Biomechanical Assessment of WorkSafeNB’s Recommended *Back in Form*

Techniques

by

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ABSTRACT

In New Brunswick (N.B.), nursing homes have one of the highest industry assessment rates, $4.48 for every $100 of payroll (WorkSafeNB, 2017a). In NB, some nursing homes, in collaboration with New Brunswick Community College (NBCC) and the WorkSafeNB have implemented Back in Form (BIF), a transfer and repositioning training program for the care staff in nursing homes. Back in Form is based on using proper body mechanics, and the concept of no lifting to transfer or reposition residents. The techniques are designed to transfer or reposition residents rather than manually lifting residents therefore improving comfort and independence of the resident. The BIF techniques were developed using biomechanical principles and claims to reduce the risk of injury for nursing staff, but it has not yet been quantified. The purpose of this study was to investigate three Back in Form transfer techniques (pivot transfer, turning the client in bed and 2-person hammock repositioning) to determine if they were below published joint loading thresholds. Although there are no published shoulder loading thresholds, peak and cumulative spine compression thresholds have been recommended at 3,500N and 30MNs, respectively. Results from this study indicate that the peak and cumulative spinal joint loading for Back in Form techniques were below published threshold limits, and the majority of the time was spent in neutral postures of the spine, shoulders and neck while performing techniques.
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Chapter 1: Introduction

1.1 Introduction

In recent years, health care workers, specifically nursing staff have become a focus of health and safety interventions. The incidence rate of lower back disorders in nurses’ aides was determined to be higher than in the traditional heavy physical occupations (Jensen, 1987). Nursing homes report a work related musculoskeletal injury (MSI) incidence rate of 13.5 per 100 workers (Nelson & Baptiste, 2006). In New Brunswick (N.B.), nursing homes pay one of the highest basic worker’s compensation rates of any industry at $4.48 for every $100 of payroll. The average assessment rate for the province is $1.70 per $100 of payroll for all industries, making nursing homes well above the provincial average (WorkSafeNB, 2017a).

There are many challenges presented to care givers in long term care facilities due to the variations in residents’ size (height and weight), physical ability, cognitive function and level of cooperation. There are several other critical risk factors associated with manual resident handling: uncoordinated lifts, balance of lifter and resident, lifting pairs with significant anthropometric differences, awkward postures, untrained lifters, lack of mechanical lifts or assists use, and fatigue and injury of nurses (Nelson & Baptiste, 2006). In a recent study, it was determined that the most dangerous manual patient handling tasks involved lateral transfer and repositioning due to the higher level of physical exertion and extended duration of these tasks (McCoskey, 2007). It is known that the loads currently being lifted by nurses and caregivers are significantly above
current NIOSH guidelines for manual handling which recommends 23kg as the maximum load to be handled (NIOSH, 1992).

The National Institute for Occupational Safety and Health (NIOSH) Traumatic Injury Research and Prevention Program Evidence Package, published in March 2007, summarizes the concern for acute injury risk due to patient handling (Waters et al., 2006). It is estimated that direct and indirect costs associated with back injuries in the healthcare sector are $20 billion annually. Nurses’ aides and orderlies report the highest prevalence of back pain, 18.8%, in the female working population. In New Brunswick, some nursing homes, in collaboration with WorkSafeNB have implemented Back in Form (BIF) (WorkSafeNB, 2012a), a transfer and repositioning training program for the care staff in nursing homes. BIF is based on using proper body mechanics, and the concept of no lifting, to transfer or reposition the residents. Those who are unable to bear weight on at least one foot require a mechanical lift. The manual techniques involve the use of the body as a unit, shifting the caregiver’s weight from one foot to the other to generate force. The 23 techniques defined by the BIF program were developed using biomechanical principles and claim to reduce the risk of injury for nursing staff, but it has not yet been quantified. This thesis focuses on three commonly used transfer and repositioning techniques: 1) pivot transfer: used to transfer a patient from a bed to a wheelchair; 2) turning the client in bed: used to reposition a patient onto their side; and 3) 2-person hammock repositioning): used to reposition patient to the head of the bed. Full details of the technique and its purpose are provided in Appendix C.
Peak compressive forces on the spine have been the basis of most ergonomic tools and guidelines used to analyze jobs (Callaghan, Salewytsch, & Andrews, 2001). Reducing only the high peak forces to minimize the risk of injury has a noticeable effect for individuals performing the job or tasks, but may not reduce the risk of injury for those who repeat handling tasks frequently (Daynard et al., 2001). More recently, studies have shown that cumulative spinal loading should also be considered when assessing risk factors for a particular job or task (Daynard et al., 2001; Kumar, 1990; Norman et al., 1998). Studies have also demonstrated that cumulative loads while patient handling are high (Daynard et al., 2001; Marras, Davis, Kirking, & Bertsche, 1999).

1.2 Purpose and Hypothesis

The purpose of this study was to determine if the three selected WorkSafeNB promoted BIF techniques are biomechanically safe based on published spinal cumulative and peak loading threshold limits. The following hypotheses were put forward:

1. The Back in Form techniques will require peak and cumulative spinal joint loading below published threshold limits of 3400N and 30MNs, respectively.

2. Cumulatively, more than 90% of the task time will be spent in neutral postures of the spine, shoulders and neck while performing Back in Form techniques.
Chapter 2: Literature Review

2.1 Introduction

Research has shown that manual patient handling poses an inherent injury risk to workers. In a research survey, it was found that 3.5% of nurses were leaving their jobs because of back pain. Of those, 46% were leaving the nursing profession for good (Stubbs, Buckle, Hudson, Rivers, & Baty, 1986) LBP, in conjunction with an aging workforce and a nursing shortage, impact the level of care provided in the healthcare industry. A range of intervention strategies have been implemented over the years in attempt to minimize the risk of musculoskeletal injuries to nursing staff. Most of these interventions are comprised of biomechanically-based manual patient handling techniques which have been shown to have mixed results (Bos, Krol, van der Star, & Groothoff, 2006; Hignett, 1996; Moens, Johannik, Dohogne, & Vandepoele, 2002; Pheasant & Stubbs, 1992; Stubbs, Buckle, Hudson, & Rivers, 1983; Videman et al., 1989). A review by Hignett (2003) examined patient handling research from 1960 to 2001 and found strong evidence against interventions based only on technique training and strong evidence for a multifactorial intervention comprised of a combination of the seven most common strategies; equipment, education and training, risk assessment, policies and procedures, patient assessment system, work environment redesign, and work organization and practices changes. An a recent economic analysis of a safe resident handling program (SRHP) concluded that the decreased cost of worker injury compensation claims and turnover were at least partially attributable to the SRHP and of
the 110 centers analyzed, over half saw a positive return on investment for the SRHP (Lahiri, Latif, Punnett, & the ProCare Research Team, 2013).

### 2.2 Nursing Home Industry

The nursing shortage is emerging as a serious problem in the health care industry. Recent Canadian statistics would indicate that more nurses are entering the field and the supply of nurses has grown almost 9% since 2007 and that there was a 9% increase in the proportion of young nurses ("Nursing Statistics," n.d.). Demand for senior care is also on the rise, and the growth in the nursing workforce is unlikely to be able to keep up ("Growth in nursing workforce unlikely to keep up with demand for seniors care | Canadian Nurse," n.d.). The working conditions in a health care setting, particularly long-term care facilities, are very different than those found in industrial or manufacturing settings. There are a series of factors including, physical, social, organizational and psychological factors (Daraiseh et al., 2003) that when combined, may contribute to the high injury rates found in this industry. In New Brunswick, nursing homes have one of the highest injury rates of all industries. The primary injuries in nursing homes are those to the back, shoulder and neck and most are reported to be caused by manual patient handling ((Daraiseh et al., 2003; WorkSafeNB, 2017b). Back and shoulder injuries account for 43% of claims in New Brunswick nursing homes (WorkSafeNB, 2017b). It has also been reported that nurses’ aides report more injuries than nurses (Pheasant & Stubbs, 1992). This may be due to the amount of patient handling performed by nursing aides compared to the nurses. According to WorkSafeNB statistics, the total number of care staff injuries in N.B. nursing homes was 1,157 of which 48% were coded as nursing
aides and orderlies, 38% as nursing assistants, and only 14% as nurse graduates (registered nurses). It has also been suggested that the amount of manual patient handling performed is a better predictor of injury than specific professions. Stobbe (1988) examined the relationship between the incidence of back injury and the amount of patient handling activities. Significant differences were found between “frequent” and “infrequent” patient handlers regardless of which profession they belonged (Stobbe et al., 1988), with frequent patient handlers more than twice as likely to develop a back injury. A more recent study had similar results when examining whether the prevalence of low back pain increased in hospital nurses with high patient care load (Shieh, Sung, Su, Tsai, & Hsieh, 2016).

2.3 Injuries in the Nursing Home Industry

Back, shoulder and neck injuries are the most prevalent injuries reported in New Brunswick nursing homes. Twenty-seven percent of all claims in N.B. nursing homes are due to back injuries, and 16% are shoulders and neck injuries (WorkSafeNB, 2017b). In nursing professions the incident of LBP is almost 30% higher than in the general population (Pheasant & Stubbs, 1992). Research indicates that the risk of LBP is 3.7 times higher for care givers who frequently performed patient handling tasks (Jensen, 1990). This is supported by Byrns (2004) who examined the risk factors associated with work related LBP in registered nurses. The most significant risk factors associated with work related LBP were “combined lifting” and “more years worked in nursing”.

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2.4  Low Back Pain

2.4.1  Anatomy and Injury Mechanism

An injury occurs when the applied loads exceeds the failure tolerances or strength of a tissue (McGill, 1997). It is said that over 80% of the adult population will experience LBP at some point in their lives (Waddell, 1987). To fully understand how LBP affects the worker, one must understand the mechanisms of how back pain occurs (Marras, 2000).

Mechanical loading is the force acting on the musculoskeletal system. There are two types of forces that act on the spine: external forces, which are those due to gravity acting on the worker’s body and the object being moved, and internal forces which are produced as a reaction to the external forces to maintain equilibrium (Marras, 2000). Mechanical loads on the spine can be applied in any direction since they occur in three-dimensional space. Compression loads are applied along the axis, shear loads are applied across the axis and torsion loads are applied around its axis (Marras, 2000). Injury results from either a load exceeding the failure tolerances, or cumulative trauma from low loads causing a degradation in the failure tolerance levels, or sustained loads (McGill, 1997). The spine has been shown to be at greater risk of sustaining shear injury, (>1000 N) than compressive injury (3400 N), yet most injury reduction tools examine and aim at reducing compression forces (McGill, 1997). To offset the anterior shear forces, an individual must maintain a neutral spinal posture and flex at the hip rather than from the spine to create posterior shear forces (McGill, 2004).
2.4.2 Risk Factors Associated with Low Back Pain

Risk factors for low back pain can be divided into physical factors and psychosocial factors. Some of the physical risk factors associated with musculoskeletal injuries (MSI) are awkward postures, forceful exertion, repetitive work, or whole-body vibration. Psychosocial risk factors include, job dissatisfaction, monotonous work, limited job control and lack of social support (Marras, 2000). It has been suggested that static work postures are a physical risk factor for MSI, but Marras (2000) found insufficient evidence to support that theory.

Fatigue has also been proposed as a risk factor for musculoskeletal injuries. In a study by Hui (2001), subjective ratings and objective measure of intensity of nursing activities were compared with back fatigue before and after a standard shift. Female nurses with at least two years of experience in a geriatric care setting and no history of back injury were recruited. Perceived anticipated exertion was recorded and heart rate was monitored throughout the shift to determine physiological demands. Muscle fatigue was determined using surface electromyography (sEMG) to measure the muscle activation during a horizontal trunk holding test performed before and after their shifts. sEMG using electrodes placed on the skin over the muscle belly of interest to record the electrical activity beneath the skin as the muscle contracts. The electrical signal captured by the electrodes can be analyzed with respect its amplitude and frequency characteristics. In terms of assessing fatigue in isometric contractions, the change in median frequency of the signal is often the characteristic of interest. Muscle fatigue was found to be higher at
the end of the shift then at the end. The initial median frequency of the erector spinae in the post shift measurements was lower than the pre-shift measurements and had an increased negative slope.

2.4.3 Cumulative Loading

Back injuries and other MSIs are rarely caused by one acute peak load exceeding the tissue tolerance level. Kumar (1990) suggested that cumulative fatigue due to repeated load application would reduce a tissue’s stress bearing capacity, which may reduce the threshold stress at which tissues fail. This is called cumulative loading. Kumar (1990) investigated the difference in “pain” and “no pain” groups of institutional aids. The researchers collected anthropometric, demographic, pain, and work information using a questionnaire. Posture details were transcribed to a two-dimensional drawing. One hundred and sixty-one institutional aids participated, of these, 42.8% of males and 64.6% of females reported back pain. The cumulative compression at the thoracolumbar and lumbosacral discs was significantly higher in the pain group. The cumulative shear was significantly higher in the male pain group, but among the female participants there was no significant difference between the pain and no pain groups. The total time spent working was significantly higher in both the male and female pain groups (Kumar, 1990). The investigator concluded that injuries could occur after multiple sub-threshold loading repetitions over a period of time.

The risk of cumulative injury is not as obvious as for acute or overexertion injury since it is usually caused by repeated sub-maximal loads that may fall within the ergonomic guidelines or limits for peak exposure. A study by Norman et al. (1998) conducted in the
automotive industry examined peak and cumulative loading as predictors of reporting LBP. The researchers concluded that cumulative loading variables measure different demands of the jobs than peak load variables. Cumulative quantifies the repetitive strain as it incorporates the magnitude of the load, duration, and repetitiveness of the exposure. This could indicate that both peak and cumulative force need to be considered when assessing workplace MSI risk factors.

### 2.4.4 Measurement Techniques

Identifying and calculating cumulative loading presents difficulties due to the variation in spinal loads with respect to time. Several techniques have been used in an attempt to find the most accurate prediction method for cumulative loads. Callaghan et al. (2001) assessed the amount of error in five different approaches to calculating cumulative loads varying from multiplying the peak load over the entire exposure time, to integrating the load and each point in time over the exposure, to decreasing the sampling rate. The researchers used a biomechanical model as the “gold standard” comparison to the other techniques. Results indicated that reducing the sampling rate to 5Hz produced very small errors across all tasks performed and participants analyzed.

### 2.4.5 Posture Matching -3DMatch

Assessing 3D movement in the workplaces has been challenging due to environmental constraints such as equipment, machinery and safety procedures. Methods have been used in laboratory settings, but they were not practical for use in the workplaces. A posture matching software program called 3DMatch was developed that is easy to use,
allows for faster analysis than digitization (Jackson, Reed, Callaghan, Albert, & Andrews, 2003) and has the detail and accuracy of rigid link modeling (Callaghan, 2006). 3DMatch calculates three-dimensional joint forces using postures identified from the imported two-dimensional video (Sutherland, Albert, Wrigley, & Callaghan, 2007). Posture bins were developed based on range of motion and data from other postural approaches. Each of the four joints — elbow, shoulder, neck and lumbar spine — is matched with a posture bin that best represents the posture. Each frame is “integrated” to determine the exposure time and calculates the cumulative loads (Callaghan, 2006).

2.4.6 Validation

Preliminary validation of 3DMatch revealed that the software program tended to underestimate the L4/L5 flexion/extension moment by 12.2% (Callaghan, Jackson, Albert, Andrews, & Potvin, 2003). Sensitivity analysis revealed that finer resolution may be required in certain bins because there were large differences for adjacent trunk flexion (39.7%) and lateral bending (47.2%) posture bins. The largest possible cumulative moment error if one of the trunk flexion posture was mismatched was found to be 5.34%, but this error would increase with increased mismatching of postures.

In a study by Sutherland, Albert, Wrigley, & Callaghan, (2007), the effect of camera viewing angle on posture assessment repeatability and cumulative spinal loading was examined. Four standard video cameras, placed at viewing angles of 0°, 45°, 60° and 90° to the frontal plane, captured the lifting trial at 30 frames/s. The researchers found that the recording angle had a minimal impact on the ability of the raters to assess postural positions. Sutherland et al. (2008) further identified a strong intra observer (ICC > 0.811)
reliability for compression and reaction shear, and fair to good reliability for joint anterior and posterior shear (ICC > 0.590). They also found no significant difference in inter-observer reliability.

2.5 Patient Handling

Patient handling has been identified as the task representing the highest risk of injury to nursing staff (Byrns, Reeder, Jin, & Pachis, 2004; Jensen, 1990; Marras et al., 1999). In a study by Marras et al. (1999) one-person and two-person transfers were evaluated for risk of LBP. Twelve experienced and five inexperienced participants with no history of back pain performed patient handling tasks under various conditions. In the first portion of the study, participants performed patient transfers using one of three transfer techniques while performing six different tasks. The second portion involved a “standard’ patient (50kg female) with a standard level of dependency. The researchers concluded that manual patient handling, with either one or two persons, was an extremely hazardous job with a high risk of causing low-back injury. Forty-six percent of shear loads for the two-person transfers exceeded the limits, and the rest approached the limits. The compressive loads for the transfers were all above 3400N, and 20% were above 6400N, which indicated that some people may be at risk even with two-person transfers (Marras et al., 1999).

In a field study by Karwowski (2005), the perceived risk of injury for nurses was investigated. The purpose of the study was to determine how nurses view the physical demands of their work. The nurses rated their perceived exertion as well as a questionnaire on their perceived risk for low back injury. The results of the study showed
a relationship between the participants’ evaluation of their work, and the perceived task demands. Perceived muscular effort and reported low back pain were associated with manual patient handling. Sustained static postures, such as drawing blood, were also perceived as high risk by the participants.

A study by Byrns (2004) examined the relationships between perceived causes of work related LBP, opinions about mechanical lifts, frequency of using lifting devices, and reporting work related LBP. Responses indicated that years in a nursing job and the amount of patient handling performed had high associations with work related LBP.

2.6 Interventions

2.6.1 Training

Research investigating the effectiveness of workplace interventions to reduce the risk of injury have had mixed results. Many interventions are based on education and training in lifting techniques and proper body mechanics. These have been found ineffective in preventing back injuries in nursing staff (Bos et al., 2006; Hignett, 1996; Moens et al., 2002; Pheasant & Stubbs, 1992; Stubbs et al., 1983; Videman et al., 1989). Most effective programs included multiple interventions such as; patient handling assessment criteria, ergonomic assessment protocols, assistive equipment, and supporting policies and procedures (Nelson et al., 2006).

Several different types of assistive equipment have been designed and developed to help alleviate some of the manual patient handling required by care staff in long term care facilities such as ceiling lifts, floor lift systems, stand-up lifts, low-friction repositioning
devices and handling aids. It has been suggested that transfer aids, such as hoists, stand-
aids, sliding sheets, transfer boards, transfer belts, and height adjustable beds and baths
should be considered the minimum equipment for patient handling in health care facilities
(Hignett, 2003).

2.6.2 Friction reducing devices

There are two types of friction reducing devices: those that are placed under the patient
before the transfer and removed after the transfer or repositioning is completed, and those
that are kept under the patient at all times. McGill (2005) found that friction reducing
transfer devices decreased friction by 50% between the moving device and the bed
surface, compared to the controlled, standard, sheet. All the friction reducing devices
tested required lower initial and sustained pushing forces than the control sheet. In terms
of L4-L5 compression, personal techniques and the movement strategy proved to be more
important factors in reducing spine loads over reducing the required applied hand force,
so getting the full benefit of the transfer devices requires proper techniques (McGill &
Kavcic, 2005).

2.6.3 Mechanical transfer devices

Research indicates that mechanical aids can reduce spinal loads and decrease the risk of
injury and decrease workers compensation costs when compared to manual patient
transfers (Chhokar et al., 2005; Engst, Chhokar, Miller, Tate, & Yassi, 2005; Miller,
Engst, Tate, & Yassi, 2006; Zhuang, Stobbe, Hsiao, Collins, & Hobbs, 1999). Research
found that the use of overhead ceiling mechanical lifts resulted in lower spinal loads
during the transport phase than floor mechanical lifts (Santaguida, Pierrynowski, Goldsmith, & Fernie, 2005). Mechanical transfer aids are more widely available for use in nursing homes, but there is still a reluctance to use these devices. Byrns et al. (2004) examined potential obstacles to using mechanical devices. Only eleven percent of participants in their study reported using mechanical lifts even though 87% of the participants worked with patients that required patient handling. Some of the reported reasons for not using mechanical devices were: lack of availability of lifts, no time to use the lifts, lack of training in using the lifts, and the patients’ weight exceeded the capacity of the lift. These results were consistent with those of Holman, Ellison, Maghsoodloo, & Thomas (2010) in which the nurses stated that: time, availability of equipment and lack of space did not allow for use. A qualitative study exploring decision-making regarding the use of safe patient handling and mobility (SPHM) technology among nursing staff revealed three major themes similar to those of Byrns et. al. (2004): barriers to use, perceived risk, and coordination of care (Kanaskie & Snyder, 2018).

Other research has indicated that the use of mechanical lifts may decrease peak spinal compression but increase the cumulative spinal loads (Daynard et al., 2001). This increase in cumulative spinal loads may be explained by increased amount of time required to use the mechanical lifts. The care staff spends more time in forward flexion while readying the patient for the equipment. In this same study by Daynard et al., (2001), compliance with interventions was affected by the perceived risk of injury, meaning that staff was more likely to comply with interventions if they were handling patients that were heavy and passive.
2.7 Back in Form

*Back in Form* (*BIF*) is a multifactorial program that includes training on transfer and repositioning techniques and is a component of a musculoskeletal injury prevention initiative in nursing homes in New Brunswick. *Back in Form* was developed in the 1990’s by WorkSafeNB (formerly Workplace Health and Safety and Compensation Commission - WHSCC) in response to the high incidence of musculoskeletal injuries that stemmed from issues due to client handling in the health care sector. The *BIF* program is unique, in that it allows the caregiver to gain an in-depth understanding of posture and body mechanics. This knowledge provides them with physical skills required to reprogram their bodies and integrate efficient weight shifts and counterbalances movements into their daily work practices (WorkSafeNB, 2012a).

The biomechanical training aspect of the program consists of 23 techniques performed by one or two care givers. The program is based on biomechanical principles and a zero-lift philosophy. The use of transfer aids such as friction reducing sheets, transfer belt and transfer boards are encouraged and in the case of the transfer belt, mandatory in some techniques. Transfer belts are widely used in nursing homes, but they are often placed incorrectly, around the waist and sometimes just below the armpits. In the *BIF* program, the transfer belt must be snuggly placed on the residents’ lower-abdomen-hip area as close to the center of gravity as possible (WorkSafeNB, 2012b).

The *BIF* program has evolved since the 1990’s and now incorporates policies and procedure templates to support the implementation and sustainability of the training, a comprehensive client assessment process with pictograms for the resident rooms,
literature from WorkSafeNB and support from their ergonomics consultants on implementation. Despite these efforts, nursing home incident rates continue to climb in the province. WorkSafeNB uses injury frequency rates to measure rates among different industries and firms. Injury frequency rate is a ratio of injuries to hours worked. The calculation is based on the hours worked by 100 workers which is 200,000, divided by the actual number of hours worked (“Hacking the TRIF | Canadian Occupational Safety,” n.d.). Since 2012, the NB nursing home frequency rate has increased by 0.76 while the rest of the province has decreased its frequency rate by 0.06 (WorkSafeNB, 2017b). BIF provides a tiered system of delivery consisting of modular training at the master trainer, trainer and employee levels. The master trainer has a higher level of training than a trainer and is responsible for providing “train the trainer” courses to trainers, who then train employees in the nursing home. Each tier of training has its own responsibilities and prerequisites for training which are described in detail in the BIF documentation (“WorkSafeNB Back in Form Overview,” 2012).

Although the BIF techniques were developed with strong biomechanical principles in mind, they have never been assessed for their biomechanical robustness. As such, the techniques have strong face validity but there is a need to determine the biomechanical impact of the transfer and repositioning techniques to insure the recommendations of BIF are appropriate for health care professions involved in patient handling. The thesis investigated three common transfer and repositioning tasks to determine their level of spine and joint loading and to assess the percentage time the caregiver is required to maintain a non-neutral posture.
Chapter 3: Methodology

3.1 Participant Recruitment

Twenty-nine female volunteers were recruited for this study. Participants were employees of New Brunswick nursing homes working as either, nurses (RN), Licensed Practical Nurse (LPN) or Resident Attendants (RA). The participants were all Back in Form trainers, and postural data was collected during one of the refresher sessions offered through 2013 by WorkSafeNB. As part of the requirements in the BIF training, trainers must attend a refresher once every three years. Interested volunteers were provided information pertaining to the purpose of this study and were given the opportunity to ask questions, prior to giving their informed consent. This study was approved by the research ethics board at the University of New Brunswick (REB File # 2010-028).

3.2 Residents

The data was collected in a simulated environment. One of the participants played the role of the resident either in the bed or the chair so that the other participants could practice and demonstrate the techniques. There were four participants, two male and two female that acted as nursing home residents for the data collection. The two males weighed 77.1kg, and 77.4kg, respectfully and the two female participants weighed 53.9kg and 82.0kg. Actual patients were not used in this study due to ethical requirements that would have been difficult to obtain in the nursing home environment.
3.3 Protocol

Data collection took place at several refresher sessions for trainers, given by WorkSafeNB master trainers. Participant anthropometrics were obtained for input into the biomechanical modeling of joint loading. The weight of the patient was also documented to determine the load manipulated by the participant. The refresher session evaluated several BIF techniques, but only the three most used techniques were recorded and examined for this study. Each participant performed all three techniques on the same patient during the refresher session and was observed by a master trainer to ensure the techniques were being performed correctly. Appendix C has detailed descriptions of the techniques shown below. The techniques of interest for this study were:

3.3.1 The pivot transfer

This technique is used to transfer a patient/resident from bed to chair or chair to bed. Patient must be able to bear weight on at least one leg, and the technique can be achieved with one or two caregivers.

Figure 3.1 Pivot transfer (one person)
3.3.2 Turning the client in bed (towards and away from the care giver) -

This technique is used to turn the client to their side. Clients can be turned towards or away from the caregiver and can be achieved with one or two caregivers.

![Figure 3.2 Turning the client to the Side (Away)](image)

3.3.3 Two-person hammock 1 (bed)

This technique is used to reposition the patient from the foot of the bed to the head of the bed if they have shifted down. The technique is performed with two caregivers using a counterbalance movement.

![Figure 3.3 Two-Person Hammock 1 (Bed)](image)

3.4 Instrumentation

Trainer performances of each BIF transfer or repositioning techniques were videotaped using a Canon PowerShot SD950IS. The camera was arranged to permit the best field of view of the entire transfer. For the purposes of posture matching it was not necessary to
have the camera perpendicular to the performance but it was important to have an unobstructed view of the participant.

3.5 Data Reduction and Processing

3.5.1 Importing, cutting and decimating videos

Each video file was imported into video capture software (Roxio Creator 11) and separated by participant and by BIF technique. Each video clip was then clipped using the video capture software and converted to AVI format. Each video clip was decimated to 5Hz to decrease the processing time without loss of biomechanical validity (Callaghan et al., 2003).

3.5.2 Posture Matching

Processed videos were transferred into 3DMatch. This allowed the researcher to analyze body segment angles frame-by-frame throughout the duration of the transfers. From this, the percentage of time spent in neutral and non-neutral postures was computed. Video clips of each task were analyzed frame-by-frame and then the postures from the video were matched to a set of pre-determined posture categories (see Appendix A), viewed in 3DMatch on the computer screen. Posture categories include: trunk flexion, trunk lateral deviation, trunk rotation, neck flexion, neck lateral deviation, shoulder flexion, shoulder abduction, and elbow flexion. Trunk flexion was represented by six posture categories from −30 to 130 degrees. The frontal and transverse planes of the trunk motion were each represented by six categories. Similar bin selections are conducted for the neck flexion (four categories), neck lateral bend (four categories), flexion/extension of the right and
left elbow (three categories), and flexion/extension (six categories) and abduction of the right and left shoulder (four categories). Each category was developed from previous posture-based tools and by considering the range of motion for each joint. 3DMatch also generates information regarding time and percent of work cycle spent in principal joint posture. The height and body mass of each participant were put into 3DMatch to develop customized biomechanical models for each participant.

3.6 Joint Loading

3.6.1 Load on the Hands

To determine the load on the hands while performing the transfers, a pilot study using a Chatillon Force gauge (model CSD200) was used while performing the techniques. Attached with the hook attachment to the transfer belt for the pivot, and the repositioning draw sheet for the hammock. The large round pushing attachment was used for turning to the side at both the shoulder and the thigh to determine the force on each hand. The force readings on the gauge were used to calculate the mean load in each hand as a percentage of client body weight. This percentage was applied to the “patient handled” weight in 3DMatch to estimate the hand loads for the different clients used in the study. Table 3.1 summarizes the forces in the hands for each technique in percent of client weights.
Table 3.1 Percent of participant handled on hands per technique.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Percent of client body weight on the hands (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pivot (per hand)</td>
<td>6.8</td>
</tr>
<tr>
<td>Hammock (per hand)</td>
<td>9.19</td>
</tr>
<tr>
<td>Turning Client</td>
<td></td>
</tr>
<tr>
<td>Hand on shoulder</td>
<td>7.28</td>
</tr>
<tr>
<td>Hand on knee</td>
<td>7.0</td>
</tr>
</tbody>
</table>

3.6.2 Extrapolating Cumulative Loads

To determine the daily cumulative loads for the employees, the number of daily repetitions pivot transfers, 2-person hammock (1) and turning client to the side was needed. This information was extrapolated using the shift assignments and the BIF assessments of the residents and the daily tasks performed with residents from nursing homes in the Saint John area. A sampling of two nursing homes was used to determine the mean transfers per day for caregivers. Data collected from two nursing homes provided the number of times caregivers perform each of the techniques during a shift for each shift (day, evening and night). Table 3.2 summarizes the number of techniques for each shift.

Table 3.2 Mean number of techniques performed per shift

<table>
<thead>
<tr>
<th>Shift</th>
<th>Pivot Day</th>
<th>Pivot Evening</th>
<th>Pivot Night</th>
<th>Hammock Day</th>
<th>Hammock Evening</th>
<th>Hammock Night</th>
<th>Turning Day</th>
<th>Turning Evening</th>
<th>Turning Night</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.3</td>
<td>1.3</td>
<td>1</td>
<td>6.5</td>
<td>9.2</td>
<td>13.9</td>
<td>32.1</td>
<td>29.2</td>
<td>33.5</td>
</tr>
<tr>
<td>St. Dev</td>
<td>2.3</td>
<td>2.3</td>
<td>1.7</td>
<td>4.3</td>
<td>4.9</td>
<td>5.5</td>
<td>27.6</td>
<td>22.5</td>
<td>22.5</td>
</tr>
</tbody>
</table>
3DMatch uses the postures from the posture matching process to estimate the location of the segments based on their angular orientation. The program uses the weight of each segment multiplied by its distance from the axis of rotation (shoulder or lower back) to provide a simple sum of distance by Force ($rXF$) multiplication to calculate joint (moments). Throughout the posture matching process, the weight for each of the clients was inputted into the corresponding hand whenever the participant was seen to bear a load or apply force to the client. From this, shoulder, low back peak, and cumulative loads were computed by technique (pivot, hammock and turning client to the side). The cumulative load for each activity was determined providing daily cumulative loading exposures.

3.7 Data Analysis

The output data from 3DMatch were transferred to Excel worksheets for each participant. The target variables (table 3.3) for each participant were collated onto one summary sheet and the mean and standard deviation across each participant for the target variables were calculated.

Table 3.3 Target variables for spine and shoulder loading

<table>
<thead>
<tr>
<th>Posture Variable (% time in posture)</th>
<th>Load variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spine</td>
<td>Force weighted compression</td>
</tr>
<tr>
<td></td>
<td>Joint anterior shear</td>
</tr>
<tr>
<td></td>
<td>Anterior reaction shear</td>
</tr>
<tr>
<td></td>
<td>Right lateral reaction shear</td>
</tr>
<tr>
<td></td>
<td>Left lateral reaction shear</td>
</tr>
<tr>
<td>Spine Flexion</td>
<td></td>
</tr>
<tr>
<td>Spine Lateral bend</td>
<td></td>
</tr>
<tr>
<td>Spine Axial twist</td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td>Abduction/adduction moments</td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td></td>
</tr>
<tr>
<td>Shoulder Adduction/abduction</td>
<td></td>
</tr>
<tr>
<td>Shoulder Flexion</td>
<td>Flexion moments</td>
</tr>
<tr>
<td>Shoulder Adduction/abduction</td>
<td>Caudal shear</td>
</tr>
</tbody>
</table>
Chapter 4: Results

4.1 Participants

The participants handled were weighed and measured as part of the data collection. For each session, the same participant handled (patient) was used throughout. Table 4.1 reports their relevant measurements.

Table 4.1 Demographics of the four participants handled in the study.

<table>
<thead>
<tr>
<th>Patient handled</th>
<th>Sex</th>
<th>Age (yrs)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Male</td>
<td>43</td>
<td>77.1</td>
</tr>
<tr>
<td>P2</td>
<td>Male</td>
<td>38</td>
<td>77.0</td>
</tr>
<tr>
<td>P3</td>
<td>Female</td>
<td>48</td>
<td>53.9</td>
</tr>
<tr>
<td>P4</td>
<td>Female</td>
<td>34</td>
<td>82.0</td>
</tr>
</tbody>
</table>

In order to compare the participants handled to residents in a nursing home, the weights of the residents were collected, and the mean weights are presented in Table 4.2. The measurements of the participants in this study as well as which participant from Table 4.1 was handled is presented in Table 4.3.

Table 4.2 Mean weight of nursing home residents compared to study participants handled

<table>
<thead>
<tr>
<th></th>
<th>Mean Weight (kg)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing home Residents</td>
<td>64.7</td>
<td>16.6</td>
</tr>
<tr>
<td>Nursing Home Residents Female</td>
<td>62.3</td>
<td>16.8</td>
</tr>
<tr>
<td>Nursing Home Residents Male</td>
<td>74.6</td>
<td>14.2</td>
</tr>
<tr>
<td>Study participant handled Mean</td>
<td>72.5</td>
<td>10.9</td>
</tr>
<tr>
<td>Study Female participant handled</td>
<td>67.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Study Male participant handled</td>
<td>77.1</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Table 4.3 Participant demographics and assigned participant handled (refer to table 4.1)

<table>
<thead>
<tr>
<th>Participant</th>
<th>age</th>
<th>Weight (kg)</th>
<th>Height (m)</th>
<th>Patient handled</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>46</td>
<td>71.0</td>
<td>1.63</td>
<td>P2</td>
</tr>
<tr>
<td>F2</td>
<td>41</td>
<td>65.7</td>
<td>1.58</td>
<td>P2</td>
</tr>
<tr>
<td>F3</td>
<td>38</td>
<td>93.0</td>
<td>1.60</td>
<td>P2</td>
</tr>
<tr>
<td>F4</td>
<td>30</td>
<td>90.7</td>
<td>1.80</td>
<td>P2</td>
</tr>
<tr>
<td>F5</td>
<td>61</td>
<td>88.9</td>
<td>1.70</td>
<td>P2</td>
</tr>
<tr>
<td>F6</td>
<td>56</td>
<td>66.0</td>
<td>1.60</td>
<td>P2</td>
</tr>
<tr>
<td>F7</td>
<td>45</td>
<td>58.9</td>
<td>1.60</td>
<td>P3</td>
</tr>
<tr>
<td>F8</td>
<td>50</td>
<td>67.1</td>
<td>1.57</td>
<td>P3</td>
</tr>
<tr>
<td>F9</td>
<td>40</td>
<td>52.1</td>
<td>1.60</td>
<td>P3</td>
</tr>
<tr>
<td>F10</td>
<td>47</td>
<td>63.5</td>
<td>1.63</td>
<td>P3</td>
</tr>
<tr>
<td>F11</td>
<td>44</td>
<td>65.7</td>
<td>1.64</td>
<td>P3</td>
</tr>
<tr>
<td>F12</td>
<td>47</td>
<td>74.8</td>
<td>1.65</td>
<td>P3</td>
</tr>
<tr>
<td>F13</td>
<td>50</td>
<td>77.1</td>
<td>1.56</td>
<td>P3</td>
</tr>
<tr>
<td>F14</td>
<td>45</td>
<td>74.8</td>
<td>1.57</td>
<td>P3</td>
</tr>
<tr>
<td>F15</td>
<td>42</td>
<td>77.0</td>
<td>1.75</td>
<td>P1</td>
</tr>
<tr>
<td>F16</td>
<td>49</td>
<td>58.5</td>
<td>1.60</td>
<td>P4</td>
</tr>
<tr>
<td>F17</td>
<td>49</td>
<td>72.5</td>
<td>1.56</td>
<td>P1</td>
</tr>
<tr>
<td>F18</td>
<td>40</td>
<td>59.0</td>
<td>1.58</td>
<td>P4</td>
</tr>
<tr>
<td>F19</td>
<td>43</td>
<td>87.0</td>
<td>1.52</td>
<td>P4</td>
</tr>
<tr>
<td>F20</td>
<td>43</td>
<td>84.0</td>
<td>1.58</td>
<td>P4</td>
</tr>
<tr>
<td>F21</td>
<td>50</td>
<td>79.3</td>
<td>1.63</td>
<td>P4</td>
</tr>
<tr>
<td>F22</td>
<td>38</td>
<td>69.3</td>
<td>1.74</td>
<td>P4</td>
</tr>
<tr>
<td>F23</td>
<td>42</td>
<td>84.0</td>
<td>1.68</td>
<td>P1</td>
</tr>
<tr>
<td>F24</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>P1</td>
</tr>
<tr>
<td>F25</td>
<td>59</td>
<td>90.7</td>
<td>1.70</td>
<td>P1</td>
</tr>
<tr>
<td>F26</td>
<td>54</td>
<td>63.5</td>
<td>1.65</td>
<td>P1</td>
</tr>
<tr>
<td>F27</td>
<td>27</td>
<td>63.0</td>
<td>1.60</td>
<td>P1</td>
</tr>
<tr>
<td>F28</td>
<td>49</td>
<td>79.0</td>
<td>1.68</td>
<td>P1</td>
</tr>
<tr>
<td>F29</td>
<td>43</td>
<td>95.0</td>
<td>1.80</td>
<td>P1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Female</th>
<th>Mean ± SD</th>
<th>Mean ± SD</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>45.4±7.4</td>
<td>73.9±11.7</td>
<td>1.6±0.1</td>
</tr>
</tbody>
</table>
Table 4.4 Mean time for each technique to be performed:

<table>
<thead>
<tr>
<th>Technique</th>
<th>Mean time (seconds)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pivot</td>
<td>11.75</td>
<td>5.69</td>
</tr>
<tr>
<td>Hammock</td>
<td>9.93</td>
<td>4.55</td>
</tr>
<tr>
<td>Turning client</td>
<td>7.43</td>
<td>2.35</td>
</tr>
</tbody>
</table>

4.2 Postural Analysis

The percent time spend in spinal flexed, lateral bent, and axially twisted postures was examined for each technique using the binning of postures in 3DMatch.

4.2.1 The Pivot Transfer

While performing a pivot transfer, participants were in neutral posture for lateral bent, 98% of the time, axial twist 92% and forward spine flexion, only 34%. Mild forward flexion was observed for almost 60% of the pivot cycle time. Severe forward flexion accounts for over 8% of the cycle time.
Figure 4.1 Percent work cycle in flexed, lateral bend and axial twist of the spine while performing a pivot transfer.

The results for the right and left shoulder were almost identical to each other for the pivot transfer. As seen in figures 4.4 and 4.5, the right shoulder was in mild flexion over 99% of the cycle, and 98% for the left. Both shoulders were in neutral posture for abduction 94% of the cycle with the right spending 4% of the time in adducted posture and the left shoulder in mild abduction 6% of the time.

4.2.2 Hammock

Participants spent much of their time in neutral posture for lateral bend (100%) and axial twist (78%) while performing the hammock repositioning. For flexed postures, they spend most of their time (91%) in a mild posture, and 9% of their time in severe spinal flexion.
Figure 4.2 Percent work cycle in flexed, lateral bend and axial twist of the spine while performing a hammock repositioning technique.

Figures 4.4 and 4.5 shows that participants spent the majority of their time in mild flexion (89% and 87% for the right and left respectively) with over 10% of the cycle in severe flexion for both the right and left shoulders. Seventy eight percent of their time was in neutral abduction posture for both shoulders, and the rest of the time spent in adduction.

4.2.3 Turning Client to the Side

Participants spent 100% of their time in neutral lateral spinal bend, 91% in neutral axial twist. Eighty-four percent of the time was spent in mild spinal flexion while turning clients to the side, with 15% in severe flexion.

Figure 4.3 Percent work cycle in flexed, lateral bend and axial twist of the spine while performing a turning the client repositioning technique.
Due to the nature of the turning technique, the right and left shoulder posture results deviate from each other more than the other techniques. The right shoulder is in neutral abduction 93% of the time whereas the left only 77%. Flexed shoulder postures are in the mild category for over 70% of the cycle for each the right and left shoulder as seen in figure 4.4 and figure 4.5.

Figure 4.4 Percent work cycle in flexed, abducted posture of the right shoulder while performing the transfers and repositioning techniques.
The peak spinal loads are presented in Table 4.5. All three techniques resulted in spinal compression loads lower than the NIOSH limit of 3400N (McGill, 1997). The hammock technique is closest to the NIOSH recommended limit at 2657N, and the pivot is a little over half the recommended limit with 1924N.

The anterior shear values were also highest for the hammock technique at 196N for joint shear and 311N for reaction shear. The magnitude of shear did not exceed the action limit value of 500N for the techniques examined.

Figure 4.5 Percent work cycle in flexed, abducted posture of the left shoulder while performing the transfers and repositioning techniques.

4.3 Biomechanical Loading Analysis

4.3.1 Peak Spinal Loading

The peak spinal loads are presented in Table 4.5. All three techniques resulted in spinal compression loads lower than the NIOSH limit of 3400N (McGill, 1997). The hammock technique is closest to the NIOSH recommended limit at 2657N, and the pivot is a little over half the recommended limit with 1924N.

The anterior shear values were also highest for the hammock technique at 196N for joint shear and 311N for reaction shear. The magnitude of shear did not exceed the action limit value of 500N for the techniques examined.
Table 4.5 Peak mean spinal loads (N).

<table>
<thead>
<tr>
<th>Back in Form Technique</th>
<th>Pivot</th>
<th>Hammock</th>
<th>Turning Client</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Variable Loads</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Maximum Compression</td>
<td>1924.5</td>
<td>392.4</td>
<td>2657.2</td>
</tr>
<tr>
<td>Anterior Joint Shear</td>
<td>169.4</td>
<td>38.1</td>
<td>196.1</td>
</tr>
<tr>
<td>Anterior Reaction Shear</td>
<td>289.2</td>
<td>47.6</td>
<td>311.4</td>
</tr>
<tr>
<td>Lateral Reaction Shear (Left)</td>
<td>22.1</td>
<td>43.7</td>
<td>16.5</td>
</tr>
<tr>
<td>Lateral Reaction Shear (Right)</td>
<td>25.5</td>
<td>52.6</td>
<td>57.9</td>
</tr>
</tbody>
</table>

4.3.2 Cumulative Spinal Loading

The cumulative spinal loads in Table 4.6 reports the loads by shift, and the mean on any given day on any shift. These values are based on the mean performance of the three techniques on each of these shift times. The cumulative spinal loads for day and night shift appear to be almost identical for all variables, and there is an increase in loading during the night shift for all variables. When comparing the techniques, the cumulative compression loads are greatest for turning the client to the side (207498.1 N*s) which is almost double the cumulative compressive loads of the hammock (105393.1N*s)
Table 4.6 Cumulative mean spinal loads for day, evening and night shifts (8 hours)

<table>
<thead>
<tr>
<th>Response Variable Loads</th>
<th>Day</th>
<th>Evening</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Compression (kN*s)</td>
<td>1006.4</td>
<td>660.1</td>
<td>1001.6</td>
</tr>
<tr>
<td>Anterior Joint Shear (kN*s)</td>
<td>-47.3</td>
<td>17.7</td>
<td>-47.1</td>
</tr>
<tr>
<td>Posterior Joint Shear (kN*s)</td>
<td>1.6</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Anterior Reaction Shear (kN*s)</td>
<td>-99.6</td>
<td>35.3</td>
<td>-99.1</td>
</tr>
</tbody>
</table>

Table 4.7 Cumulative mean spinal loads per technique

<table>
<thead>
<tr>
<th>Response Variable Loads</th>
<th>Pivot</th>
<th>Hammock</th>
<th>Turning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Compression (N*s)</td>
<td>9687.7</td>
<td>2342.6</td>
<td>105393.1</td>
</tr>
<tr>
<td>Anterior Joint Shear (N*s)</td>
<td>-404.4</td>
<td>170.8</td>
<td>-4498.4</td>
</tr>
<tr>
<td>Posterior Joint Shear (N*s)</td>
<td>49.6</td>
<td>34.4</td>
<td>0.00</td>
</tr>
<tr>
<td>Anterior Reaction Shear (N*s)</td>
<td>-921.8</td>
<td>353.9</td>
<td>-8907.8</td>
</tr>
</tbody>
</table>

4.3.3 Peak and Cumulative Shoulder Forces

Figures 4.6 and 4.7 outline the results of the peak shoulder loads for the right and left shoulder respectively. The pivot transfer had the highest peak loads of all examined variables (abductor moment, adductor moment, flexion moment and caudal shear). The
loads on the right and left shoulder are similar for the hammock and turning the client to the side with the greatest difference found in the left shoulder abductor and adductor moments.

![Figure 4.6 Peak mean right and left shoulder joint moments (abductor, adductor and shear)](image-url)
The daily cumulative shoulder loads are reported in table 4.8 for each of the variables analyzed. As with the peak loads, the pivot transfer had the greatest cumulative shoulder loads for adduction, abduction and flexion moments, but has the lowest values for caudal shear for both the right and the left shoulders. Turning the client to the side has the highest value of caudal shear (right 2597.5N and left 2388.5N) for both right and left sides.
Table 4.8 Cumulative mean shoulder loads by technique (for one 8hr shift)

<table>
<thead>
<tr>
<th></th>
<th>Technique</th>
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<tr>
<td></td>
<td>Pivot</td>
<td>Hammock</td>
<td>Turning</td>
<td>Pivot</td>
<td>Hammock</td>
<td>Turning</td>
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</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Adduction Moment</td>
<td>Right</td>
<td>115.1</td>
<td>295.6</td>
<td>18.02</td>
<td>27.2</td>
<td>87.2</td>
<td>104.8</td>
</tr>
<tr>
<td>(Nm*s)</td>
<td>Left</td>
<td>-131.7</td>
<td>332.1</td>
<td>-19.2</td>
<td>30.0</td>
<td>-141.2</td>
<td>127.1</td>
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<tr>
<td>Abduction Moment</td>
<td>Right</td>
<td>-481.1</td>
<td>1122.4</td>
<td>-21.3</td>
<td>31.14</td>
<td>-159.19</td>
<td>212.4</td>
</tr>
<tr>
<td>(Nm*s)</td>
<td>Left</td>
<td>626.6</td>
<td>1308.8</td>
<td>23.1</td>
<td>25.06</td>
<td>258.52</td>
<td>273.9</td>
</tr>
<tr>
<td>Flexion Moment</td>
<td>Right</td>
<td>1346.4</td>
<td>2560.4</td>
<td>135.3</td>
<td>92.7</td>
<td>574.2</td>
<td>350.0</td>
</tr>
<tr>
<td>(Nm*s)</td>
<td>Left</td>
<td>1271.7</td>
<td>2493.3</td>
<td>140.7</td>
<td>113.4</td>
<td>402.2</td>
<td>229.5</td>
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<tr>
<td>Reaction Caudal</td>
<td>Right</td>
<td>197.7</td>
<td>61.1</td>
<td>620.8</td>
<td>334.0</td>
<td>2597.5</td>
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<tr>
<td>Shear (N*s)</td>
<td>Left</td>
<td>200.2</td>
<td>64.2</td>
<td>593.3</td>
<td>53.6</td>
<td>2388.5</td>
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<tr>
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<td>Shift</td>
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<td>SD</td>
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<tr>
<td></td>
<td>Day</td>
<td>Evening</td>
<td>Night</td>
<td>Day</td>
<td>Evening</td>
<td>Night</td>
<td></td>
</tr>
<tr>
<td>Adduction Moment (Nm*s)</td>
<td>Right</td>
<td>3947.4</td>
<td>9905.5</td>
<td>3927.6</td>
<td>9855.9</td>
<td>4779.3</td>
<td>11993.2</td>
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<tr>
<td></td>
<td>Left</td>
<td>-4563.3</td>
<td>11138.9</td>
<td>-4540.5</td>
<td>11083.2</td>
<td>-5525.1</td>
<td>13486.6</td>
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<tr>
<td>Abduction Moment (Nm*s)</td>
<td>Right</td>
<td>-16017.5</td>
<td>7081.3</td>
<td>-15937.3</td>
<td>36896.3</td>
<td>-19393.4</td>
<td>44897.5</td>
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<tr>
<td></td>
<td>Left</td>
<td>20905.8</td>
<td>43229.2</td>
<td>20801.2</td>
<td>43012.8</td>
<td>25312.0</td>
<td>52340.3</td>
</tr>
<tr>
<td>Flexion Moment (Nm*s)</td>
<td>Right</td>
<td>45291.2</td>
<td>84510.1</td>
<td>45064.5</td>
<td>84087.1</td>
<td>54837.0</td>
<td>102321.8</td>
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<tr>
<td></td>
<td>Left</td>
<td>42652.3</td>
<td>82249.5</td>
<td>42438.8</td>
<td>81837.7</td>
<td>51641.9</td>
<td>99584.6</td>
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<tr>
<td>Reaction Caudal Shear (N*s)</td>
<td>Right</td>
<td>12261.2</td>
<td>5242.5</td>
<td>12199.8</td>
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<td>14845.4</td>
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<tr>
<td></td>
<td>Left</td>
<td>11968.3</td>
<td>5070.6</td>
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<td>6139.3</td>
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</table>
The cumulative shoulder loads for each nursing home shift (day, evening and night) were compared to each other for each of the loading variables in Table 4.9. The night shift results were higher than the two other shifts. The results for the day and the evening shifts were similar for all the variables.

For all three *BIF* techniques the biomechanical joint loading of the spine were all found to be at levels considered below published safe guidelines. Similarly, the techniques allowed caregivers to maintain neutral postures of the upper extremity throughout the task.
Chapter 5: Discussion

The purpose of this study was to determine if the three selected WorkSafeNB promoted BIF techniques are biomechanically safe based on published spinal cumulative and peak loading threshold limits. The results of this study appear to support that the techniques are below known threshold values for peak and cumulative loading and that the majority of the time is spent in neutral postures while performing the Back in Form techniques.

5.1 Spinal Postures

The spinal posture results support the second hypothesis for spinal axial twist and lateral bend in all three techniques examined. The other variable was forward flexion and results indicate that the participants spend most (60-91%) of the time handling clients in mild forward flexion of the spine. This outcome may be of concern if we consider the work of Punnet et. al. (1991) who reported that time spend in non-neutral postures can significantly increase the risk of back disorders. Their results indicated that mild trunk flexion exceeding 10% of the cycle time lead to a 6.1 times greater risk of back injury. Looking at the time spent in severe posture, as little as 10% would produce an odds ratio (OR) of 4.4 and that rises to 8.9 when time spent in severe forward flexion exceeded 10% (Punnett et al., 1991). In this study, participants spent 15% of the time in severe flexion while turning the client to the side. The pivot transfer had the highest non-neutral trunk flexion. In order to initiate the pivot transfer, the caregiver needs to get close to the patient in the chair to use
momentum of their body rather than the back extension to complete the task. As such, the trunk position allows for the reduction of spine compression and shear loading as the legs are used to transfer the body rather than pulling the patient by extending the back and flexing the arms. Unlike many of the occupations investigated in Punnett et al.’s work, tasks examined only represent a small portion of a full shift.

In a more recent study on caregivers (Hye-Knudsen, Schibye, Hjortskov, & Fallentin, 2004) which specifically measured trunk motion during patient handling task, 9 different repositioning and transfer techniques were measured. The ones that most closely resemble the ones from this study were “turning in bed (away)”, “transferring from bed to chair “and “higher upwards in bed”. Their results suggested that patient handling requires extensive angular displacement in the sagittal plane (Hye-Knudsen et al., 2004). The reason the results of Hye-Knudsen et al., (2004) differ from this study could be related to the extensive training provided to the Back in Form trainers. Much of the instructions provided focuses on preventing “torso tipping” which would be spinal flexion in the sagittal plane.

5.2 Spinal Loading

The peak compressive and shear loads are below the published risk threshold levels of 3400N for compression (Waters, Putz-Anderson, Garg, & Fine, 1993) and 500N for shear (McGill, 1997; Norman et al., 1998) which supports the first hypothesis. The BIF techniques are below known threshold limits for peak spinal loads. Other studies, such as that by Marras et. al (1999) had very different results in comparison.
Their research yielded results where over half their one-person techniques were above the published recommended limits (Marras et al., 1999). Garg & Owen (1992) also found higher compressive and shear forces in their results. Interestingly, Marras et al. found that the two-person draw sheet method had the lowest lateral shear and compressive loads, but the loads were still over the 3400N limit and anterior posterior shear approached the tolerance limit. In this study, the hammock, which is a two-person draw sheet repositioning up in bed method, had the highest compression (2657N) and shear (311N) values. One possible explanation for this difference could be that the Marras (1999) study did not make use of transfer aids like a transfer belt or friction reducing draw sheet. The hammock technique in this study is also done differently than the one described and pictured in the Marras (1999) study in that the lateral movement is minimal. Caregivers are at the head of the bed and a 45-degree angle to the bed and sit back in a counterbalance movement rather than pulling the patient in a sideways motion.

When the results of this study are compared with those that specifically examined the use of transfer belts and friction reducing devices, the results are more comparable (Daynard et al., 2001; McGill & Kavcic, 2005). The BIF techniques are designed to make use of the transfer aids, and sound biomechanical principles based on the results of these studies so it’s not surprising that lower peak spinal loads were obtained.

In terms of cumulative loading, the calculated loads were much lower than those reported in other studies related to nursing (Kumar, 1992) and automotive industry
(Norman et al., 1996; Callaghan et al., 2006). This study underestimates the daily cumulative load as it only incorporates the cumulative load for the three techniques investigated multiplied the number of times daily that they are performed on average. This is not a true reflection of the tasks performed for an entire 12-hour nursing shift.

5.3 Shoulder Joint Postures and Loading

The hypothesis was supported for both left and right shoulder abduction. As seen in Table 4-4 and 4-5, the majority of time was spent in neutral abduction postures in all the examined techniques. For flexion, most time (71.6-99.6% on the right side and 73.6 to 98% on the left) was spent in “mild” postures.

In a study with automobile assembly workers, Punnett et al. (2000) reported that shoulder cases spent 28% of the cycle times in mild flexion of the right shoulder and 24% for the left shoulder. The participants of this study spend 3-4 times the amount found by Punnett et al. (2000) in mild flexion while performing the repositioning techniques. This might indicate a high potential for shoulder injury among caregivers. WorkSafeNB statistics would seem to support that assumption since shoulder injuries account for 16% of all injuries in nursing homes in the province (WorkSafeNB, 2017b).

There are few reliable guidelines for shoulder joint loading in which to compare the results of this study. Seaman et al. (2010) determined the peak and cumulative loading of the shoulder in an automotive seat frame manufacturing plant. The caudal shear forces were higher in workers experiencing shoulder pain. The peak flexion moments are highest for both right and left shoulder while performing the pivot
transfer (right 631.6N*m, left 618.6N*m). The night shift had a greater cumulative load than the day and evening shifts in all variables, for both the left and right shoulders. In New Brunswick, the nursing homes staff fewer caregivers on night shifts, which increases the number of times a caregiver must perform the techniques evaluated in this study during a night shift. A study investigating pepper harvesting reported peak flexion moment of 90Nm and shoulder cumulative flexion moment to be approximately 21 kNms (Gyemi, van Wyk, Statham, Casey, & Andrews, 2016).

5.4 Application

The outcomes from this study will be useful for WorkSafeNB to determine if Back in Form is a valuable program to continue promoting and updating for nursing homes in the province. Currently most nursing homes in NB have some level of implementation of the BIF program. The results of this study validate the promotion of the program by WorkSafeNB and may point to other variables as the leading causes of injury in the nursing homes.

5.5 Limitations

The ability to establish a control of either caregivers performing the technique incorrectly or comparing other techniques to perform the same tasks would have provided a stronger validation of the biomechanical robustness of the BIF techniques. Ethically, we could not require participants to perform a known risky technique. We were not able to collect data in a hospital or care facility where we might have
observed poor performance. As such a comparison against published guidelines was considered for this thesis.

There are some ethical and logistical challenges in capturing real time data in the field given the vulnerable nature of the patients/residents in nursing homes. Ideally video of care staff transferring, and repositioning real residents would have provided a better snapshot of the work being done in nursing homes on a day to day basis. This approach was attempted for this study but was modified when coordinating the residents who provided consent with the care staff who provided consent for the specific techniques became overly cumbersome. This made it necessary to take the measurements in a simulated environment with volunteers acting as patients. These volunteers did not necessarily represent a real patient in weight, level of cooperation or mobility. In a sampling from a local nursing home, the mean weight of a resident was 64.6kg (SD 16.5kg). For women, it was 62.2kg (SD 16.8) and men averaged 74.5kg (SD 14.2). The residents in this study (n=4) were divided into two males with a mean weight of 77kg (SD 0.055) and two females with a mean weight of 67.9kg (SD 14.0). The participants playing the role of the resident for this study had full mobility and were cooperative which is not always the case with real residents in nursing homes. However, the techniques developed for the BIF should be biomechanically sound regardless of the patient being transferred.

The duties of the caregiver in the nursing homes goes beyond the three techniques observed in this study. One local nursing home went through the process of having a formal study conducted to determine the tasks performed and the amount of time
associated to those tasks. This study compared newer designed nursing home facilities with older nursing home facilities. The outcome report indicated that caregivers spend 36.9% (older facilities) and 43.2% (newer facilities) of their time in what they called resident care (McCloskey, Donovan, Donovan, & Stewart, 2015). The remainder of their time was spent walking, documenting, waiting, communicating, supporting or taking breaks.

There are limitations to the programs used to analyze the spinal and shoulder postures and loads in this study. 3DMatch does not differentiate between flexion at the hip, and flexion of the spine. The risk level for hip flexion is lower than that of spinal flexion, but this is not captured in 3DMatch.

This study did not address the physical capacity or fitness of the care staff as this specific topic was not the focus. The BIF techniques do require a certain level of fitness and flexibility to perform and future research into the capability of care staff to perform the techniques, as well as how health and fitness levels of care staff affects their risk of injury would add to the greater picture of injuries rates in among nursing professionals.

**Chapter 6: Conclusion**

The thesis was aimed at determining whether three specific BIF techniques were biomechanically sound as measured by their promotion of neutral postures and low joint loading. Published levels of posture and joint loading risk were used as
benchmarks for comparing data acquired from trained BIF trainers performing the three techniques.

The following are the major findings from this study:

1. The peak and cumulative spinal and shoulder joint loading for Back in Form techniques were below published threshold limits.

2. The majority of the time was spent in neutral postures (axial twist and lateral bend) of the spine, shoulders (abduction, adduction) and neck while performing Back in Form techniques. This results in a low odds ratio for injury risk based on published risk values. Higher risk results were demonstrated for spinal flexion and shoulder flexion, which raises some concerns and suggests further investigation into modifying the techniques to reduce the spinal flexion and shoulder flexion from mild to neutral.

WorkSafeNB has advocated the use of the BIF techniques based on their biomechanical robustness which is a marker for reducing musculoskeletal injuries. The results of the joint loading and postural assessment would suggest that the technique designed for patient transfer and repositioning are designed to meet proper biomechanical principles and therefore have the potential to reduce the risk of musculoskeletal injuries related to patient transfer. Future research should assess other techniques in the BIF program and assess the techniques to those current used in hospitals and long-term health facilities. WorkSafeNB should also conduct a analysis of injury rates for the nursing homes who have implemented BIF and those who have not.
Another suggestion for future directions of BIF for WorkSafeNB would be to enforce having BIF training in all educational and preparation programs training and educating health care workers. The training should be integrated into the standard curriculum with enough importance that it becomes part of the base skills required for the discipline in question.
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https://doi.org/10.1002/ajim.22139


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Biomechanical evaluation of assistive devices for transferring residents.

Appendix A: 3DMatch Interface and Posture Bins

Figure A1. 3D Match interface

Figure A2. Trunk flexion and extension categories in 3DMatch.
Figure A3. Trunk lateral bending categories in 3DMatch.

Figure A4. Trunk rotation categories in 3DMatch.

Figure A5. Neck flexion and extension categories in 3DMatch.

Figure A6. Neck lateral bending categories in 3DMatch.
Figure A7. Neck axial twist categories in 3DMatch.

Figure A8. Right shoulder flexion and extension categories in 3DMatch.

Figure A9. Right shoulder abduction categories in 3DMatch.

Figure A10. Left shoulder flexion and extension categories in 3DMatch.
Figure A11. Left shoulder abduction categories in 3DMatch.

Figure A12. Right elbow flexion categories in 3DMatch.

Figure A13. Left elbow flexion categories in 3DMatch.
Appendix B: Participant Informed Consent

Biomechanical quantification of the Back in Form techniques

Principal Investigators: Jennifer Kenny Graduate student; Faculty of Kinesiology, jen.kenny@unb.ca, (506) 650-3403

Director of Graduate Studies (Faculty of Kinesiology, UNB) Dr. Wayne Albert; Professor; Faculty of Kinesiology, walbert@unb.ca, (506)-447-3254

Chair of the UNB Research Ethics Board Bernd Kurz Email: ethics@unb.ca Phone: 453-5189

PURPOSE OF THE STUDY
The purpose of this research study is to evaluate the postural and biomechanical demands associated with lifting techniques outlined in WorkSafeNB’s prescribed Back in Form program for patient transfer.

BACKGROUND
In New Brunswick (N.B.), nursing homes have one of the highest industry assessment rates, $6.78 for every $100 of payroll (WorkSafeNB, 2009). Some New Brunswick nursing homes, in collaboration with New Brunswick Community College (NBCC) and the WorkSafeNB have implemented Back in Form (BIF), also called Back on Track, a transfer and repositioning training program for the care staff in nursing homes. Back in Form is based on using proper body mechanics, and the concept of no lifting to transfer or reposition clients. The techniques are designed to transfer or reposition residents rather than manually lifting residents. The BIF techniques were developed using biomechanical principles and claims to reduce the risk of injury for nursing staff, but it has not yet been quantified.

PROCEDURES
If you volunteer to participate in this study the following timeline will apply: The study will be conducted during a scheduled BIF audit session in 2014. You will be asked to review and sign the informed consent form.

You will be performing approved BIF (Back in Form) techniques on a volunteer. You will be video recorded performing each of these techniques at least once.

POTENTIAL RISKS AND DISCOMFORTS
The activities that will be performed represent typical workday activities care staff while delivering daily care to residents. Since these activities are those already performed daily by you, the participant, you will not be put at greater risk by our research. Feelings of
anxiety or self-consciousness may be elicited as a result of having your actions recorded. Participation in this study is strictly voluntary, and, thus you are free to withdraw at any time.

POTENTIAL BENEFITS TO SUBJECTS AND/OR SOCIETY
Participation in this study will provide the opportunity to validate the Back in Form transfer and repositioning techniques. You also may benefit from knowing that the data collected from your trial will help researchers better understand the stresses put on nursing professionals and how better to minimize the risk in resident handling.

CONFIDENTIALITY
Any information that is obtained in connection with this study and that can be identified with you will remain completely confidential and will be only disclosed with your permission. Only the researchers will have access to the data. All data will be stored in a locked environment within the Human Performance Laboratory at the University of New Brunswick and will remain there for a period of two years, at which point it will be destroyed. A participant pin number in place of your name will be used to code the data and as such you will never be identified. In addition, the results of the study will not include your individual data unless you have given prior consent.

PARTICIPATION AND WITHDRAWAL
Participation in this project is completely voluntary. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may at any time throughout the study choose to withdraw your data from the study. You may also refuse to answer any questions you do not want to answer and still remain in the study.

QUESTIONS
Should you have any questions regarding this project, feel free to address them to either of the principal investigators. If you wish to speak to someone not associated with the project, please feel free to contact the Dean, Dr. Wayne Albert; (walbert@unb.ca) (506-453-4576) or Bernd Kurz (453-5189), (ethics@unb.ca), Chair of the University of New Brunswick’s Ethics Review Board.

If you wish to volunteer in this study, please complete the next page. Thank you for your participation.
CONSENT
The purpose of this study has been explained to me by ___________________________.
I have understood the information, including the risks of participation, and agree to participate in the study. I have been given a copy of the Study Information sheet and the Consent form, which I have read and understood. I have been given an opportunity to ask questions about the study and my participation, and I understand that I may ask questions at any time.
By signing this form, I agree to participate in the study with the understanding that I may withdraw from it at any time, without penalty.

<table>
<thead>
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<th>Signature of Participant</th>
<th>Date</th>
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If you wish to be informed of the research results, please provide contact information.

Name:

Address:

Telephone #:

Email address:
Appendix C: Original *Back in Form* Instructional Material for the

Three Techniques Examined
COMPLEX TECHNIQUE

PIVOT (ONE PERSON)

CHAIR TO BED MOBILITY
PIVOT (ONE PERSON)

TYPE OF TRANSFER: With or without force
PURPOSE: To transfer the client from chair to bed or bed to chair

Preparatory repositioning transfer: Sitting Up; Block, Squat & Rock; any transfer that repositions the client to the front of the chair
Number of caregivers: One
Weight considerations: Weight ratio
Level of difficulty: Complex
### Consider

**Direction of Movement**
Front-to-back, back-to-front, side-to-side, side-to-side (on the diagonal), or side-to-side (with pivot) = 90°; upright and forward to down and back, down and back to upright and forward.

**Line of Movement**
As close to the horizontal as possible.

**Range of Movement**
The span of movement that covers the distance between the start and end of the move. Distance of caregiver’s move equals client’s span of move.

**Point of Force Application**
The point where the force is applied to the client’s body.

**Command and Count**
Verbal command given by caregiver.

**Force Production**
The force needed to effect movement, which is relayed from your feet, knees and/or hands through the braced body and arms to the point of force application. For example, friction and weight will dictate the amount of force required.

### Client

**Out of chair and rise:**
Back-to-front
Pivot
Sit on bed

**Out of chair and rise:**
Horizontal and vertical
Pivot: Horizontal
Flex to lower: Vertical

**Out of chair:**
How far do they need to be moved to get out of the chair/bed?
Pivot: What is the distance from chair to bed or bed to chair?

**Hips.**

**Reduce friction and weight by:**
- Using a transfer belt.
- Strongest side positioned closest to bed.
- Bringing buttocks forward in chair (Block, Squat & Rock).
- Positioning feet to receive weight (strong foot forward).
- Leaning upper body forward to raise buttocks off chair.
- Initiating body rock to create momentum.
- Have client assist by pushing on chair with hands.

**Ensure they are given appropriate time after they come out of the chair to rise to their necessary level to allow them to determine if they are physically able to be pivoted.**

**Without force:**
Client controls move (client’s head positioned on side closest to bed). Physical assistance is required. Transfer belt must be used and caregiver must assume the ready position.

**Contraindications**
- Confusion, aggression or unco-operative, not consistent and reliable with balance, unable to follow commands.
- Must be able to bear weight on at least one foot.
- Must have unimpaired dorsiflexion in weight bearing leg.
<table>
<thead>
<tr>
<th>CAREGIVER</th>
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| **Out of chair and extend**: Front-to-back (1, 2, 3)  
**Pivot**: Side-to-side (with pivot) – 90° (4)  
**Flex to lower**: (5) |

<p>| | |</p>
<table>
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<tbody>
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<td>Horizontal and vertical (1, 2, 3)</td>
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<tr>
<td><strong>Pivot</strong>: Horizontal (4)</td>
<td></td>
</tr>
<tr>
<td><strong>Flex to lower</strong>: Vertical (5)</td>
<td></td>
</tr>
</tbody>
</table>

**Out of chair and extend**: Start foot faces load; end foot faces direction of move; place end foot first where client's buttocks will rest upon completion of move. Make sure end foot is placed to cover span and ensure movement will be completed within your base of support (1, 4, 5).

Proper grip on transfer belt around hips (2).

**CHEST UP, BACK STRAIGHT, ARMS BRACED... 1, 2, LOAD (2), PUSH (3), PAUSE (3)**

The momentum achieved with the body rock starts; assist the move and will allow the client to come forward out of the chair (not up). Load to the back of the chair by PUSHING through your end foot and shifting your body weight as a unit to the start foot (2). Next, PUSH through your start foot and shift your body weight as a unit to your end foot (3). The force is relayed through your braced body and arms to the transfer belt allowing the client to come forward out of the chair. Ensure you do not shift up and lift the client; maintain your shift along a horizontal line throughout the move. Pause and allow the client time to receive their weight and stabilize when they come out of the chair (3). Now pivot by allowing the toe of your start foot to rotate towards the bed. Allow your pelvis and body to rotate with your foot (4). Lower client to sit on the edge of the bed by flexing at the hips and knees (5).

**Out of chair and extend**: Do not load down, load back on a horizontal line of movement so client will rock forward out of chair and you will not lift them up. Remember to pause when the client comes out of the chair. Allow them to rise and let them do as much of the work as possible.

- Do not allow client to grasp your neck or clutch your arms.

**With force**: Caregiver controls move (client's head resting on shoulder furthest from bed). Physical assistance is required and force is needed. Transfer belt must be used and caregiver must assume the ready position. The client may be able to assist with the move by pushing with their arms. The count should change to 1, 2, 5, PUSH or an alternate count proposed by the client.
TRAINING TIPS

PIVOT (ONE PERSON)

- Reinforce the importance of client assessment for all chair to bed/bed to chair transfers. If the assessment is not adequate, the risk of acute injury increases for both the client and the caregiver.
- Have caregivers demonstrate the current technique they use to pivot the client from chair to bed/bed to chair.
- Now, have them critique their technique based upon what they have learned about body mechanics to date.
- Once this is done, demonstrate the technique being advocated here, comparing the two practices and isolating the areas in need of improvement.
- Highlight the order of movements (for example, getting out of the bed/chair and pivoting to the bed/chair) and the importance of balance and stability with each movement.
- Once the direction of each movement has been established, assess the caregiver's positioning in relation to the client and the equipment.
- Recognize the need to combine these moves into one fluid movement.
- Teach caregivers to become proficient with the first movement, the front-to-back shift over a horizontal line, before proceeding to the next movement.
- For the first movement, demonstrate our own normal sequence of movements to get out of a chair using a body rock. Now simulate this by doing a lead, push and then follow it with front-to-back shift over a horizontal plane.
- Use the momentum gained by an effective body rock to initiate the move.
- Draw attention to the fact that caregivers will naturally want to pull down and tug up on the client, unnecessarily trying to lift them. If the client makes contact with the arm of the chair during the pivoting motion, there is a good chance the caregiver is attempting to lift up instead of transferring out and the client's bottom is not clearing the chair.
- Both the client and the caregiver should avoid rising to a fully upright position. Once the client is transferred out of the chair, the caregiver should pause to allow the client to rise to their necessary level (strongest level). The caregiver should rise with the client to their own necessary level. This pause between directions of movement will also allow the caregiver to react appropriately to support or reverse a movement in the event of a collapse.
- As the second movement is added, which pivots the client to the side of the bed, watch for a torso twist. Most caregivers will anticipate the second part of the move prematurely, allowing their eyes, head, and upper body to move ahead of the lower body.
- Review the importance of how pelvic alignment is maintained throughout the entire movement. This will allow the caregiver to look to the end position by turning only the head and neck.
- To lower the client to sit on the edge of the bed, caregivers must flex at the hips, knees and ankles rather than torso tip or bend forward at the waist.
- For transfers out of the chair/bed (without force), the client controls the move. If they are able, they should be encouraged to assist the move by executing their own body rock and/or pushing with their arms. The count should change to 1, 2, 3, push or an alternate count proposed by the client.
## PIVOT (ONE PERSON)

<table>
<thead>
<tr>
<th>ELEMENT REINFORCEMENT</th>
<th>BUILDING ON THE ELEMENT</th>
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</table>
| Body shift – side-to-side (with pivot) = 90° | Indications for use  
Incorporating a change of direction  
- direction of movements  
- line of movements  
- range of movements  
- pause  
Body alignment  
- eyes and head  
- upper torso and pelvis  
- pelvis and feet  
Balance and stability  
Lowering and placement |

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<tr>
<th>ELEMENT INTRODUCTION</th>
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| Body rock | Direction of rock  
- momentum |

| Client integration | Positioning - client  
- visual field  
- strong side vs. weak side  
Positioning - caregiver  
- control  
- support  
- removing blocking movements  
- use of transfer belt  
Positioning - equipment  
- horizontal distance  
- path of travel |

---

**Note:** Due to the number of variables involved, this transfer should be taught in two separate movements (for example, getting out of chair and pivoting to the bed). As caregivers become proficient and are able to perform each move individually without compromising body alignment, they may combine these movements. Once combined safely and effectively, momentum may be increased.
TRANSITIONAL TECHNIQUE

HAMMOCK (1) BED

BED MOBILITY
HAMMOCK (1) BED

PURPOSE: To reposition the client to the head of the bed

Number of caregivers: Two
Weight considerations: No weight restriction
Level of difficulty: Transitional
# Positioning and Movement

## Consider

| Direction of Movement | Client | Line of Movement | Client | Range of Movement | Client | Point of Force Application | Client | Command and Count \n|-----------------------|--------|------------------|--------|-------------------|--------|----------------------------|--------|--------------------------|
| Front-to-back, back-to-front, side-to-side, side-to-side (on the diagonal), or side-to-side (with pivot) = 90°, upright and forward to down and back, down and back to upright and forward. | Side-to-side (up the bed) | As close to the horizontal as possible. | Horizontal | The span of movement that covers the distance between the start and end of the move. Distance of caregiver’s move equals client’s span of move. | How far do they need to be moved up in the bed? | The point where the force is applied to the client’s body. | Scapula | Verbal command given by caregiver. |

## Force Production

The force needed to effect movement, which is relayed from your feet, knees and/or hands through the braced body and arms to the point of force application. For example, friction and weight will dictate the amount of force required.

<table>
<thead>
<tr>
<th>Tips</th>
<th>Client</th>
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<tr>
<td>• Bed brakes must lock or head of bed must be positioned against wall.</td>
<td>Reduce friction and weight by:</td>
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<tr>
<td>• Exercise control if lightweight.</td>
<td>• Bracing off (raises client slightly off bed).</td>
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<tr>
<td></td>
<td>• Using a slippery repositioning draw sheet, permanently placed on bed.</td>
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<td></td>
<td>• Repositioning legs by flexing knees (if possible).</td>
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<tr>
<td></td>
<td>• When possible, have client push with feet.</td>
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## Contraindications

<table>
<thead>
<tr>
<th>Options</th>
<th>Client</th>
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<tbody>
<tr>
<td>• Heavy clients: Movements may be small and repeated several times to achieve entire move.</td>
<td></td>
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</table>
CAREGIVER

Side-to-side (on the diagonal) (1, 2, 7)
Positioned at the head of the bed
Upright and forward to back and down (4, 6, 7)
Counterbalance movement

45° Counterbalance (4, 6, 7)

Position both feet (with thighs touching the bed) in a side-to-side stance at the head of the bed; end foot should be positioned where client's head will rest upon completion of the move (1). Next, rotate start foot out to a 45° angle from the head of the bed so that the pelvis, knees and feet are aligned and facing the opposite corner of the bed (2). To achieve optimal alignment, allow the toe of the end foot to rotate inward.

At the client's shoulder level, in a wide grasp with client's shoulders positioned between caregiver's hands; roll repositioning draw sheet to produce tension and slightly raise client's shoulders off bed (grip should see the wrists neutral and palms either down or rotated slightly upward with elbows flexed) (3).

CHEST UP, BACK STRAIGHT, ARMS BRACED... BRACE OFF (5)... 1, 2, 3, PUSH (6)

Brace off. Set body weight as a unit in a backward direction to raise the client off the bed (4, 5). Next, PUSH equally through both feet as a unit back and down (counterbalance movement) (6, 7). The simultaneous 45° angle counterbalance movements will cause the client to move up the bed.

- In the start position, ensure eyes, head, shoulders, hips, knees and feet are aligned at a 45° angle to the bed and body is upright and forward over the client (4).
- PUSH equally through both feet setting body weight back and down.
- Do not sit down, pull with arms or shift body up the bed by pushing through only the start foot.
- Your arms will move up the bed with the client; however, your body should be moving at a 45° angle away from the bed.

- Do not use soaker pad as a repositioning aid.

- Bed can be at working level or in a low position.
- If bed is in a low position, the end knee should be placed on the bed, start foot placed on the floor and body positioned in exactly the same manner as when both feet are on the floor.
TRAINING TIPS
HAMMOCK (1) BED

- As a safety precaution, you may want to position a pillow against the head of the bed.
- Begin by practising the counterbalance movement. Position yourselves in a wide stance facing each other on either side of the bed. Grasp the sheet, roll it and brace off(counterbalance) against each other until comfortable with this movement.
- When possible, flex (bend) the client’s knees to reduce friction and drag.
- The caregiver’s start position should see body placement ahead of the client’s shoulder.
- Your eyes, head, shoulders, hips, knees and feet are at a 45° angle.
- The sheet should be rolled as close as possible to the client. Allow a wide enough grasp to enable both hands to align with your feet.
- When posture is corrected, look for any indications of improper alignment. For example, uneven shoulder height would indicate a torso tip and one shoulder ahead of the other would indicate a torso twist.
- The start position should ensure the caregiver’s whole body is fully upright, forward and braced over the client with the sheet rolled to produce tension, and the elbows flexed.
- As the command is given, a slow controlled push through the feet should stop the tendency to pull with the arms.
- Any method to decrease friction created by the client’s lower limbs is an asset. For example, the client’s feet may be positioned in such a manner that the knees are flexed. A pillow may be inserted to help maintain this position or a small slider sheet could be placed under the lower legs.
- Knee on, or knee off will depend on the height of the bed or the height of the caregiver and will not affect the quality of the move. For example, one caregiver (tall) may place their knee on the bed while the other caregiver (short) may have both feet on the floor.
- If able, the client may assist the move by pushing with their feet.
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<td>• repositioning draw sheet, slider sheets, pillows</td>
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<td></td>
<td>• Client assistance</td>
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<td>• push with feet</td>
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*Note: Movements will become synchronized with practice. The goal is not to memorize, but to understand the principles and concepts of body mechanics and integrate them into your daily work routine.*
INTRODUCTORY TECHNIQUE

TURNING CLIENT TO SIDE

BED MOBILITY
**TURNING CLIENT TO SIDE**

**PURPOSE:** To turn the client on their side

- Preparatory repositioning transfer: Side-to-side
- Number of caregivers: One or two
- Weight considerations: No weight restriction
- Level of difficulty: Introductory

1. Adjust the bed position.
2. Position the client's legs comfortably.
3. Lift the upper body using a lever arm.
4. Slide the client's body to the side.
5. Adjust the position for comfort.
# Positioning and Movement

## Consider

**Direction of Movement**  
Front-to-back, back-to-front, side-to-side, side-to-side (on the diagonal), or side-to-side (with pivot) = 90°, upright and forward to down and back, down and back to upright and forward.

**Line of Movement**  
As close to the horizontal as possible.

**Range of Movement**  
The span of movement that covers the distance between the start and end of the move. Distance of caregiver’s move equals client’s span of move.

**Point of Force Application**  
The point where the force is applied to the client’s body.

**Command and Count**  
Verbal command given by caregiver.

**Force Production**  
The force needed to effect movement, which is relayed from your feet, knees and/or hands through the braced body and arms to the point of force application. For example, friction and weight will dictate the amount of force required.

## Client

**Rolling toward**  
Side-to-side

**Rolling away**  
Side-to-side

*Point of reference for client on bed – Bed has four sides, no front or back.

**Horizontal**

**How far do they need to be turned?**

**Scapula and outer knee/thigh. Reposition leg by flexing outside knee.**

**Reduce friction and weight by:**
- Placing outside arm across the chest.
- Repositioning leg by flexing outside knee.

**Tips**
- Bed brakes must lock.
- Opposite side rail raised or additional caregiver positioned to receive client if rolling away.

**Contraindications**
- Slow movement if vertigo is present.
- For decreased joint mobility or limited range of motion in shoulder, bring arm closest to you out and away from the body to allow the client to roll to the side.
- If leg is flaccid and lightweight, hook a finger behind knee to support and apply leverage. If leg is flaccid and heavy, cross extended legs before rolling over.
- If touching client causes significant discomfort, grasp repositioning draw sheet on the opposite side and roll client towards you.

**Options**
- A pillow may be placed under knees to allow slight flexion and support. Slide hand down and under the pillow using a flat palm on the pillow to bring the knees over.
### CAREGIVER

**Rolling toward:** Front-to-back \((2, 5)\)
Upright and forward to down

**Rolling away:** Back-to-front
Down to upright and forward

- Approximately 30° \((2, 5)\)

Start foot faces the load, end foot faces direction of move; place end foot first to cover span and ensure backward movement will be completed within your base of support \((2, 5)\).

Place one hand on client's outer knee/thigh. The other hand should be placed behind the far shoulder at the scapula. Flex at the hips/knees/ankles and lower when reaching across bed to place hand on scapula \((1)\).

**CHEST UP, BACK STRAIGHT, ARMS BRACED... 1, 2, LOAD, PUSH \((2, 5)\)**

**Rolling toward:** Leverage starts and assists the move. On the LOAD, press down gently on client's outside knee/thigh and extend your body as a unit at the hips/knees and ankles. This will shift you to an upright and forward position over the client \((2)\). Now PUSH through the start foot and shift your body as a unit to your end foot \((3, 4)\). Flex the end knee at the completion of the move \((5)\).

**Rolling away:** As above, only perform the move in the opposite direction. Leverage is used in conjunction with a body shift and initiated during the LOAD phase. Remember, this is a front-to-back or back-to-front body shift, not a counterbalance movement. Always flex down when reaching across bed.

- Bed can be at working level or in a low position. If bed is in low position, the start knee should be placed on the bed, end foot placed on the floor and body positioned in the same manner as when both feet are on the floor.
The following demonstration should not be performed on anyone with a back problem as the torso may twist in the process.

- To demonstrate to staff, the effectiveness of using leverage to help turn clients:
  - Position a volunteer as per positioning and movement chart on previous page.
  - Apply leverage to the outer knee.
  - If the volunteer is positioned in the appropriate manner, they should roll onto their side. Most people will roll onto their side with leverage alone.
  - Now, demonstrate using two points of leverage.
  - Place one hand on the outer knee and the other behind the far shoulder and apply leverage. Ensure caregiver does not bend at the waist when reaching behind the far shoulder. Instead, have them flex at the hips, knees and ankles first, then reach across to "go get" the far shoulder.
  - This will allow the body to turn as a unit.
  - Staff should be encouraged to try these manoeuvres on each other to gain an appreciation of the effects of leverage.
- To accomplish this transfer, leverage is used in co-ordination with a body shift.
- A small amount of leverage starts the move and is followed by an effective body shift. This ensures the client’s body turns as a unit preventing trunk disassociation and avoiding unnecessary strain on the client’s joints.
- It may take some time to co-ordinate these movements effectively.
- The principle of applying the open hand grasp, combined with proper hand placement will help to avoid pulling or pushing at the actual joint site.
- Never place hand directly on top of a joint and exert force.
- Demonstrate how caregivers can decrease the amount of stress on their back using mechanically correct techniques when reaching across or working over a bed. Staff can experiment with these methods by reaching across to reposition limbs.
- Caregivers should ensure that their toe or knee faces the direction of movement. In addition, they should use their limbs unilaterally to maintain body alignment, arm and leg on same side of body.
- If the client is heavy, two caregivers should be used. Each caregiver should position themselves on opposite sides of the bed. One caregiver is positioned to roll the client away, the other is positioned to roll the client toward them. The count will remain the same. Remember, co-ordinate your movements.
- If you wish to roll the client away from you, start from a flexed position and reverse the shift. On the load, press on the client’s knee to start leverage and on the push, push from your end foot to your start foot. This will allow your body to shift forward causing the client to roll away from you.
## Trainer Instructional Content

### Turning Client to Side

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**Note:** General positioning principles that caregivers have been learning and using throughout the training will now be broadened. This will allow them to incorporate these principles into accessory movements for work and for home (reaching across to adjust bed covers, repositioning limbs, washing client’s face, adjusting equipment, reaching into cupboards, closets, reaching across the back seat of a car, loading a dishwasher/washer/dryer, vacuuming, shovelling snow, etc.).
Curriculum Vitae

Candidate’s full name: Jennifer Rachel Kenny

Universities attended: Dalhousie University Bachelor of Science in Kinesiology 1999

Publications: None

Conference Presentations: None