left ($p<0.05$) and right ($p<0.025$) trapezius, the left erector spinae ($p<0.005$) and the left ($p<0.025$) and right ($p<0.05$) external obliques in the post-training data (Figure 4.5). Similar results were observed for the maximum EMG results, with only the right trapezius being significantly different ($p<0.05$) (Figure 4.6). The right deltoid also showed a trend to decrease its mean and maximum activity during post-training.

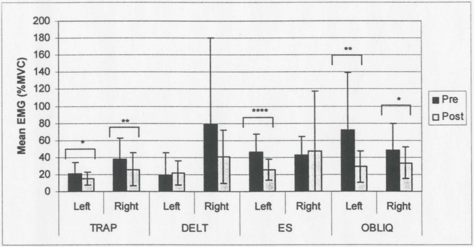

Figure 4.5: Mean EMG data for novice participants during transfer 2: repositioning up in bed, positioned at the head of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

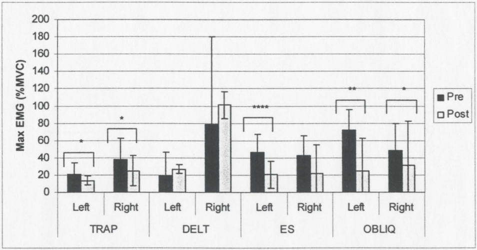

Figure 4.6: Maximum EMG data for novice participants during transfer 2: repositioning up in bed, positioned at the head of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

The mean LMM displacements had significant decreases in post training compared to the pre-training session for the following measures: maximum right bend ($p<0.001$), maximum extension ($p<0.044$), and flexion ($p<0.05$); maximum lateral range and mean lateral velocity ($p<0.01$); maximum lateral velocity ($p<0.005$) (Figures 4.7 and 4.8). A significant increase was also identified for mean results during post training test in maximum left twist ($p<0.01$).

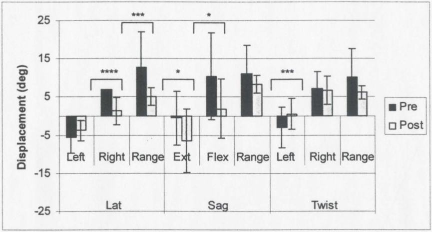

Figure 4.7: Mean LMM displacement in novice participants performing transfer 2: reposition up in bed, positioned at the head of the bed

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

Figure 4.8: Mean and maximum LMM velocity in novice participants performing transfer 2: reposition up in bed positioned at the head of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

4.2.3 Transfer 3: Bed to Chair, one person pivot technique

In light of the limited number of EMG data collection channels, it was decided that it was more important to measure the rectus femoris musculature than the deltoid muscles for the one person pivot transfer (refer to Table 3.1). Significant decreases in the mean EMG activities were identified for the left ($p<0.01$) and right ($p<0.005$) trapezius, left ($p<0.005$) and right ($p<0.005$) erector spinae and left external obliques ($p<0.005$) (Figure 4.9). A significant increase in right rectus femoris ($p<0.025$) activity was observed. Similar results were found for the maximum EMG values. There were decreases in the left ($p<0.01$) and right ($p<0.05$) trapezius, left ($p<0.025$) and right ($p<0.01$) erector spinae, left external obliques ($p<0.01$) and an increase in right rectus femoris ($p<0.005$) activity (Figure 4.10).

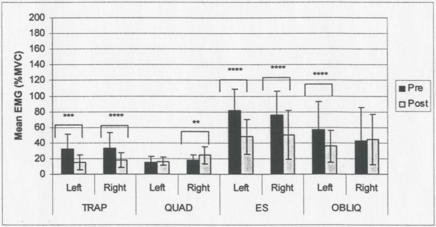

Figure 4.9: Mean EMG data for novice participants during transfer 3: bed to chair using one person pivot technique.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

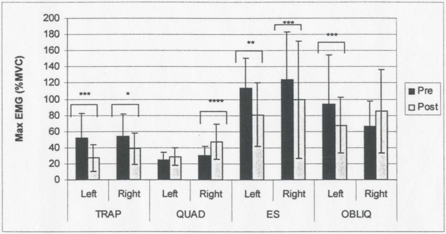

Figure 4.10: Maximum EMG data for novice participants during transfer 3: bed to chair using one person pivot technique.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

A significant increase was identified for the maximum right bend displacement (p<0.025) and maximum lateral range (p<0.01) in the post training test (Figure 4.11). The one person pivot method of transferring from bed to chair revealed a significant increase maximum lateral range (p<0.025) (Figure 4.11). A significant reduction in mean sagittal (p<0.05) and twist (p<0.005) velocities was observed (Figure 4.12). The results for novice participants indicated a significant decrease in mean twist velocity (p<0.005) and mean sagittal velocity (p<0.005) (Figure 4.12).

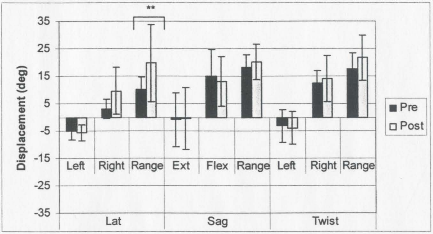

Figure 4.11: Mean LMM displacement in novice participants performing transfer 3: bed to chair using one person pivot technique.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

Figure 4.12: Mean LMM velocity in novice participants performing transfer 3: bed to chair using one person pivot technique.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

4.3 Comparison of Novice Participants and Experienced Nurses

This section compares the pre- and post- training measures of the novice participants with the data collected for the same patient transfers performed by the experienced nurses. An independent measures ANOVA was employed in recognition that two different subject pools were being considered in these analyses, although it is acknowledged that two of the three sets of grouped data come from the pre- and post-novice subjects. In this respect, one could assume that violations of homogeneity of variance are less likely and statistical interpretations using this model strategy would be valid, in light of all limitations and assumptions identified in this study.

4.3.1 Transfer 1: Repositioning up in Bed, positioned at the side of the bed for experienced nurses compared to novice participants pre- and post-training

An analysis of variance was employed to examine the difference between the novice participant results and experienced nurses' results. A significant difference identified from the ANOVA was for the left trapezius ($p<0.001$). The post-training novice participants recorded significantly lower mean (Figure 4.13) and maximum (Figure 4.14) left trapezius activation levels then the experienced nurses.

The mean EMG results were compared between groups (Table 4.1. Significant decreases in magnitudes were identified for the left ($p=0.022$) and right ($p=0.028$) trapezius between the pre-training results and the post training results for right ($p<0.001$) and left ($p=0.005$) trapezius activity. There were no significant differences found in the maximum EMG activity data (Table 4.2). In the Tables the "-" sign represents the experienced nurses recorded a significantly smaller value of the indicated measure with respect to the novice participants. A "+" sign represents the experienced nurses recorded a significantly greater value of the indicated measure with respect to the novice participants.

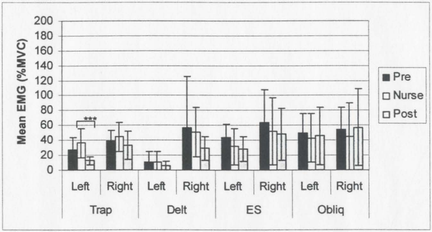

Figure 4.13: Mean EMG data for novice participants and nurses during transfer 1: reposition up in bed, located at the side of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

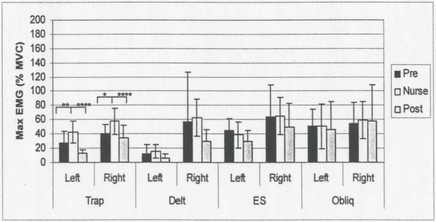

Figure 4.14: Maximum EMG data for novice participants and nurses during transfer 1: reposition up in bed, located at the side of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

Table 4.1: Summary of the significant differences of the mean EMG values (expressed as a percent of MVC) between the experienced nurses and novice participants for transfer 1: reposition up in bed, positioned at the side of the bed.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Mean	**Left TRAPEZIUS**	**Right TRAPEZIUS**	**Left DELT**	**Right DELT**
Pre	NS	NS	NS	NS
Post	p<0.001 +	NS	NS	NS
Mean	**Left ES**	**Right ES**	**Left OBLIQ**	**Right OBLIQ**
Pre	NS	NS	NS	NS
Post	NS	NS	NS	NS

Table 4.2: Summary of the significant differences of the maximum EMG values (expressed as a percent of MVC) between the experienced nurses and novice participants for transfer 1: reposition up in bed, positioned at the side of the bed.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Max	**Left TRAPEZIUS**	**Right TRAPEZIUS**	**Left DELT**	**Right DELT**
Pre	NS	p<0.028 +	NS	NS
Post	p<0.001 +	p<0.005 +	NS	NS
Max	**Left ES**	**Right ES**	**Left OBLIQ**	**Right OBLIQ**
Pre	NS	NS	NS	NS
Post	NS	NS	NS	NS

The pre-training mean results reported significantly greater maximum LMM sagittal range than the experienced nurse results ($p<0.031$) (Table, 4.3, Figure 4.15). Both the pre- ($p< 0.02$) and post-training ($p<0.028$) results showed significantly more maximum twist angle than the experienced nurses (Figure 4.16).

Table 4.3: Summary of the significant differences of the LMM values between the experienced nurses and novice participants for transfer 1: reposition up in bed, positioned at the side of the bed.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Mean	**Max L Bend**	**Max R Bend**	**Max Lat Ran**
Pre	NS	NS	NS
Post	NS	NS	NS

Mean	**Max Ext**	**Max Flex**	**Max Sag Ran**
Pre	NS	NS	p<0.031 -
Post	NS	NS	NS

Mean	**Max L Twist**	**Max R Twist**	**Max Angle**
Pre	NS	NS	p<0.02 -
Post	NS	NS	p<0.028 -

	Mean Lat Vel	**Max Lat Vel**	**Mean Sag Vel**	**Max Sag Vel**	**Mean Twist Vel**	**Max Twist Vel**
Pre	NS	NS	NS	NS	NS	NS
Post	NS	NS	NS	NS	NS	NS

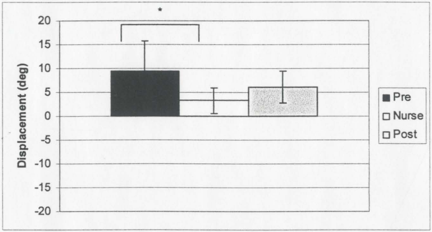

Figure 4.15: Maximum LMM sagittal range for experienced nurses and novice participants for transfer 1: repositioning up in bed, positioned at side of the bed

*Note: (*p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005).*

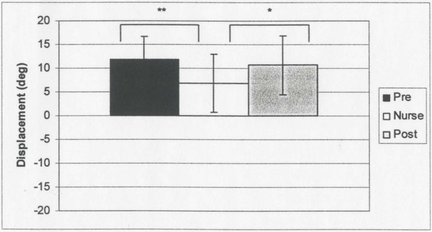

Figure 4.16: Maximum LMM twisting angle for experienced nurses and novice participants for transfer 1: reposition up in bed, positioned at side of bed

*Note: p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

The LMM displacement had significantly greater maximum left bend movement for the pre-training group ($p<0.039$) when compared to experienced nurse results (Figure 4.17).

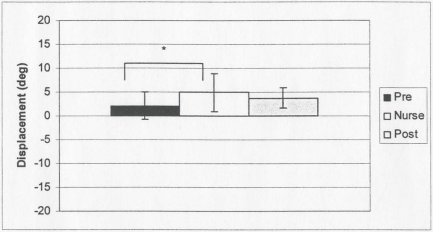

Figure 4.17: Maximum LMM left bend for experienced nurses and novice participants for transfer 1: reposition up in bed, positioned at side of bed.
*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

4.3.2 Transfer 2: Repositioning up in Bed, positioned at the head of the bed for experienced nurses compared to novice participants pre- and post-training

The post-training results for mean left trapezius activity ($p<0.023$) showed a lower level of muscle activity than that of the experienced nurses (Figure 4.18, Table 4.4). There was also a significant difference between the mean of the pre-training results and the experienced nurses for the left erector spinae. The pre-training results had higher activation ($p< 0.016$) than that recorded for the mean of the experienced nurses.

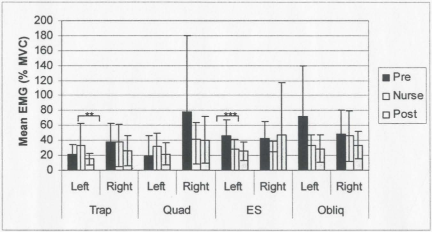

Figure 4.18: Mean EMG data for novice participants and nurses during transfer 2: reposition up in bed, located at the head of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

The pre and post-training results reported significantly lower levels of maximum muscle activity for the left trapezius ($p<0.023$ and $p<0.007$ respectively). The pre-training group had significantly lower maximum levels of left deltoid ($p<0.031$) activation than the mean of the experienced nurses (Figure 4.18, Figure 4.19, Table 4.5). The mean of the post-training group results showed significantly lower levels of maximum muscle activation for the right trapezius ($p<0.033$).

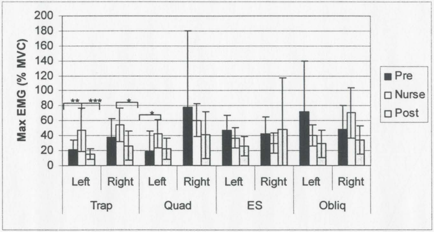

Figure 4.19: Maximum EMG data for novice participants during transfer 2: reposition up in bed, located at the head of the bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

Table 4.4: Summary of the significant differences of the mean EMG values (expressed as a percent of MVC) between the experienced nurses and novice participants for transfer 2: reposition up in bed positioned at the head of the bed.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Mean	**Left TRAPEZIUS**	**Right TRAPEZIUS**	**Left DELT**	**Right DELT**
Pre	NS	NS	NS	NS
Post	p<0.023 +	NS	NS	NS
Mean	**Left ES**	**Right ES**	**Left OBLIQ**	**Right OBLIQ**
Pre	p<0.016 -	NS	NS	NS
Post	NS	NS	NS	NS

Table 4.5: Summary of the significant differences of the mean EMG values (expressed as a percent of MVC) between the experienced nurses and novice participants for transfer 2: reposition up in bed positioned at the head of the bed.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Max	Left TRAPEZIUS	Right TRAPEZIUS	Left DELT	Right DELT
Pre	p<0.023 +	NS	p<0.031 +	NS
Post	p<0.007 +	p<0.033+	NS	NS
Max	**Left ES**	**Right ES**	**Left OBLIQ**	**Right OBLIQ**
Pre	NS	NS	NS	NS
Post	NS	NS	NS	NS

The LMM displacement data for transfer 2 revealed many more significant differences between groups than the transfer 1 (Table 4.6). The pre-training results for maximum right bend were significantly greater (p<0.001) than the experienced group. The pre-training group revealed significantly greater displacements for maximum lateral range (p<0.001) when compared to the experienced nurses. Significantly less maximal extension was measured for the mean of the post training (p<0.044) group compared to the mean extension of the experienced nurses. The pre-training results were significantly larger for maximum sagittal range (p<0.021), maximum twist angle (p<0.001), mean lateral velocity (p<0.001), maximum lateral velocity (p<0.001), mean twist velocity (p<0.015) and maximum twist velocity (p<0.004) in comparison to nurses (Figure 4.20).

Table 4.6: Summary of ANOVA post hoc results comparing the pre- and post-training results of novice participants to the experienced nurses for transfer 2: reposition up in bed positioned at the head of the bed.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Mean	**Max L Bend**	**Max R Bend**	**Max Lat Ran**
Pre	NS	p<0.001 -	p<0.001 -
Post	NS	NS	NS

Mean	**Max Ext**	**Max Flex**	**Max Sag Ran**
Pre	NS	NS	p<0.015 -
Post	NS	NS	NS

Mean	**Max L Twist**	**Max R Twist**	**Max Angle**
Pre	p<0.000 +	NS	p<0.000 +
Post	p<0.006 +	NS	p<0.006 +

	Mean Lat Vel	**Max Lat Vel**	**Mean Sag Vel**	**Max Sag Vel**	**Mean Twist Vel**	**Max Twist Vel**
Pre	p<0.001 -	p<0.001	NS	NS	p<0.015 -	p<0.004 -
Post	NS	NS	NS	NS	NS	NS

Figure 4.20: Mean LMM velocities for experienced nurses compared to novice participant's pre- and post-training result for transfer 2: repositioning up in bed, positioned at head of bed.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

4.3.3 Transfer 3: Bed to chair, one person pivot technique for experienced nurses compared to novice participants pre- and post-training

A summary of the statistical analyses of the EMG between the experienced nurses and novice participants are summarized in Table 4.7 and Table 4.8. The experienced nurses' results demonstrated significantly less activity for the left ($p<0.005$) and right erector spinae ($p<0.027$) when compared to the values recorded from the pre-training novices. The mean left rectus femoris ($p< 0.027$) activity was significantly higher for the experienced nurses then the novice pre-training trials (Figure 4.21, Table 4.7).

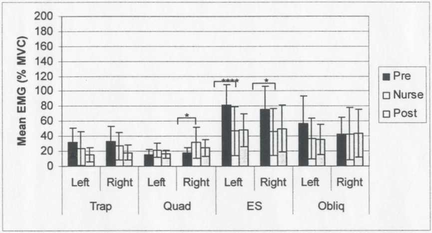

Figure 4.21: Mean EMG data for novice participants and nurses during transfer 3: bed to chair using one person pivot technique.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

The maximum values of the experienced nurses were significantly smaller for left erector spinae ($p<0.004$) activity compared to the pre-training novice group. There were increases in maximum right trapezius activity for the experienced nurse results when compared to the pre ($p<0.04$) and post-training ($p<0.011$) results (Figure 4.22, Table 4.8).

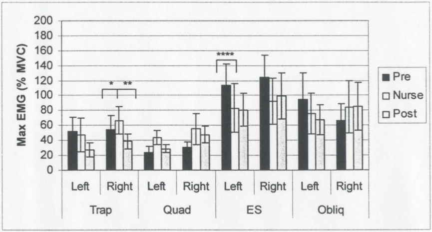

Figure 4.22: Maximum EMG data for novice participants and nurses during transfer 3: bed to chair using one person pivot technique.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

Table 4.7: Summary of the significant differences of the mean EMG values (expressed as a percent of MVC) between the experienced nurses and novice participants for transfer 3: bed to chair using one person pivot technique.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Mean	**Left TRAPEZIUS**	**Right TRAPEZIUS**	**Left QUAD**	**Right QUAD**
Pre	NS	NS	NS	p<0.027 +
Post	NS	NS	NS	NS
Mean	**Left ES**	**Right ES**	**Left OBLIQ**	**Right OBLIQ**
Pre	P<0.005 -	p<0.032 -	NS	NS
Post	NS	NS	NS	NS

Table 4.8 Summary of the significant differences of the maximum EMG values (expressed as a percent of MVC) between the experienced nurses and novice participants for transfer 3: bed to chair using one person pivot technique.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Max	**Left TRAPEZIUS**	**Right TRAPEZIUS**	**Left QUAD**	**Right QUAD**
Pre	NS	p<0.04 +	NS	NS
Post	NS	p<0.011 +	NS	NS
Max	**Left ES**	**Right ES**	**Left OBLIQ**	**Right OBLIQ**
Pre	P<0.004 -	NS	NS	NS
Post	NS	NS	NS	NS

The mean LMM displacements for the experienced nurses for transfer 3 were compared to the novice participants' pre and post-training group (Figure 4.23, Table 4.9). The pre-training results were significantly greater for maximum twist angle ($p<0.028$), mean lateral velocity ($p<0.008$), mean sagittal velocity ($p<0.014$), mean twist velocity ($p<0.000$) and maximum twist velocity ($p<0.015$). In one instance, the mean of maximum right bend displacement, the post-training results were significantly smaller then the experienced nurses. The post-training group however recorded significantly greater results for the maximum lateral range displacement ($p<0.017$), the maximum twist angle ($p<0.027$), mean lateral velocity ($p<0.024$), maximum lateral velocity ($p<0.022$) and mean twist velocity ($p<0.005$) (Table 4.9, Figure 4.24).

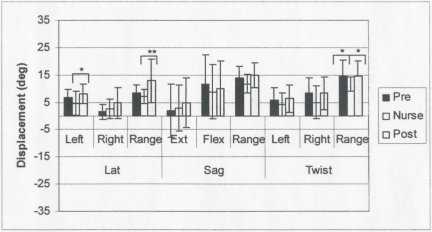

Figure 4.23: Mean LMM displacements for experienced nurses compared to novice participant's pre- and post-training result for transfer 3: bed to chair, one person pivot transfer.

*Note: *p< 0.05, **p< 0.025, ***p< 0.01, ****p< 0.005.*

Table 4.9: Summary of ANOVA post hoc results comparing the pre- and post-training results of novice participants to the experienced nurses for transfer 3: bed to chair, one person pivot technique.

Note: (-) and (+) denotes the direction of the change relative to the experienced nurses.

Mean	**Max L Bend**	**Max R Bend**	**Max Lat Ran**
Pre	NS	NS	NS
Post	p<0.043 +	NS	p<0.017 -

Mean	**Max Ext**	**Max Flex**	**Max Sag Ran**
Pre	NS	NS	NS
Post	NS	NS	NS

Mean	**Max L Twist**	**Max R Twist**	**Max Angle**
Post	NS	NS	p<0.028 -
Pre	NS	NS	p<0.027 -

	Mean Lat Vel	**Max Lat Vel**	**Mean Sag Vel**	**Max Sag Vel**	**Mean Twist Vel**	**Max Twist Vel**
Pre	p<0.008 -	NS	p<0.014 -	NS	p<0.001 -	p<0.015 -
Post	p<0.024 -	p<0.022 -	NS	NS	p<0.005 -	NS

Figure 4.24: Mean LMM velocities for experienced nurses compared to novice participant's pre- and post-training result for transfer 3: bed to chair, one person pivot transfer.

Note: $*p < 0.05$, $**p < 0.025$, $***p < 0.01$, $****p < 0.005$.

CHAPTER 5: DISCUSSION

5.1 Introduction

This study analysed two experimental hypotheses. The acceptance of the first null hypothesis would suggest that the back injury prevention program (BIPP) does not have any positive effect on lumbar motions and upper musculoskeletal electromyographical activities during patient transfer tasks. A repeated measures t-test between pre- and post-training novice participants indicated that the first null hypothesis was rejected, as there was a significant difference between groups in both the EMG and LMM measures. Employing the BIPP transfer protocols seemed to create a reduction in both lumbar motions as measured by a lumbar motion monitor (LMM) and upper musculoskeletal activity as measured by electromyography (EMG) in this study.

Accepting the second stated null hypothesis would signify that there is no significant difference between the pre- and post-training novice participants' lumbar motions and muscle activities compared to that of experienced nurses. An analysis of variance (ANOVA) between the results of the pre- and post-trained novice participants and the experienced nurses supports a rejection of the null hypothesis as there was a significant difference between the novice participant pre-training results and the experienced nurses. Having some training in the BIPP protocols seemed to have reduced lumbar motions as measured by a LMM and upper musculoskeletal activity as measured by EMG in this study.

5.2 Limitations of the Study

Discussion of the results of this study must be done in light of the limitations in this study.

5.2.1 Construct limitations

In any investigations of human performance, especially those conducted outside a typical work setting, there is the possibility for the Hawthorne effect to influence the results. The Hawthorne effect explains the changes to human behaviour that occurs as a result of being observed (Muchinsky, 2000). When knowingly being observed, humans will modify behaviour to more closely satisfy what the subject perceives to be the expectations of the researchers or what they assume is the correct experimental response (Muchinsky, 2000). In this study the experienced nurses may have been more mindful of their posture when performing patient transfers than they would have been during a typical work shift. Therefore, the lumbar motions and muscle activity during testing protocols for the experienced nurses may have been less then what may actually measured when not being tested.

There are limitations to using EMG activity and LMM measures to reasonably discuss musculoskeletal loading and therefore risk of low back disorder (LBD). The EMG unit that was employed in this study had the capability to analyze eight muscles simultaneously. However, the number muscles required to perform the patient transfer tasks would likely exceed those selected to be analyzed. Therefore, the EMG activities recorded is only providing a partial picture of the overall muscle recruitment needed to complete the patient transfer.

To be able to compare results for all participants with varying morphologies and therefore varying muscles masses, the EMG values were normalized using maximal voluntary isometric contractions (MVC) taken at the beginning of each testing protocol. There are limitations to using a MVC for this purpose, in particular considering the repeated measures model employed for the novice participants. In the situation where the participant was not familiar with this protocol, the results of the MVC's taken from their first experience with MVC's would likely differ when compared to their second day of MVC's. Therefore comparing these data can introduce higher measures of intra- and inter-subject variability, masking changes that may otherwise be found to be statistically different.

Although the LMM is considered a reliable method to estimate thoracolumbar motions it is not a direct measure of lumbar motion (McGill and Kavcic, 2005; Marras, 1999). However, this technology has been widely acknowledged as a surrogate metric for measuring thoracolumbar motions.

5.2.2 Methodological limitations

Ethical concerns must always be considered in human investigations and often result in limitations within the experimental protocol. In this study the novice participants were never truly unaware of the proper techniques employed in patient transfers as each viewed a BIPP training video prior to the pre-training testing protocol. This was done in consideration of participant safety as patient handling can be considered a heavy materials handling task.

The tasks selected for this study were based on previous research that reported certain transfers to be a higher risk for injury to a nurse or allied health professional (Yip, 2001; Engvist, Hagberg, Hjelm, Menckel and Ekenvall, 1998). However, two of the three transfers selected required a second person to assist in the transfer the patient. This second person underwent training in these patient transfer tasks in order to maintain consistency in performance from subject to subject. However, it is possible that the actions of this second experimental personnel influenced how the participant attempted the transfer.

The participant was required to perform the transfers on the right side of the bed. The control of the side of the bed was consistent regardless of the handedness or side preference of the participant. Therefore, the transfer for some participants may have been more awkward than other participants.

In light of these limitations there are statistical trends that emerged from the data collected during this study which suggest that level of experience and training will reduce the magnitude of biomechanical metrics assumed to be related to the risk of overexertion injuries such as LBD.

5.3 Transfer 1: Repositioning up in bed, positioned at the side of the bed

A significant reduction in normalized muscle activity was observed for novice participants in both left and right erector spinae post-training with BIPP (see Figure 4.1). When also considering the LMM results, there was a significant decrease between the pre and post-training sagittal lumbar extension and flexion (see Figure 4.3). The biomechanical principle important for this BIPP transfer requires the participant to employ a weight shift from side to side to create momentum in a horizontal plane for the transfer (Bouchier, 1995). In the experiment the participants were consistently located to the left of the patient, and therefore the head of the bed and the direction of the transfer would be to the right for the participant. The weight shift for participants in the study would then consist of transferring the body weight from their left leg, located in line with the hip level of the patient, to the right leg. The participant performed this transfer with the mirror volunteer. The participant gave a count of three to commence the movement. Using such a weight shift approach, the participant was able to reduce the amount of hip flexion and extension motions as seen in the decrease in sagittal range and muscle activity in the left and right erector spinae (see Figures 4.1, 4.3).

The results also demonstrated a decrease in lateral lumbar range and right bend displacements in post-training results. After BIPP training, novice participants were able to transfer the patient to their right with weight shifting again while maintaining a more neutral thoraco-lumbar posture (see Figure 4.3).

There was a reduction in maximum left trapezius muscle activity following BIPP training (see Figure 4.1). The BIPP program instructs patient handlers to brace their elbows at their sides, to elevate the bed height such that their upperarms and forearms are forming a 90 degree angle (see Figures 3.2, 3.3), and while transferring the patient using the drawsheet their knuckles should skim along the bed (Bouchier, 1995). These postures were recommended to minimize the use of the neck, shoulders and arms to transfer the patient towards the head of the bed. The mean and maximum activities of the left trapezius were higher for the pre-training conditions as participants likely tended to try and lift the patient using the drawsheet and, with the aid of the left arm, pull the patient up in bed (Figure 4.1).

When comparing the results from novice participants to that of experienced nurses, the post training group had significantly lower mean left trapezius activity levels than the experienced workers (see Figure 4.13). The maximum EMG values revealed that both the pre- and post-training result for left and right trapezius were significantly less then that recorded from the experienced nurses (see Figure 4.14). These results would suggest that perhaps more emphasis on the posture of the shoulder girdle needs to be given during BIPP instruction. Currently the BIPP instructs the patient handler to maintain a 90 degree orientation at the elbow while they are braced against the sides of the handler and to skim the knuckles along the bed, as not to lift the patient during the transfer. It has been acknowledged that when adjusting postures to minimize risk of low back pain that the loads are transferred to another joint, such as the shoulders, increasing the risk of injury to tissues other than those of the back (Gagnon, Chehade, Kemp and Lortie, 1987, MacKinnon and Vaughan, in press). Keir and MacDonell (2004) noted that there has not been many muscle activity studies during patient transfer tasks, especially for muscles other than the back extensors. This knowledge gap makes it difficult to decide whether the level of upper extremity muscle activity observed in this study relates to levels of exertion sufficient to increase the risk of injury or not. Results from this study are comparable to Keir and MacDonnel (2004) who reported similar trends in normalized EMG values recorded for trapezius activity. In their study, regardless of the side of the bed or the transfer technique used, the experienced nurse consistently had higher trapezius activity levels. Keir and MacDonell (2004) theorized that this increase was due to the experienced nurses activating their trapezius as a protective strategy to stabilize the elbows at their sides. Similar interpretations can be made for this study.

When comparing experienced nurses' LMM values to those collected pre- and post-training for the novice participants, the experienced nurses were not significantly different from the novice participants for most LMM measures recorded. The pre-training novice participant results had significantly higher maximum left bend, sagittal range and twist angle than the nurses (see Figures 4.15, 4.16, 4.17). This would indicate that the post training group and the experienced nurses were able to adopt a more neutral body posture which allowed for less twist and flexion/extension than those who have not received previous training.

These results would indicate that the experienced nurses were not significantly different from the post-training group suggesting that the training from BIPP which has previously been provided to improve biomechanics of patient transferring are still influencing the experienced nurses' transfer techniques. This result suggests that consideration be given to the frequency of re-training in order to optimize learning retention. The experienced nurses that volunteered for this study varied in respect to the time since they were last trained in the BIPP techniques. The standard deviations for the experienced group, however, appear to be no greater than those calculated for the pre- and post-training groups. Previous research has focused on the efficacy of transfer education or the use of lift assisting devices pre- and post-training (Finch Gutherie, Westphal, Dahlman, Berg, Behnam & Ferrell, 2004; Johnsson, Carlsson and Lagerstrom, 2002; Goodridge & Laurila, 1997). To date there is little known research regarding the retention of learning transfer techniques and the appropriate duration before retraining should occur, and perhaps more importantly, if retraining is in fact effective.

When reflecting on the results recorded for thoracolumbar positions and displacements for the post-training group and the experienced nurses, the values obtained are below those Marras et al.. (1995) considered to be correlated with low risk, with the exception of left bend (Figure 5.1). The lumbar velocities recorded for all experimental groups were lower compared to Marras et al..'s (1995) velocities suspected to put operators in a low risk category for overexertion injuries (Figure 5.2). Marras et al.. (1995) examined various occupational "lifting" tasks. While the patient transfers considered in this study have a "lift" component, the BIPP principles attempt to minimize the motions in the vertical direction and promote motions in the horizontal direction. Furthermore, the average load masses considered in Marras' data set are considerably lower than loads typical of patient transfers. Therefore, comparison between these data and the data set from Marras (1995) may not be appropriate. However, in light of the lack of suitable guidelines for safe transfer techniques, these empirical data may still provide some benchmark comparisons as to whether or not the lumbar motions typical of patient transfer tasks can be considered safe.

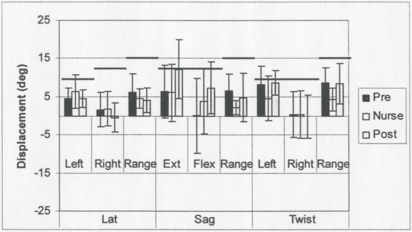

Figure 5.1: Comparison of novice participant pre and post-training, experienced nurses and Marras et al. (1995) reported low risk values for maximum displacement for transfer 1: reposition up in bed, positioned at side of bed.

Note: Bold line represents Marras et al.. (1995).

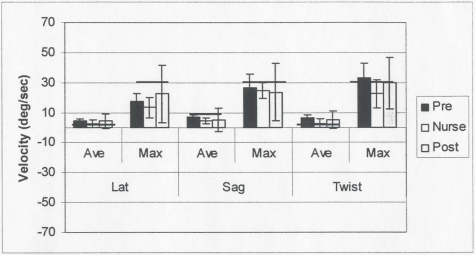

Figure 5.2 Comparison of novice participant pre and post-training; experienced nurses and Marras et al. (1995) reported low risk values for maximum velocity for transfer 1: reposition up in bed, positioned at side of bed.

Note: Bold line represents Marras et al.. (1995).

5.4 Transfer 2: Repositioning up in bed, positioned at the head of the bed

A decrease in maximum EMG activity was observed between pre- and post-training novice participants for both left and right external oblique, the left and right trapezius, and left erector spinae muscles (see Figure 4.6). The participants also had a reduction in lateral right bend and range, sagittal extension and flexion, left twist and lateral velocities following the BIPP training (see Figure 4.7). From these results it appears that prior to training, the novice participants would use a combination of sagittal extension, lateral velocity and twist to reposition the patient up in bed when the participant initiated the transfer from the head of the bed. BIPP instructors instruct the patient handlers to use a weight shift technique to transfer the patient up in bed. The participant is instructed to stand "tall" on their knee while holding the drawsheet tight, then to transfer body weight by sitting on their back heel. The participant will have been positioned at an angle such that the midline of their body is inline with the opposite end of the footboard (see Figure 3.5). Since this is a two person transfer, the same position is mirrored by the second patient handler on the opposite side of the bed. The participant would communicate verbally with the other handler when to initiate the transfer. Both would then transfer weight from the knee to sitting back onto the heel (sees Figure 3.4, 3.5). The system mechanics considered in this transfer require that both persons performing the transfer be at equivalent relative angles to the patient when the weight transfer is applied. Thus, an equal effort would create a resultant force vector in the direction towards the head of the bed.

When comparing the normalized EMG for all experimental groups for the repositioning up in bed while at the head of the bed, reveals the post-trained novice participants having a significantly higher left trapezius activity then the nurses (see Figure 4.21). As previously discussed, recruitment of the trapezius muscle can be considered a protective strategy that nurses can employ during such a maneuver (Keir & MacDonnell, 2004; Gagnon et al., 1987). The left deltoid activity was lower for the post-trained novices when compared to the nurses. The position during the transfer may have dictated the reason why the deltoid activity would be higher for nurses. The BIPP program would situate the patient handler at a diagonal to the footboard of the bed, however if the patient handler was not on an exact diagonal to the opposite foot of the bed, it was observed that the left arm was held in a more extended position during the transfer, increasing the involvement of the arms during the transfer (see Figures 3.4, 3.5). A recommendation from this study would be to attempt a more in depth study of the muscle activities of the neck, shoulders and arms during this transfer.

The experienced nurses and the post-training measures had consistently smaller LMM displacements and velocities than the novice participants prior to training. When comparing the results of all experimental groups to the low risk values determined by Marras et al. (1995), all motions were smaller, with exception of left bend (Figures 5.3, 5.4).

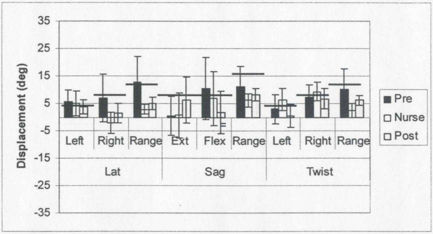

Figure 5.3: Comparison of novice participant pre and post-training, experienced nurses and Marras et al.. (1995) reported low risk values for maximum displacement for transfer 2: reposition up in bed, positioned at the head of the bed.

Note: Bold line represents Marras et al. (1995).

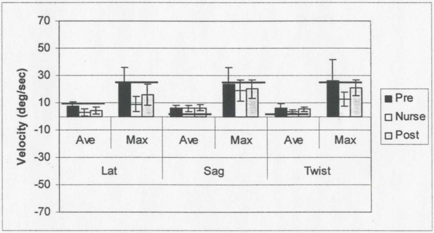

Figure 5.4: Comparison of novice participant pre and post-training, experienced nurses and Marras et al.. (1995) reported low risk values for maximum velocity for transfer 2: reposition up in bed, positioned at the head of the bed.

Note: Bold line represents Marras et al. (1995).

5.6 Transfer 3: Bed to chair, one person pivot technique

During the transfer from bed to chair using the one person pivot technique, following training, the novice participant demonstrated a reduction in normalized EMG activity for left and right trapezius, left and right erector spinae, and left oblique (see Figure 4.9, 4.10). The right quadriceps increased its maximum and mean EMG activity following training. The LMM results indicated a reduction in lateral displacement, as well as sagittal and twisting velocities (see Figure 4.11, 4.12). During this transfer the BIPP instructs patient handlers to begin the lift by gaining momentum by initiating a rocking motion from the front to the back of the feet. The hips of the patient handler are to be square to the patient. The patient will then be rocked until enough momentum is produced to clear the patient's gluteus from the bed. The patient handler then pivots and guides the patient towards the wheelchair which is positioned at an angle of 45 degrees to the bed. The participant was instructed to pivot on the right foot and to follow the patient, remaining in a parallel position to the patient and to squat using the legs to place the patient gently in the chair (see Figure 3.6). The reduction in lateral displacement, twist velocity and oblique normalized EMG activity would indicate that the participants are pivoting with their patients when turning to place them in the wheelchair.

The reduction in trapezius and erector spinae normalized EMG activity and increases in quadriceps activity along with reduction in sagittal LMM velocity would indicate that following training the participants are adhering more consistently with the weight transferring from the front to back foot as opposed to employing a strategy of extending and flexing the trunk in the sagittal plane.

While the one person pivot technique does not require communication between two patients handlers, this transfer appeared to be the most difficult to master of those considered in this study. Higher maximum and mean normalized EMG values were recorded for right trapezius activity for experienced nurses when compared to both pre- and post training values. As previously discussed, Keir and MacDonnel's (2004) indicate that increases in trapezius activity may serve as a protective strategy. The normalized EMG values obtained for both left and right erector spinae of the pre-training novice participants were significantly higher then those recorded for the experienced nurses (see

Figures 4.27, 4.28), suggesting that after BIPP training, using a weight shift from front to back with a staggered stance is effective in reducing thoracolumbar extension and flexion while still generating sufficient momentum to clear the patient fully from the bed. Further support of this interpretation is the significant increase in left quadriceps activity for the experienced nurses compared to the pre-trained novices. Due to standardized equipment set up, the wheelchair in which the patient was required to be placed into was consistently to the right of the participant; thus, the left leg would be lunged forward and the right leg extended backward to have the staggered leg posture necessary to perform the weight shift. When adopting the techniques instructed by BIPP, the left quadriceps would experience more activity as the legs are in a bent position to allow the nurse to lower her trunk to that of the patient without forward flexion at the lumbar spine.

When considering the LMM results, more support can be given for the use of weight shifting by the participants. A reduction in thoracolumbar twisting displacements and velocities, lateral displacement and velocities and sagittal displacements and velocities were recorded for the experienced nurses when compared most often to the pre-training novices (see Table 4.29, Figure 4.32). This indicates that that they are keeping the pelvis more square and reducing motion in the thoracolumbar spine. When comparing all experimental groups' lumbar motions to those reported by Marras et al. (1995), all of the results are below those indicated to be low risk (Figure 5.5, 5.6).

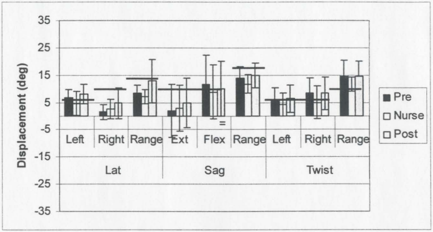

Figure 5.5: Comparison of novice participant pre and post-training, experienced nurses and Marras et al. (1995) reported low risk values for maximum displacement for Transfer 3: Bed to chair, one person pivot technique.

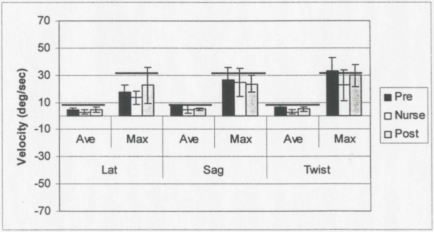

Figure 5.6: Comparison of novice participant pre and post-training, experienced nurses and Marras et al.. (1995) reported low risk values for maximum velocity for Transfer 3: bed to chair, one person pivot technique.

Considering all transfers of the BIPP analyzed in this study, the postures and techniques that the BIPP instructs was able to reduce the degree of motion and amount of muscle activation when compared to those who have not received training. The results of this study indicate that some back education such as that received by the post-training novice participants and the nurses, had more favorable postures and muscle activity levels then not having any training as represented by the pre-training novice participants.

CHAPTER 6: CONCLUSION

6.1 Conclusion

This study rejected both null hypotheses upon reflection of the data collected in this study. The first null hypothesis was rejected suggesting that the back injury prevention program (BIPP) has a positive effect on lumbar motion and upper musculoskeletal electromyographical activity during patient transfer tasks. The results of this study indicated that there is a significant difference in transfer technique between pre and post-training novice participant's techniques.

The second null hypothesis was also rejected inferring that there was a significant difference between the pre- and post-training novice participant's lumbar motions and muscle activity compared to that of experienced nurses. The analysis of variance (ANOVA) employed to compare the data from the novice participants' and the experienced nurses indicated that there is a significant difference in the metrics employed to assess these patient transfers. In all three transfers the post-training results showed more favorable muscle activities and lumbar motions that those before training. Whether the experienced nurses had a better technique with regards to the dependent measures that have been measured during this experiment than the post-training data from the novice participants was variable depending on the measure and the transfer. However, since all the experienced nurses that participated in the study would have been trained with the BIPP program at some point in their career, it can be concluded from this evidence that training from the BIPP program should induce lower muscle activity level in the trunk, neck and shoulders, as well has less lumbar motions compared to no previous training.

A recommendation from this study would be to further research the retention of the BIPP by participants. Another recommendation of this study would be to assess the availability of transfer aids, such as the transfer belt, as well as assess if there is adequate nurses available during each shift such that two person transfers can be efficiently performed when appropriate. Further research should also investigate the capability of the nurses to employ the BIPP techniques in the workplace when factors such as inadequate space, lack of available staff, and fatigue from shift work are present.

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