# ERGONOMIC EXPOSURES OF NURSING HOME PERSONNEL FOLLOWING A SAFE RESIDENT HANDLING INTERVENTION

BY

ALICIA BETH KUROWSKI

B.S. NORTHEASTERN UNIVERSITY (2004)

M.S. UNIVERSITY OF MASSACHUSETTS LOWELL (2007)

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF DOCTOR OF SCIENCE

DEPARTMENT OF WORK ENVIRONMENT

UNIVERSITY OF MASSACHUSETTS LOWELL

**Signature of Author:** Alicia Kurowski **Date:** April 6, 2011

**Signature of Dissertation Chair:** Laura Punnett

**DR. LAURA PUNNETT**

**Signatures of Other Dissertation Committee Members**

**Committee Member Signature:** ______________________

**DR. BRYAN BUCHHOLZ**

**Committee Member Signature:** Rebecca Gore

**DR. REBECCA GORE**

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ALICIA BETH KUROWSKI

ABSTRACT OF A DISSERTATION SUBMITTED TO THE FACULTY OF THE DEPARTMENT OF WORK ENVIRONMENT

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF SCIENCE
DEPARTMENT OF WORK ENVIRONMENT
UNIVERSITY OF MASSACHUSETTS LOWELL
2011

Dissertation Supervisor: Laura Punnett, Sc.D.
Professor, Department of Work Environment

# ABSTRACT

The efficacy of a nursing home Safe Resident Handling Program (SRHP) to reduce the ergonomic exposures of nursing assistants was evaluated. The healthcare version of the PATH method was used by 12 observers to examine postures, manual handling, and resident handling pre-intervention and at three months, 12 months, 24 months, and 36 months post-intervention. There were marked downward trends in proportion of work time spent repositioning and transferring residents, and increased use of handling equipment in transferring (Cochran-Armitage tests: all p-values $< 0.001$). While resident handling post-intervention, nursing aides were more likely to be in neutral trunk postures, walking rather than standing still, working with both arms below 60 degrees, and less likely to lift loads greater than 50 pounds. Lateral transfer devices were infrequently observed in use for repositioning; additional training on the use of this equipment is recommended to increase the potential benefits of the intervention program.

A biomechanical index was developed that combined the compressive forces on the spine resulting from the observed postures and manual handling, in order to obtain a comprehensive analysis of the physical workload of nurses and nursing assistants in long-term care facilities. Informed by a prior biomechanical model that incorporated workers' self-reported frequencies of postures and manual handling, observational data of ergonomic job features was used. The University of Michigan's Three-Dimensional Static Strength Prediction Program (3DSSPP) was used to calculate compressive forces on the lumbar spine resulting from 17 combinations of trunk, arm, and leg postures and manual handling activities. Each force estimate was then used as a weight for the

observed frequency of that combination of PATH variables by job group, and the contributions were summed to obtain total physical loads. These total loads were computed for the four observational surveys from before to three years after the ergonomics intervention. Over the follow-up period the physical workload index (PWI) decreased both for nursing assistants (-24.2%) and for nurses (-2.5%). The index for nursing assistants was much higher during resident handling than other tasks. By the end of follow-up, the index for nursing assistants while resident handling decreased by 40.9% of the baseline value.

Differences in the efficacy of the SRHP in five of the nursing homes in the sample were examined. Two outcome measures were considered: changes in equipment use while resident handling and changes in the PWI for nursing assistants over a two-year period following SRHP implementation. Questionnaires, administrative data, employee satisfaction surveys, and staff exit interviews following the collection of ergonomic observations were examined for explanatory factors of between-center differences in outcomes. Of the explanatory factors, significant correlations related to the outcome measures were the percentages of agency staff used to fill shifts, work shifts involving obstacles to getting work done, 'never' feeling time pressure, adequacy of supplies and equipment, 'poor' ratings for quality of teamwork and staff-to-staff communication, and observed understaffed shifts. The facility with the most positive outcome measures was associated with many positive changes in explanatory factors and the facility with the least positive outcome measures experienced negative changes in the same explanatory factors. These explanatory factors might also inform future analysis of the outcome measures on individuals.

*To all the healthcare workers who have touched my life and inspired my research!*

# ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my thesis advisor Dr. Laura Punnett for her advice, support, for being an excellent teacher and for sharing with me her knowledge and expertise in the fields of occupational ergonomics and musculoskeletal epidemiology. I would also like to thank Dr. Bryan Buchholz for sharing with me his expertise in the field of biomechanics. This research would have been incomplete without Dr. Rebbeca Gore's proficiency in the field of statistics and valuable advice for conducting analyses. I would also like to thank Dr. Jon Boyer who taught me everything I know about leading a team of researchers in the field, and along with Scott Fulmer and Jamie Tessler, for training and preparing me for data collection and for providing excellent company on data collection trips.

I would like to express my appreciation to the rest of the data collection team for their efforts out in the field and a special thanks to the Pro-Care administrative staff, Lindsay Casavant, Sandy Sun, Suzanne Nobrega, and Kim Winchester, for their organization, attention to detail, and for always ensuring things would run smoothly in the field.

I would like to thank my dissertation writing support group, Miriam Weil, Kathy Sperazza, Lisa Hix, Jamie Tessler, and Gabi Kernan, for their sound advice and encouragement over the last few months. I would like to thank my friends Homero Harari, Fred Wafula, and Helena Miranda for their encouragement and support from the beginning. A special thanks to my parents, Beth and Walter; my sister Katie, and my husband Narendra for their unconditional help and support throughout the course of this thesis and for encouraging and understanding me when I needed it most.

I would like to thank Dr. Amanda Young, Dr. Manuel Cifuentes, and Dr. Glenn Pransky for encouraging me and expanding my research interests. Last but not the least; I would like to express my gratitude to my professor and mentor at Northeastern University, Dr. Beverly Jaeger, for first introducing me to the field of Ergonomics.

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# ABBREVIATIONS

3DSSPP – THREE DIMENSIONAL STATIC STRENGTH PREDICTION PROGRAM

BLS – BUREAU OF LABOR STATISTICS

CMA – CERTIFIED MEDICINE AIDE

CNA – CERTIFIED NURSING ASSISTANT

DON – DIRECTOR OF NURSING

EMG - ELECTROMYOGRAPHY

FTE – FULL TIME EMPLOYEE

GNA – GERONTOLOGICAL NURSING ASSISTANT

IRR – INTER-RATER RELIABILITY

LPN – LICENSED PRACTICAL NURSE

MCPHI – MULTI-COMPONENT PATIENT HANDLING INTERVENTION

MSD – MUSCULOSKELETAL DISORDER

NIOSH – NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

OHSAH – OCCUPATIONAL HEALTH AND SAFETY AGENCY FOR HEALTHCARE

OSHA – OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

PATH – POSTURES, ACTIVITIES, TOOLS, AND HANDLING

PDA – PERSONAL DIGITAL ASSISTANT

PWI – PHYSICAL WORKLOAD INDEX

RN – REGISTERED NURSE

SRHP – SAFE RESIDENT HANDLING PROGRAM

UC – UNIT COORDINATOR

# CHAPTER I: INTRODUCTION

## 1.1 OBJECTIVES AND SPECIFIC AIMS

In 2003 the Occupational Safety and Health Administration (OSHA) released ergonomic guidelines for the nursing home industry based on reviewing existing ergonomics practices and programs, State OSHA programs, and scientific research (OSHA, 2003). This document recommends eliminating manual resident lifting whenever possible. The patient care industry has developed devices to prevent exposure to the forceful exertions required to lift and move patients who are not fully ambulatory, and several studies have evaluated their efficacy (Park, 2009; Enkvist, 2006; Nelson, 2006; Collins, 2004; Nelson, 2003a, 2003b; Silverstein, 2003).

The objective of this study was to assess the ergonomic exposures of nursing assistants in nursing homes after a company-implemented Safe Resident Handling Program (SRHP). Baseline pre-intervention measurements as well as 3-month, 12-month, 24-month, and 36-month measurements were collected using the PATH method (Buchholz, 1996) and evaluated overall and by facility.

The specific aims of the first study were to evaluate the effects of a multi-component Safe Resident Handling Program (SRHP) over a three-year follow-up period in a sample of nursing homes by examining observed changes in manual handling and resident handling activities, use of handling equipment, as well as trunk, leg, and arm postures among nursing assistants. Cochran-Armitage trend tests were used to identify significant trends over time for postures and manual handling.

The second study's specific aims were to evaluate further the efficacy of the SRHP by modifying and computing a Physical Workload Index (PWI) for nurses and nursing assistants using an additive biomechanical model. The index was based on a prior model (Klimmer, 1998; Hollmann 1999) and consisted of inputs reflecting the frequencies of observed postures and manual handling activities resulting from the direct ergonomic observations and biomechanical weighting factors resulting from the observational variables. In order to evaluate the SRHP, the PWI for nursing assistants was used to describe physical workload both overall and while restricted to resident handling activities for each time period. The physical workload of nursing assistants was also compared to that of a population of Licensed Practical Nurses (LPNs) and Registered Nurses (RNs) both before and after the SRHP intervention in nursing homes.

The specific aims of the third study were to examine the efficacy of the SRHP among nursing assistants on the facility level by examining possible explanatory factors for differences in the outcome measures in five nursing homes. Changes in equipment use while resident handling as well as changes in the PWI for nursing assistants were examined over a two-year period following SRHP implementation. Center and shift characteristics that might explain differences were identified by reviewing questionnaires, administrative data, employee satisfaction surveys, and staff exit interviews following ergonomic observations. Correlation coefficients were computed between explanatory factors and outcome measures were examined to identify potential relationships (and to inform future analyses on the individual level).

## 1.2 BACKGROUND

### 1.2.1 The Nursing Home Industry

The U.S. National Nursing Home Survey conducted in 2004 reported that there were 1,324,500 residents 65 years and older living in nursing homes (Jones, 2009). This constituted 3.7 percent of the US population age 65 and older (Wan, 2005). The number of nursing home beds increased by 12 percent from 1.62 million to 1.81 million between the years of 1985 and 1999. Three-quarters of the residents required assistance in at least three activities of daily living (for example bathing, getting dressed, eating, and toileting), and 42 percent of the residents are diagnosed with dementia (AARP, 2001).

Nursing homes typically consist of several units made up of bedrooms which are usually shared by at least two residents. Central to each unit is a nursing station, where RNs and LPNs perform most administrative work. In addition to bedrooms, each unit has at least one shower room where residents are bathed, a dirty linen closet, and a supply closet. Units also have dining areas and common areas where the residents can attend activities. These facilities mainly cater to long-term care for the elderly; however certain facilities also maintain rehabilitation units and/or assisted living units. There may also be specialized units such as those which provide care for residents with dementia and similar disorders. Many nursing homes also have rehabilitation rooms, dining rooms, hair salons, and activity rooms, as well as other services such as administrative offices.

### 1.2.2 Clinical Staff in Nursing Homes

Occupations of nursing home staff include rehabilitation, recreation, dietary, housekeeping, administration, and social work. Clinical nursing staff includes RNs, LPNs, Certified Nursing Assistants (CNAs), Geriatric Nursing Assistants (GNAs), and

Certified Medicine Aides (CMAs). In some states, employees are first trained as CNAs, and upon completion of an approved GNA course and examination they are promoted to the status of GNA. CMAs are GNAs who have completed additional training requirements which allow them to mix and administer medications. Some Unit Coordinators (UCs) are promoted from certified GNA, CNA, or CMA positions, and thus must perform some direct care to maintain their certification.

Because residents require 24-hour care, there must be clinical nursing staff working nights and weekends. Facilities are typically staffed in three shifts: days (7:00 am to 3:00 pm), evenings (3:00 pm to 11:00 pm), and nights (11:00 pm to 7:00 am). Most of the clinical staff are assigned to a permanent shift, as opposed to rotating shifts.

RNs in nursing homes perform minimal resident handling. They supervise the actions of LPNs, GNAs, CNAs, and CMAs. Their job duties are mainly administrative in nature, such as completing paperwork and creating care plans for residents. However, RNs also evaluate residents' health conditions and perform complicated procedures such as starting intravenous fluids (Jervis, 2002). At the start of each shift, RNs meet with those from the previous shift to discuss each resident, specifically changes in health status, medications, rehabilitation, or care plans. RNs communicate with the employees they supervise, as well as with physicians, family members, and visitors.

Typically, LPNs in nursing homes work under the direction of RNs. In some cases, LPNs supervise nursing home units. They also perform medical tasks such as mixing and distributing medications, wound care, and checking vital signs (Jervis, 2002). Medications are usually administered twice per shift. On the day shift, for example, medications are delivered once in the morning, and once in the afternoon. Administrative tasks such as completing paperwork and making phone calls to physicians and physical therapists are also performed.

The majority of resident handling activities are performed by GNAs and CNAs. Their main job duties include bathing, dressing, toileting, feeding, and otherwise assisting the residents in the facilities (Jervis, 2002). These types of activities frequently include manual handling actions such as transfers and repositions and often require the use of mechanical lifts. When a shift starts, GNAs and CNAs meet with their supervisors and are given their work assignments. On the first shift GNAs and CNAs are required to wake up each resident, assist in bathing them, dressing them, and delivering breakfast. Because of the amount of work required in the early morning in addition to residents' preferences, tasks are not always completed in this order. A typical goal for GNAs and CNAs is to complete all of these tasks by the time lunch is served (between 11:30 am and 12:00 pm). Due to the varied acuity of residents, some may be able to bathe, dress, and feed themselves, while others require additional care. After lunch is served, GNAs and CNAs make rounds to each resident for whom they are responsible, which involves toileting activities such as assisting residents to the bathroom and changing diapers. At the end of each shift GNAs and CNAs are required to complete some basic paperwork about each resident. Other tasks which are performed throughout the day include toileting, making beds, and cleaning up food trays.

CMAs perform medical tasks such as mixing and administering medications, which is traditionally part of an LPN's job duties. CMAs are not permitted to administer injections or perform wound care. In many facilities, if understaffing of GNAs arises, CMAs are often pulled from their medical positions and required to work on the units as GNAs.

### 1.2.3 Risk of MSDs in Clinical Work

Manually lifting, transferring, and repositioning residents by clinical nursing staff results in elevated physical effort and high internal loading in muscles, ligaments, and joints which can increase the likelihood of developing work-related musculoskeletal disorders (MSDs) (Waters, 2007). CNAs and LPNs in nursing homes had more than twice the risk of developing work-related low back disorders compared to all other female workers (NIOSH, 1998). In 2009 nursing assistants had the highest incidence rate of MSDs per 10,000 full-time workers and they ranked second for work-related injuries and illnesses requiring days away from work for all eligible occupations (BLS, 2010).

The NIOSH guide, "Safe Lifting and Movement of Nursing Home Residents" (Collins, 2006), addressed the challenges of manual resident handling in nursing homes stating,

> "These conditions contributed to the 211,000 occupational injuries suffered by caregivers in 2003. … Due to the ongoing demand for skilled care services, musculoskeletal injuries to the back, shoulder, and upper extremities of caregivers are expected to increase."

The relationship between physical work factors and MSDs has been documented in nursing home and hospital workers (e.g. Lagerstrom, 1998; Smedley 1995, 1997; Trinkoff 2003; Fujimura, 1995). A review of 42 studies researching low back pain among nursing jobs reported relationships between low-back pain and patient/resident handling, 'save the patient' situations, awkward work postures, static standing, and working as a nursing aide compared to a registered nurse (Lagerstrom, 1998).

In 2003, Trinkoff reported on perceived physical demands of randomly selected RNs. Twelve physical demands items including physical effort, repetitive motion, lifting heavy objects or people, and working in awkward postures were analyzed for their association with neck, shoulder, and back MSDs. All physical demands were significantly associated with back MSDs, and 11 of 12 demands were significantly associated with neck and shoulder MSDs (Trinkoff, 2003).

A cross-sectional study based on questionnaires distributed to 1616 nurses in hospitals (Smedley, 1995) found the risk of low back pain to increase with perceived frequency of manual patient handling, including repositions and transfers. A follow-up study (Smedley, 1997) surveyed the same population of nurses with an 88% response rate, and results mirrored the 1995 study.

A 1995 study in Japanese nursing homes indicated that nursing assistants with low back pain perceived resident handling activities, especially toileting, repositioning, and transferring, to be more stressful than did workers without back pain (Fujimura).

### 1.2.4 Interventions in Healthcare to Reduce MSD Risk

Safe patient handling interventions are fundamental for reducing MSDs among healthcare workers (Collins, 2006). Typical multi-component patient handling interventions include patient assessment, provision of patient handling equipment, written policies for equipment use, and training on patient handling procedures (Hignett, 2003). Systematic reviews of patient handling interventions indicated that multi-component interventions were more effective than manual handling training only for preventing back pain and injuries in nurses (Dawson, 2007), and equipment use alone was not as effective as multifaceted interventions (McCoskey, 2007). Research on safe patient handling programs has been performed in hospital, nursing home, and home health settings. Nurses have been studied more often than other workers. Findings have included reductions in forces on the lumbar spine (Nelson, 2003), back injuries (Engkvist, 2006), workers' compensation claims and lost injury days (Park, 2009; Engkvist, 2006; Nelson, 2006; Collins, 2004; Li, 2004), OSHA 200 log incidents (Collins, 2004; Evanoff, 2003), self-reported injury rates (Collins, 2004), and claim costs (Park, 2009; Alamgir, 2008; Badii, 2006; Miller, 2006; Nelson, 2006; Engst, 2005; Chhokar, 2005; Li, 2004; O'Reilly Brophy, 2001).

Mechanical devices were evaluated in an Australian hospital and compared to two control hospitals (Engkvist, 2006). The cross-sectional study used a questionnaire to examine the number of injuries, pain and symptoms, and absence from work among nurses. The nurses at the intervention hospital reported significantly smaller numbers of back injuries, less pain, fewer symptoms, and less absence from work due to musculoskeletal symptoms.

Another intervention study examined the effectiveness of mechanical aids such as total body lifts and sit-stand lifts in reducing musculoskeletal symptoms, injuries, lost workday injuries, and workers' compensation costs for 138 nurses in a community hospital (Li, 2004). Questionnaires were distributed, and OSHA logs and workers' compensation data were analyzed. The authors reported considerable increases in musculoskeletal comfort (as ranked on a five point scale) for all body parts studied, a decrease in injury rates, lost workday injuries and workers' compensation costs.

In 2004, Collins et al. reported on an injury prevention program consisting of implementation of mechanical lifting equipment and repositioning aids along with a written "zero lift" policy and staff training for all nursing staff in several nursing homes. Three years of pre- and post-intervention data were collected. Injury rates were examined through workers' compensation claims, incidents on OSHA 200 logs, employee reports, and human resources data. The authors reported a 61% decrease in the number of claims from workers' compensation, a 46% decrease in OSHA 200 log incidents, and a 35% reduction in employee injury first-reports. Severity and cost of injuries also decreased in this period.

Nelson et al, (2003c) examined nine different patient handling tasks, of which ceiling lifts were introduced for bed-to-wheelchair transfers. The intervention was assessed in a laboratory setting through the use of a 3-D electromagnetic tracking system, surface EMG, and questionnaires. The study reported that lumbar force was reduced by 58%, and moments at the lumbar spine, left shoulder, and right shoulder were decreased by 54%, 69%, and 45% respectively. The nurses in the study population reported increased comfort when transferring patients with the ceiling-mounted lifts as opposed to manual handling. In addition to evaluating interventions in patient handling tasks, this study also reported on some reasons why patient lifts were not used, such as, "difficulty using in confined spaces, extra time required, lack of accessibility or availability, difficulty using and storing, and poor maintenance."

The effects of a lifting device intervention in four hospitals and five nursing homes were examined (Evanoff, 2003). Mechanical lifting devices were provided to assist caregivers with patient handling activities. Pre- and post-intervention musculoskeletal injury rates were examined and interviews regarding device use were carried out in both settings. The authors reported overall decreases in the number of injuries, number of lost day injuries, and the total number of days lost due to injuries. However, these decreases were larger for nursing homes than hospitals. Injury rates in hospitals declined from 6.6 to 5.7 per 100 full time employees (FTEs) while injury rates in nursing homes declined from 6.9 to 4.9 per 100 FTEs. Results from interviews indicated a significant difference in the frequencies of perceived lift use between hospitals and nursing homes (16% vs. 38%), which was partially attributed to the quickly changing nature of patient acuity observed in hospital settings.

### 1.2.5 Biomechanical Modeling of Clinical Work

Biomechanical modeling is technique that is valuable for investigating the effects of multiple exposures. Ergonomic exposures such as the physical workload of healthcare workers has been modeled in laboratory settings using static and dynamic models and incorporating patient handling tasks such as transferring and repositioning with and without the use of mechanical handling equipment (OHSAH, 2006; Skotte, 2002; Marras, 1999; Zhuang, 1999; Garg, 1992a; Garg, 1992b; Gagnon, 1986).

A biomechanical evaluation of compressive and shear forces on the lumbar spine while performing manually and mechanically assisted patient handling was conducted by the Occupational Health and Safety Agency for Healthcare (OHSAH) in British Columbia, Canada (2006). Ground reaction forces and hand reaction forces were used as input variables in a linked segment model of the body. Peak compressive and shear forces resulted from the manual repositioning of a patient. Additionally, peak shear forces were observed while turning patients.

Compressive and shear forces of the L4/L5 joint were examined (Skotte, 2002) using a biomechanical model that minimized the sum of 14 cubed muscle stresses. Ten female healthcare workers performed nine patient handling tasks using a male stroke patient in a laboratory setting. Individual peak compressive forces ranged from 1283 to 5509 N. Compressive forces for the two tasks involving lifting the patient were significantly higher than all other tasks. The mean compressive forces for these two tasks were 4132 N and 4433 N which exceed NIOSH's proposed safety limit of 3400 N for manual handling.

An EMG-assisted biomechanical model was used (Marras, 1999) to determine spinal loading for four repositioning techniques and three patient transferring techniques while performing six tasks. Twelve experienced (nursing assistants at a long-term care facility) and five inexperienced participants volunteered to perform the tasks using a 50 kilogram female as a 'patient.' Maximum values of compressive force, anterior-posterior shear forces, and shear forces on the L5/S1 joint were used to estimate spinal load. The authors reported high forces for all transferring and repositioning techniques; compressive forces ranged from about 4000 N to 9000 N. It was determined that even the 'safest' task would put a healthcare worker at risk for low-back injury. It was acknowledged that in a real-time setting there would be potential for greater risks to caregivers considering the 'patient' used in this study was small and cooperative.

Another study (Zhuang, 1999) explored the effects of transfer methods and resident weight on the biomechanical stress of nursing assistants. Nine nursing assistants were recruited from nursing homes to participate in evaluating nine electrically controlled lifting devices, a slide board, a gait belt, and a manual transfer. Force platforms and a three-dimensional biomechanical model were used to measure low-back loading. It was reported that low-back compressive forces were significantly reduced when using lifting devices, and were also reported to be lower than NIOSH's recommended lifting limit.

Biomechanical evaluations of patient transferring tasks were performed in two studies by Garg et al. in 1992 (a,b). Five manual transfers and three mechanical transfer devices were evaluated for performing bed-to-wheelchair and wheelchair-to-bed transfers and wheelchair-to-showerchair and showerchair-to-wheelchair transfers. These were laboratory studies where six female nursing students served as subjects and 'patients.' It should be noted that the mechanical transfer devices utilized at the time required manual cranking to raise and lower patients. Static biomechanical evaluation showed that pulling techniques required lower compressive forces on the L5-S1 vertebra than lifting techniques used for transfers. Although the compressive forces at L5-S1 were reduced when using mechanical devices to perform transfers, the subjects felt that two of the three lifting devices examined were as physically stressful as manual transferring methods.

In 1986 Gagnon et al. used six male nursing assistants as subjects for modeling the load on the L5/S1 vertebra while raising a manikin or a live person from a chair using three different manual lifting techniques. These techniques include placing the hands on the manikin's sides and lifting (hand method), hooking the elbows under the manikin's arms (forearm method), and lifting the manikin by grabbing a gaitbelt on the manikin's torso. The experiment was conducted in a laboratory setting with the use of a force plate, electromyography (EMG), and video recording. Maximum compressive force was recorded while performing lifting using the belt method (7951 N), while the hand method produced the lowest recorded maximum compressive forces (5744 N).

### *1.2.5.1 Index of Physical Workload*

A study reported on the computation of an index of physical workload for 610 nursing home workers (Klimmer, Hollmann et al., 1998). Physical care, psychosocial care, and housekeeping employees completed a questionnaire self-reporting frequencies of postures and manual handling using a five-point Likert scale ranging from 'never' to 'very often.' The index considered the relative contribution of compressive forces to the overall load of the spine. Weighting factors were calculated for 15 combinations of postures and manual handling activities using a pre-existing biomechanical model of lumbar loading on the L5/S1 disc (Jager, 1991). The standard compressive force of the spine was subtracted from the compressive force of the spine due to a specific posture in order to compute the weighting factors used in the index. Four identified postures (neutral trunk, standing, sitting, and both arms below shoulder height) resulting in the lowest calculated compressive forces on L5/S1 based on an average person with a height of 174 centimeters and a weight of 66 kilograms were designated as the standard compressive forces. The weighted frequencies were summed to give an overall approximation of lumbar load for each job type.

A total of 455 of the original employees in physical care/nursing, services jobs, social work, and management were followed up in a validation study (Hollmann, Klimmer et al., 1999). Both studies reported that the nursing staff (physical care employees) had the highest index of physical workload when compared to other occupations. Musculoskeletal symptoms for the participants were compared to results from the index of physical workload model, and were found to be significantly related, with proximal musculoskeletal symptoms being more strongly related than distal symptoms.

Several other applications of the index of physical workload have been reported on. In 2005, Klimmer revisited the original study and compared the index to a different self-reported measure of physical workload for the same population of nursing home workers. Janowitz et al. (2006) adapted the index and used it in hospitals as part of an ergonomics assessment tool, and Nabe-Nielsen et al. (2008) comparing two self-reported measures of work demands in hospitals using a questionnaire that included the index.

**1.2.7 Explanatory Factors for Successful SRHPs**

Safe patient handling intervention studies in varied healthcare settings were reviewed to identify individual and environmental barriers and facilitators to successful implementation (Koppelaar, 2009). The impact of barriers and facilitators on the efficacy of interventions was not quantified in any of the reviewed studies. However, commonly identified environmental barriers and facilitators included 'convenience and easy accessibility,' 'supportive management climate,' and 'patient-related factors,' and the most commonly acknowledged individual barrier or facilitator was 'motivation.'

Individual and organizational factors influencing the use of ergonomic devices for patient handling were assessed in 19 hospitals and 19 nursing homes with existing patient handling programs in the Netherlands in a cross-sectional study (Koppelaar, 2010). Nursing personnel were observed performing patient handling then interviewed to obtain insight into factors affecting their use of handling equipment. Multivariate logistic regression identified the individual factors 'motivation' and 'back complaints in the pasts

12 months,' as well as the organizational factor 'availability of patient specific protocols with strict guidelines for ergonomic device use' as causes of increased equipment use.

## 1.3 SIGNIFICANCE

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A review study focusing on low back pain in nursing jobs (Lagerstrom, 1998) reported that nursing assistants had a higher prevalence of work-related low back problems than registered nurses, and on average, those with low back disorders perform more strenuous tasks and find resident handling more stressful than those who are free from pain.

Ergonomic exposures among clinical nursing staff, particularly nursing assistants, must be evaluated in greater depth in order to develop strategies for preventing their rates of MSDs from increasing. Some physical exposures for nursing assistants, particularly those in nursing homes, often far exceed those of registered nurses (Boyer, 2008) because they perform the majority of direct care, including resident handling. A systematic review examining intervention studies in healthcare settings (Tullar, 2010) identified only three quality evaluations of multi-component patient handling interventions (MCPHIs), and only one of these investigated a population of nursing assistants. This study, examining the effects of SRHPs on ergonomic exposures of nursing assistants in nursing homes, could help promote proactive health and safety practices in the nursing home industry.

Typically questionnaires have been used to assess ergonomic stressors of nursing assistants in nursing homes, and injury reports and workers' compensation claims have been reviewed to study work-related injuries. While these measures can be useful, investigating actual physical exposures collected using an observational method will provide more objectivity and more specificity about particular changes in postures and resident handling activities in a real-time nursing home environment. Results from this analysis of direct observations may be useful for improving approaches for MSD prevention.

Previous uses of the index of physical workload have been based on self-reported frequencies of time spent in various postures and manual handling activities. A conclusion from the original study recommended using observational data for future testing of the index, and a response to the study stated "...these approaches, based on self-reported data, can only yield rather crude estimates of biomechanical load (Burdorf, 1999)." Modification of the index of physical workload using data representing real-time workloads in nursing home settings will provide more insight into the actual physical workload of nursing assistants.

Few studies have attempted to quantify the impact of explanatory factors on the success of SRHPs. However, studies have reported on factors that appear to benefit or create obstacles to SRHP efficacy, including staffing levels (Park, 2009; Enkvist, 2007; Trinkoff, 2005), turnover (Rockefeller, 2002), resident acuity (Park, 2009; Enkvist, 2007), equipment factors (Hunter, 2010; Koppelaar, 2009; Enkvist, 2007), organizational factors (Park, 2009), and relationships with co-workers (Koppelaar, 2009; Enkvist, 2007; Schaefer, 1996). Research identifying explanatory factors for SRHP success will be important for the promotion of multifaceted patient handling interventions. This study examines factors from self-reported and administrative data sources over time, including pre-intervention measurements, to better understand the relationships between the factors and efficacy of the SRHP.

## 1.4 DISSERTATION ORGANIZATION

This dissertation is organized into five chapters. The first chapter explains the central themes, motivation, and the significance of this research. Chapter Two reports on changes in ergonomic exposures of nursing assistants in nursing homes three years after the introduction of a SRHP. Observational data including postures, manual handling, resident handling, and equipment use was examined pre- and post-intervention. Chapter Three uses the observational data of nurses and nursing assistants to modify and calculate a Physical Workload Index (PWI) to further evaluate the efficacy of the SRHP. The fourth chapter assesses possible explanatory factors relating to differing changes in physical workload and the use of handling equipment for nursing assistants in five nursing homes. Explanatory factors were selected from questionnaire responses, administrative data, employee satisfaction surveys, and post-observation employee exit interviews. Chapter Five concludes this dissertation by reiterating the accomplishments achieved in these studies and by recommending possible future research topics.

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# CHAPTER II: CHANGES IN ERGONOMIC EXPOSURES OF NURSING ASSISTANTS AFTER THE INTRODUCTION OF A SAFE RESIDENT HANDLING PROGRAM IN NURSING HOMES

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## 2.1 INTRODUCTION

High rates of back and other musculoskeletal disorders (MSDs) have been reported in healthcare workers in both nursing home and hospital settings. Much of this excess is thought to be due to manual handling (lifting, transferring, repositioning) of patients or residents (Collins, 2006; Trinkoff, 2003; Lagerstrom, 1998; Smedley 1995, 1997; Fujimura, 1995). In 1998, the National Institute for Occupational Safety and Health (NIOSH) reported that, compared to all other female workers, Certified Nursing Assistants (CNAs) and Licensed Practical Nurses (LPNs) in nursing homes had more than twice the risk of developing work-related low back disorders (NIOSH, 1998). In 2009, nursing aides ranked second for occupations with the most reported work-related injuries and illnesses requiring days away from work and had the highest incidence rate of MSD cases per 10,000 full-time workers (BLS, 2010).

A 1998 review of 42 studies on low back pain among nursing jobs reported relationships between low-back pain and physical factors such as lifts, transfers, 'save the patient' situations, awkward work postures, static standing, and working as a nursing aide compared to a registered nurse (RN) (Lagerstrom, 1998). Studies of nurses in hospitals reported associations between musculoskeletal disorders and physical demanding tasks such as repositioning and transferring residents. Four of the 42 studies focused on nursing assistants in nursing homes; results indicated that on average, those with low back disorders performed more strenuous tasks and found resident handling more stressful than those who were free from pain.

A guide published by NIOSH, "Safe Lifting and Movement of Nursing Home Residents" (Collins, Nelson, Sublet, 2006), addressed the challenges of caregiver responsibilities, including manual resident handling in nursing homes. According to the NIOSH report,

> "These conditions contributed to the 211,000 occupational injuries suffered by caregivers in 2003. … Due to the ongoing demand for skilled care services, musculoskeletal injuries to the back, shoulder, and upper extremities of caregivers are expected to increase."

Intervention studies are useful for confirming causal relationships, demonstrating feasibility, and evaluating practicality. Many intervention studies have evaluated ergonomics programs, especially for nurses, in hospital and laboratory settings. These interventions included different types of lifting techniques (Videman, 1989), the use of slings (Elford, 2000), ceiling-mounted lifts (Nelson, 2003a), and mechanical patient lifts (Engkvist, 2006). Results from these studies of nurses have shown smaller numbers of back injuries, less pain, fewer symptoms, and less absence from work due to musculoskeletal symptoms post-intervention.

These studies have assessed interventions for hospital nurses, primarily in laboratory settings; however, some physical exposures for nursing assistants in nursing homes, such as trunk flexion and heavy manual handling, can exceed those of nurses

(Boyer, 2008). The majority of direct care in nursing homes, including resident handling, is performed by nursing assistants. Some injury reduction programs for nursing assistants have reported reductions in workers' compensation claims and lost injury days (Park RM, 2009; Nelson, 2006; Collins, 2004), OSHA 200 log incidents (Collins, 2004; Evanoff, 2003), self-reported injury rates (Collins, 2004), and claim costs (Park RM, 2009; Nelson, 2006); and increased frequencies of perceived lift use (Evanoff, 2003).

A 2010 review examined studies of exercise interventions and multi-component patient handling interventions (MCPHI) in healthcare settings (Tullar). The authors defined a MCPHI as a program that includes injury reduction policies, the purchase of handling equipment, and ergonomic training that covers safe patient handling and equipment usage. Although three of these studies were deemed quality evaluations of MCPHI, only one studied a population of nursing assistants.

Ergonomic stressors of nursing assistants in nursing homes have been assessed through questionnaires, and work-related injuries have been examined by reviewing injury reports and workers' compensation claims. These measures can be extremely useful; however, examining actual physical exposures using an observational method will provide objectivity to specific changes in postures and manual handling activities in a real-time nursing home work environment and confirm that exposure reduction is the mechanism by which injury rates have gone down. These types of measurements can be useful in developing strategies for preventing MSDs. The goal of this study was to evaluate a company-implemented multi-component Safe Resident Handling Program (SRHP) over a three year follow-up period in a sample of nursing homes by examining observed changes in resident handling activities, equipment use, and body postures among nursing assistants.

## 2.2 METHODS

### 2.2.1 Background to the Intervention Process

In 2004, a large nursing home corporation instituted a SRHP to reduce exposure to MSDs. Mechanical devices and training were provided by a third-party firm, which offered the incentive that all equipment purchased would be reimbursed if injury rates were not reduced in one year. In each center, prior to receiving the equipment, nurses in the facilities assessed residents' needs for safe patient handling. Next, the third-party trainers visited each facility to conduct orientation meetings with department heads and nurses. Equipment was purchased by each facility, to be received one week after these meetings, and representatives from the third-party company provided training on equipment use and maintenance at this time. Two weeks after the introduction of the equipment, follow-up visits were made by the third-party company to provide training and emphasize policies to the clinical nursing staff. Additional follow-up visits to enforce policies and ensure compliance took place after 4 weeks, 10 weeks, 20 weeks, 30 weeks, 40 weeks, and 50 weeks. All staff had to demonstrate competency in using the equipment in order to remain in their jobs.

The equipment was purchased based on the baseline evaluation of the needs of residents in each facility. Residents were also to be assessed upon admission, re-admission, when a significant change in health occurred, and in quarterly reviews. Assessments for safe patient lifting indicated whether a resident was ambulatory, required a sit-stand lift, or required a total body lift of either 450-pound or 600-pound capacity. Assessment results were documented in the care plans, aide sheets, and electronically. In addition, stickers were applied to the residents' door nameplates to indicate the type of equipment to be used (if any), the size of the sling needed, and the number of staff required for turning and repositioning activities.

### 2.2.2 Study Design

At the initiation of this prospective study in 2006, eight centers in the greater Baltimore area and the Eastern Shore of Maryland were identified as eligible for baseline questionnaire surveys (eight centers) and ergonomic observations (four centers) based on their scheduled enrollment in the SRHP. Subsequently, data was collected at 3-month, 12-month, 24-month, and 36-month follow-up periods.

In January of 2007, two facilities in Massachusetts were selected as locations for on-site training in observational methods for University of Massachusetts Lowell staff. These facilities had implemented the SRHP at least one year prior to site visits, so 12-month and 24-month data were collected. In addition, the nursing home corporation purchased several facilities in Maine in 2007 and implemented the SRHP later that year. Ergonomic observations were conducted at one of these newly purchased facilities. Thirty-six month data were collected in 2010 at five additional centers previously enrolled in the study as part of a health-promotion intervention in Maine, Massachusetts, and Rhode Island. All procedures were reviewed and approved by the University of Massachusetts Lowell Institutional Review Board.

### 2.2.3 Ergonomic Exposure Assessment Method

An adaptation of the method called "Postures, Activities, Tools, and Handling (PATH)" (Buchholz, 1996) was used to record the frequencies of ergonomic exposures in nursing home work. PATH is a direct observation work-sampling-based method developed for analysis of work without short, regular work cycles. Multiple ergonomic exposures are recorded in categorical form for a single moment in time, followed by a fixed time interval (in this case, 60 seconds); the data are used to estimate the percentage of observations that employees are exposed to each posture or activity. PATH has been validated relative to direct instrumentation (Paquet, 2001), conditional upon adequate observer training and good inter-rater agreement (Park JK, 2009). Clinical nursing work lacks short, repetitive work cycles, making the PATH method a useful choice for exposure assessment.

### 2.2.4 PATH Template Development

In order to obtain comparative data on a large number of healthcare job titles, it was necessary to augment the original PATH method in some areas and simplify it in others. Customization for the jobs to be observed relied upon literature review of studies in nursing homes and hospitals (Myers, 2002; Smedley, 1995; Nelson, 2003a); PATH observations by Rockefeller (2002) among nursing home workers in Washington; and other studies describing nurses' tasks in this sector.

The template, "Resident Handling" (Appendix A), was designed to record trunk, leg, and arm postures, manual material handling, resident handling, task information, and space constraints. The template included a mix of ordinal, nominal, and dichotomous variables. To allow for data entry from short-term memory, trunk posture, leg posture, and arm posture were the first three items in the template, because postures were deemed more difficult to remember than tasks, equipment, and handling activities.

Tasks were grouped into four mutually exclusive categories: 'direct care,' 'medical care,' 'administrative,' and 'other care.' 'Resident handling activity was coded when employees were repositioning, transferring, transporting, or assisting with ambulation.

Repositioning occurred when a resident (or body part) was moved from one area to another on the same surface (e.g. boosting up in bed). Transfers occurred when moving a resident from one surface to another (e.g. bed to wheelchair). Transporting involved taking a resident from one place to another by use of equipment (e.g. wheelchair). Assisting with ambulation involved helping an ambulatory resident while walking or moving from one place to another. 'Team handling,' 'resident status,' and 'resident compliance' were only coded if a 'resident handling activity' was coded in the template. Resident handling equipment included total body lifts, sit-stand lifts, slings, slide boards, slipsheets and gait belts.

Manual material handling was only encoded if a load of more than ten pounds was being handled. The load weight categories were 'less than ten pounds,' 'ten to 50 pounds,' and 'greater than 50 pounds.' The largest weight in hands category resulted from the combination of two categories on the PATH template ('50 to 150 pounds' and 'greater than 150 pounds'). At each time period, very few observations fell into the 'greater than 150 pounds' category, so they were combined with the '50 to 150 pounds' category.

### 2.2.5 Data Collection Procedures

Twelve observers were trained to collect PATH data. Data collectors were professional ergonomists, graduate students in ergonomics, and undergraduate students in biology or kinesiology at the University of Massachusetts Lowell and the University of Connecticut; several of them had previous experience with its use in other settings. Training included review of the template and definitions, viewing video samples, several hours of discussion regarding the technique of posture coding, and evaluation of inter-rater agreement prior to field data collection.

Data were collected on three Dell Axim X50 and three Dell Axim X51 personal digital assistants (PDAs) equipped with touch screen technology, which facilitated field data collection via a stylus pen. The observation software used was InspectWrite™, marketed by Penfact Inc. (Boston MA). The software allowed creation of electronic templates containing the sets of specific administrative and physical exposure variables of interest to the study. The PDAs were re-charged each day prior to field data collection and PATH data were downloaded into the authoring workstation at the close of each observation day.

Inter-rater reliability (IRR) was tested among pairs of observers who simultaneously observed a single subject. Agreement between paired observations was evaluated by raw percent agreement and kappa statistics (using SAS 9.1). In accordance with the original PATH investigations by Buchholz et al (1996), 80% agreement was considered adequate IRR for this study.

The modified PATH data collection protocol involved observation of clinical employees [nursing assistants (CNAs/GNAs), medicine aides (CMAs), and nurses (LPNs, and RNs)] in sessions lasting from one to eight hours. Trained observers who had satisfied project criteria for inter-rater reliability acquired permission to enter the facility, obtained informed consent from the targeted employees, and recorded demographic characteristics for each employee recruited.

Because of the large amount of resident handling performed by nursing assistants, they were preferentially selectively recruited for ergonomic observations. Registered nurses were rarely recruited once it became clear that they performed little resident handling. Individual workers were selected by convenience from the members of the clinical nursing staff and followed exclusively for the duration of the observation session. Due to the sensitive nature of their work, some residents were not comfortable allowing researchers to observe tasks such as bathing and toileting. In these instances, the missing observations were recorded as 'not observed/not sure.' As much as possible, follow-up observations were completed with the same individual workers who had volunteered to participate in the baseline observation period. Subjects were paid an incentive for participation following each observation period.

**2.2.6 Supplemental Cover Sheets**

The PATH method does not permit identification of certain exposures such as static posture. Other job features of interest are unlikely to change during a shift (e.g. staffing or equipment variability), therefore supplemental data covering the observed shift were recorded in an exit interview following observation of each subject. The exit interview included demographic and specific work context information required for meaningful interpretation of the physical exposure data collected on that day. Several types of supplemental data were recorded on standardized forms called "cover sheets" (Appendix B):

(1) Tasks typically performed by the employee and the sequence (if regular) of performing such tasks.

(2) Employee demographics.

(3) To what extent the work period observed is typical, or is altered in either direction by understaffing, unusual deadlines, broken equipment, unusual weather circumstances, atypical patient census or other variable workload factors.

(4) Psychosocial stressors such as deadlines, time pressure, obstacles and the ability to take scheduled breaks/meals.

(5) Physical exposures that the PATH method cannot capture, such as static postures of long duration, lumbar support while seated and floor surfaces.

(6) Thirteen safety hazards: exposure to sharps, slip/trip/fall hazards, chemicals, electrical and heat sources, etc. Routine use of personal protective equipment is recorded here as well.

(7) The degree of work routinization [Gold et al., 2006]; and the degree of responsibility for safety of residents and others.

**2.2.7 Data Management and Analysis**

Physical exposure data recorded on the PDA were downloaded into the authoring workstation, cleaned, and documented in a standardized format. Cover sheet data were scanned into an Access database. Each entry was identified by facility, department, and job code for data linkage; each individual employee was identified by ID number. Data were analyzed using SAS 9.2. Cochran-Armitage trend tests (Agresti, 2002), p-values and confidence limits were computed to determine the statistical significance of changes in ergonomic exposures over time.

An analysis of observations by time of day was performed to determine whether equipment use and resident handling activities were distributed similarly across data collection periods. Observations were grouped according to 'heavy,' 'medium,' and 'light' work for the analyses of resident handling activities and equipment use. The 'heavy' manual handling activities were observed between the hours of 7:00 am and 11:00 am, when most direct care of residents takes place. The 'light' manual handling activities were observed at mealtimes, between 11:00 am to 1:00 pm and again from 3:00 pm to 5:00 pm; toileting activities occurring between 1:00 pm and 3:00 pm represented a more intermediate level ('medium') of manual handling.

### 2.2.8 Healthcare Workers Questionnaire

As noted above, a questionnaire was distributed to all clinical staff in each eligible facility at each of the five time periods. The questionnaires focused on general health, musculoskeletal symptoms, psychosocial risk factors, workplace factors, and demographic information. Questions focusing on the frequency of lifting device use and reasons for not using devices were identified for analysis.

## 2.3 RESULTS

Fifty-one observation periods of nursing assistants were completed at baseline, 56 at the 3-month follow-up, 100 at the 12-month follow up, 88 at the 24-month follow-up, and 58 at the 36-month follow up. This resulted in a total of 98,903 observation moments with more than 15,000 observations at each survey period. Demographic information on the workers observed was compiled from the observers' coversheets (Table 2.1).

**Table 2.1: Population Demographics**

| | Baseline | 3-Month | 12-Month | 24-Month | 36-Month |
|---|---|---|---|---|---|
| *Number of Observation Periods* | 81 | 69 | 135 | 103 | 58 |
| *Number of Observation Moments* | 15,185 | 16,031 | 25,472 | 24,652 | 17,563 |
| *Gender (% Female)* | 81% | 85% | 95% | 95% | 93% |
| *Mean Tenure (years)* | 5 20 | 4 86 | 4 71 | 4 61 | 4 50 |
| *Job Titles* | | | | | |
| GNA/CNA | 74% | 81% | 74% | 85% | 98% |
| CMA | 4% | 7% | 9% | 1% | 0% |
| LPN | 11% | 9% | 16% | 11% | 0% |
| RN | 5% | 3% | 1% | 3% | 2% |
| Other | 6% | 0% | 0% | 0% | 0% |
| *Race* | | | | | |
| White | 27% | 40% | 35% | 33% | 43% |
| Black | 70% | 60% | 60% | 57% | 30% |
| Latino | 0% | 0% | 5% | 7% | 23% |
| Asian | 3% | 0% | 0% | 3% | 3% |
| *% Hispanic* | 0% | 0% | 6% | 8% | 23% |

### 2.3.1 Baseline Activities and Ergonomic Exposures

Resident handling activities most frequently occurred during direct care tasks such as bathing or grooming, dressing or undressing, and toileting. More of these tasks were performed during the first shift (7:00 am to 3:00 pm) than in the second or third shifts. At baseline, CNAs and GNAs were observed performing more resident handling activities (13.8% of total observations) than CMAs (6.9%), LPNs (2.4%), and RNs (0.3%). RNs were not discussed further in this paper due to sparse data.

Baseline trunk postures while resident handling were compared among LPNs, nursing assistants, and nursing assistants while handling residents (Figure 2.1). It is clear that nursing assistants work in more severe trunk angles (flexion, lateral bent and twisted postures) than LPNs, especially when they are completing resident handling. LPNs were observed working with a neutral trunk about 75% of the time.

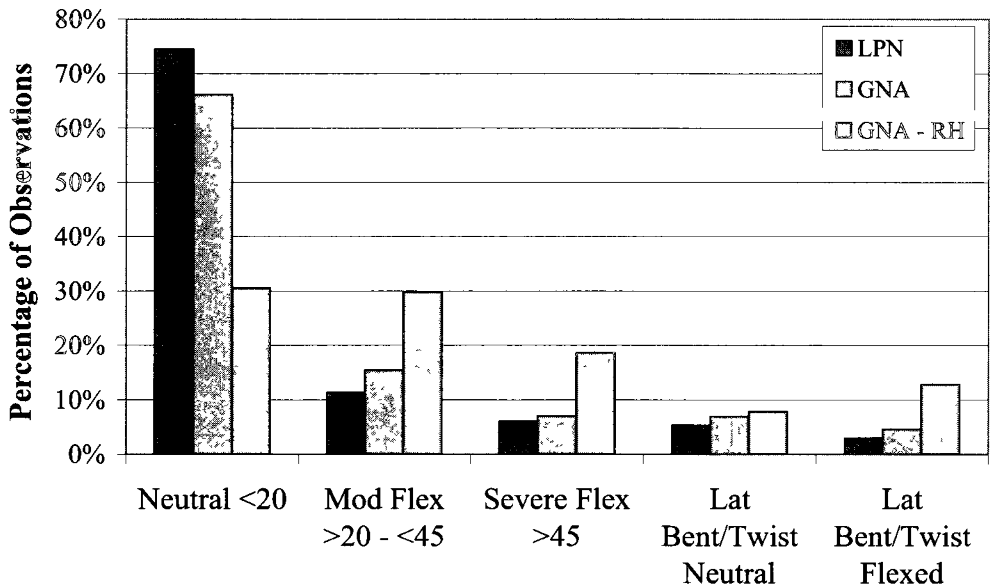


**Figure 2.1: Baseline Trunk Angle for Observations of LPNs and Nursing Assistants**

Nursing assistants, especially while handling residents, were more often observed in static standing than LPNs, who were more likely to use dynamic leg actions (e.g., walking). Additionally, nursing assistants, particularly while handling residents, worked with at least one arm raised above 60 degrees more often than did LPNs, who spent more time with both arms below 60 degrees. Nursing assistants were also observed performing more manual handling of heavier loads (greater than ten pounds), both with a neutral and a flexed trunk, than LPNs.

### 2.3.2 Resident Handling and Equipment Use after SRHP Implementation

At each time period, between 50 and 60% of observations were collected at times of the day when participants were performing 'heavy' work. At the 36 month follow-up, the proportion of resident handling activities decreased. The proportion of resident handling observations in which equipment was used increased from 9.9% to 32.1%. The proportion of resident handling observations with a neutral trunk posture increased from 30.5% to 66.7%, while the proportion in severe flexion, twisted or laterally bent postures decreased from 39.4% to 18.3%.

The percentage of time that nursing assistants were observed performing resident handling activities decreased substantially two years after the program began, but by the end of three years the percentage of time had increased slightly ($p < 0.001$ test of overall trend) (Figure 2.2). There was a substantial increase in the frequency of using any resident handling equipment over the three-year follow-up ($p < 0.001$) (Figure 2.3).

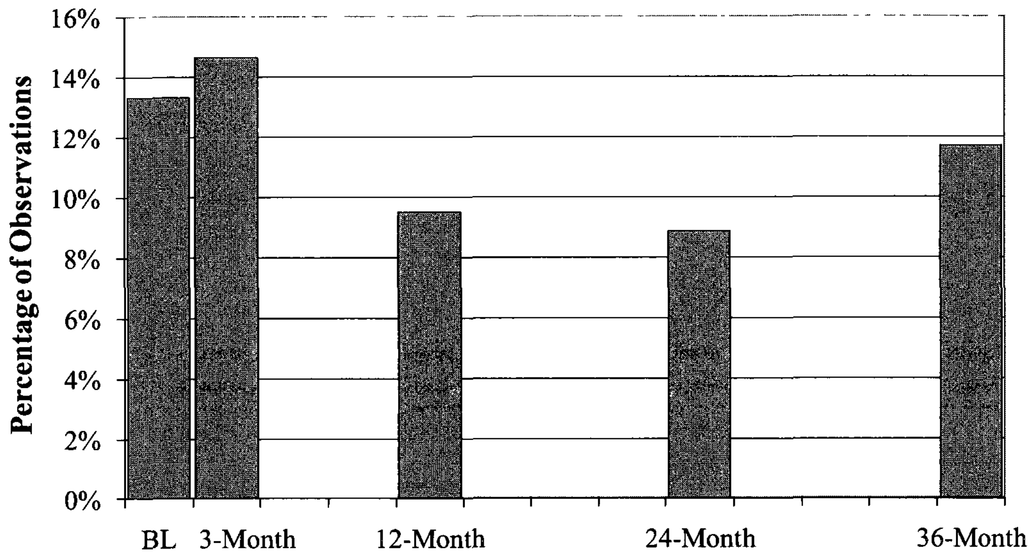


**Figure 2.2: Frequency of Resident Handling*†**

* Resident Handling includes manual and mechanically assisted Ambulation Assist, Reposition, Transfer and Transport

† $p < 0.001$ (Cochran-Armitage test of trend)

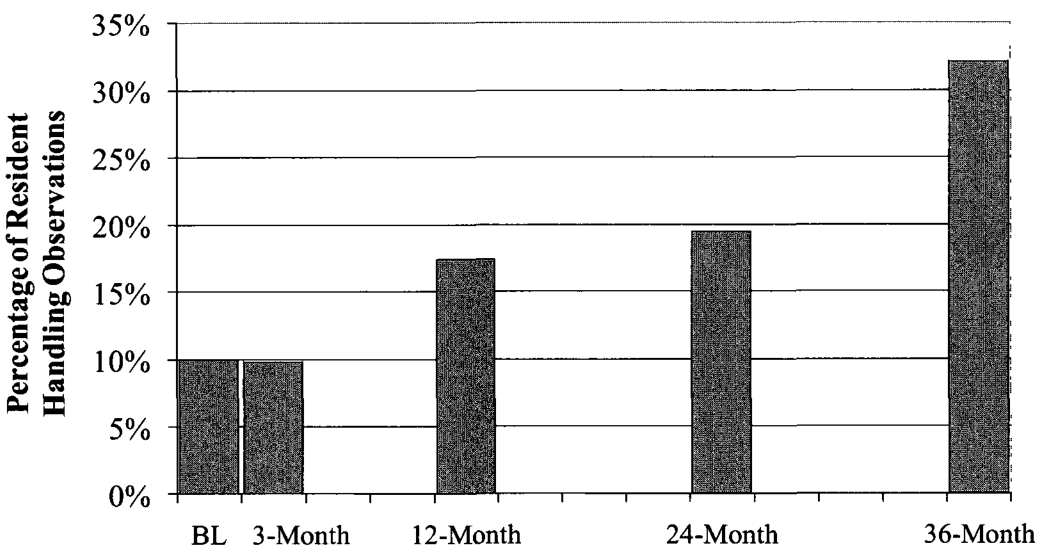


**Figure 2.3: Equipment Use* While Resident Handling† ††**

* Equipment: Total Body Lift, Sit-Stand Lift, Sling, Slideboard, Slipsheet, & Gait-belt

† Resident Handling includes manual and mechanically assisted Ambulation Assist, Reposition, Transfer and Transport

†† $p < 0.001$ (Cochran-Armitage test of trend)

Within resident handling activities, repositioning and transferring were of particular interest because they require more physical effort than assisting with ambulation or transporting residents in wheelchairs, which also do not require the use of (or benefit from) lifting equipment. The percentage of work time observed repositioning decreased from 9.3% at baseline to 3.4% at the 36-month follow-up (p < 0.001), while the percentage of time observed transferring (manual or mechanically assisted) remained about the same for two years then increased at the 36-month follow-up (Figure 2.4).

The frequency with which aides were observed in the task 'Retrieve/Replace Equipment' was examined. The percentage of time spent performing this task decreased by the end of the 36-month follow-up (Fıgure 2.4).

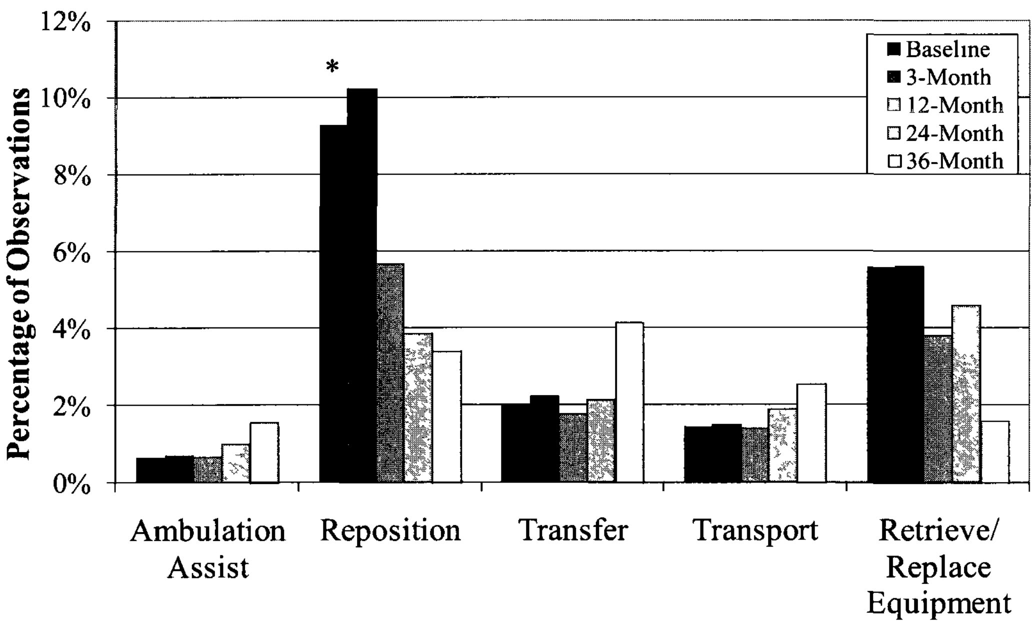


**Figure 2.4: Frequency of Resident Handling Activities**

* p < 0.001 (Cochran-Armitage test of trend)

The extent of equipment usage while repositioning and transferring increased over time (both p-values < 0.001); this trend was more pronounced for transfers (Figure 2.5).

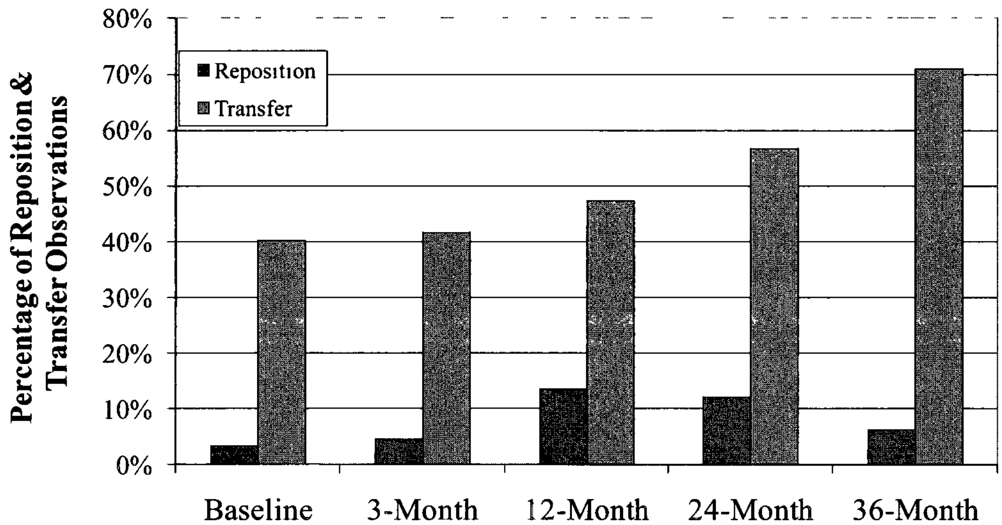


**Figure 2.5: Equipment Use* While Repositioning† and Transferring†**

* Equipment includes Total Body Lifts, Sit-Stand Lifts, Slings, Slideboards, Slipsheets, and Gaitbelts
† p < 0.001 (Cochran-Armitage test of trend)

At this survey period, handling equipment was used for about 57% of the transferring observations and about 12% of the repositioning observations. At the 24-month follow-up, the healthcare workers' questionnaire responses indicated that about two-thirds of the population 'often' or 'always' used patient lifting devices. Some of the main reasons given on the questionnaire for not using equipment every time it was needed were 'device unavailable when needed (25.4%),' 'residents dislike them (13.8%),' 'I feel I don't need them (13.6%),' 'not enough time (7%),' 'too much extra effort (5%),' and 'my co-workers don't use them (4.4%)' (responses not mutually exclusive). When asked to report additional reasons why lifting equipment is not always used, the most commonly reported answers included 'some residents do not require lifts,' 'it is not part of my job,' 'there are not enough staff,' and 'someone else is using it.'

Weight in hands while repositioning and transferring was also examined (Figure 2.6). While the middle weight in hands category of ten to fifty pounds only decreased at 36 months, there was an observed decrease ($p < 0.001$) in the amount of time spent handling loads greater than fifty pounds, from 10% to 2.2% of the repositioning and transferring observations. This corresponded to an increase in the lowest weight category of less than ten pounds. A similar pattern was observed when repositioning and transferring observations were examined separately (data not shown).

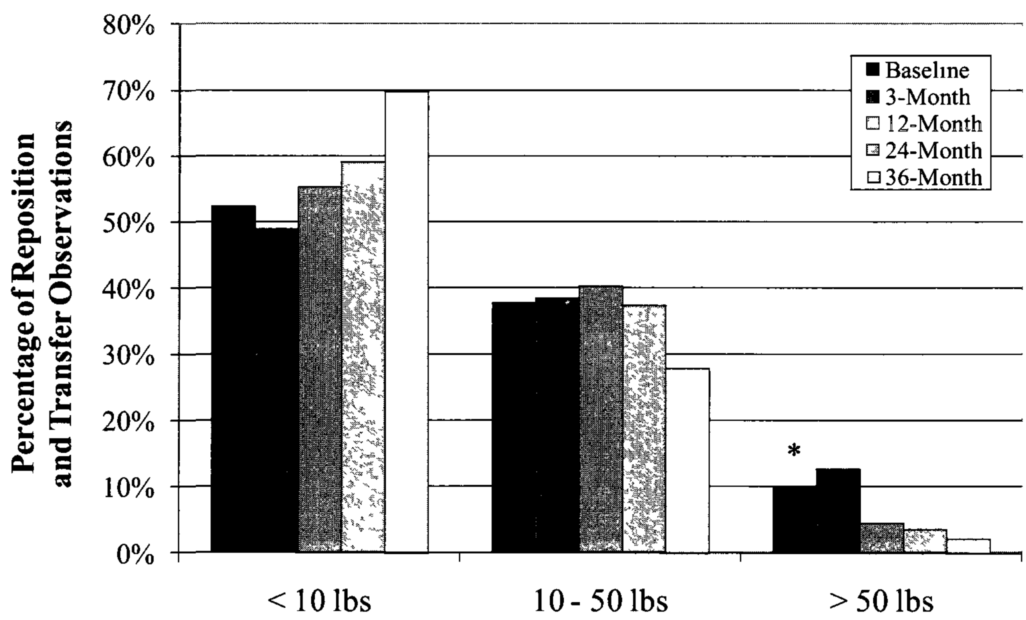


**Figure 2.6: Weight in Hands While Repositioning and Transferring**

* $p < 0.001$ (Cochran-Armitage test of trend)

### 2.3.3 Changes in Body Postures after SRHP Implementation

There were considerable differences across the five time periods in body postures while resident handling. By the 36-month follow-up, the observed occurrence of neutral trunk postures increased from 30.5% to 66.7% ($p < 0.001$), while moderate and severe flexion as well as lateral bent and twisted trunk postures all declined (Figure 2.7).

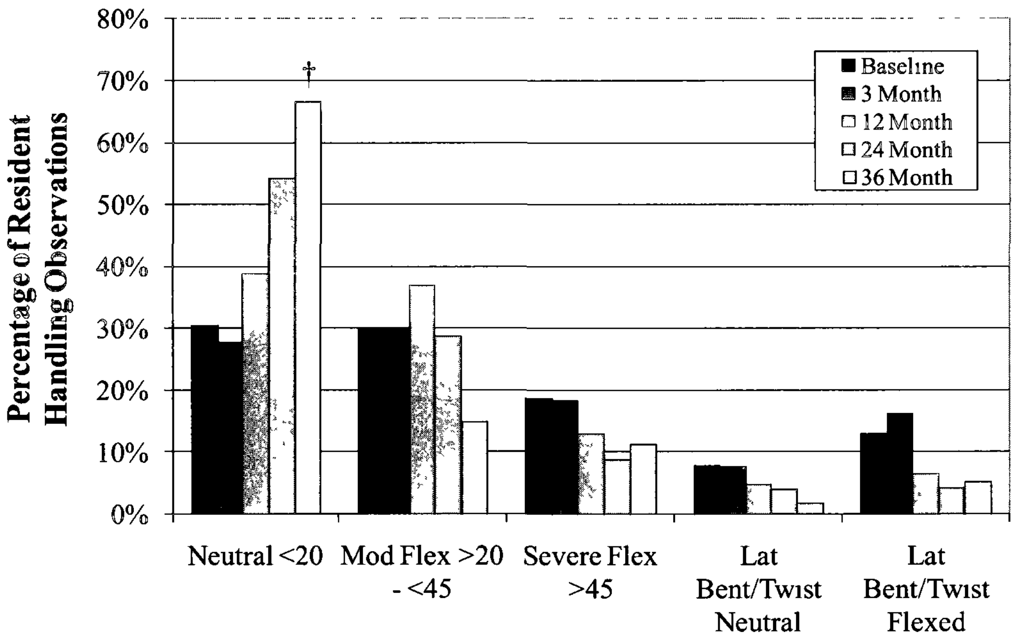


**Figure 2.7: Changes in Trunk Posture While Resident Handling***

* Resident Handling includes manual and mechanically assisted Ambulation Assist, Reposition, Transfer and Transport

† $p < 0.001$ (Cochran-Armitage test of trend)

After 36 months, nursing assistants were observed performing resident handling with both arms below 60 degrees about 75% of the time, compared to 38% at baseline, while the proportion of time spent working with one or both arms greater than 60 degrees decreased ($p < 0.001$) (Figure 2.8).

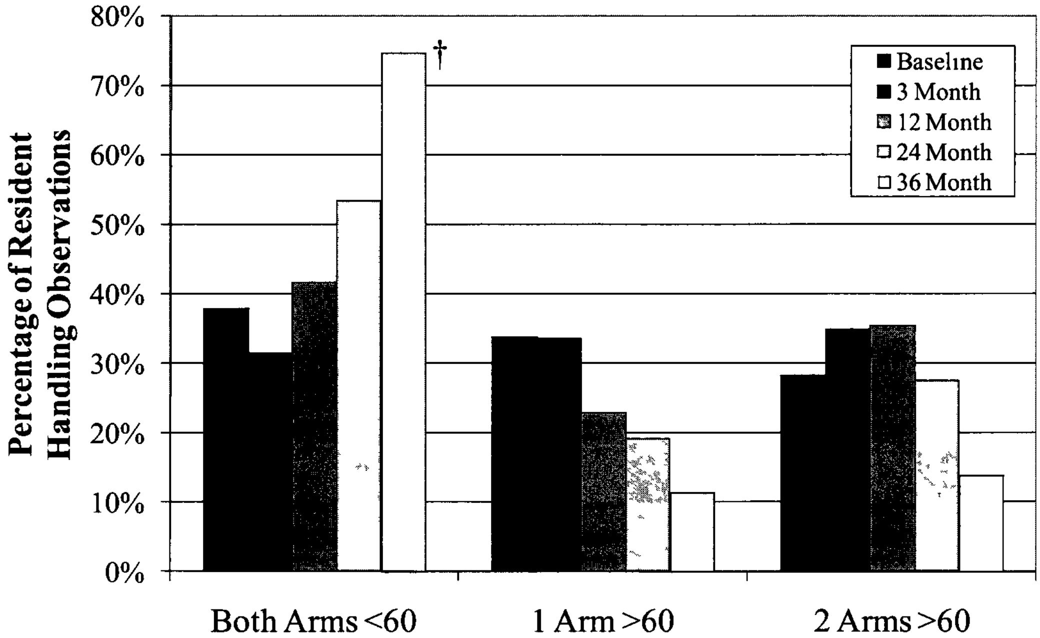


**Figure 2.8: Changes in Arm Angle While Resident Handling***

* Resident Handling includes manual and mechanically assisted Ambulation Assist, Reposition, Transfer and Transport

† $p < 0.001$ (Cochran-Armitage test of trend)

After 36 months, it was also observed that nursing assistants were standing still while resident handling 62.5% of the time compared to 81.3% of the time at baseline ($p<0.001$). This corresponded to a direct increase in dynamic leg action such as walking and running ($p<0.001$) (Figure 2.9).

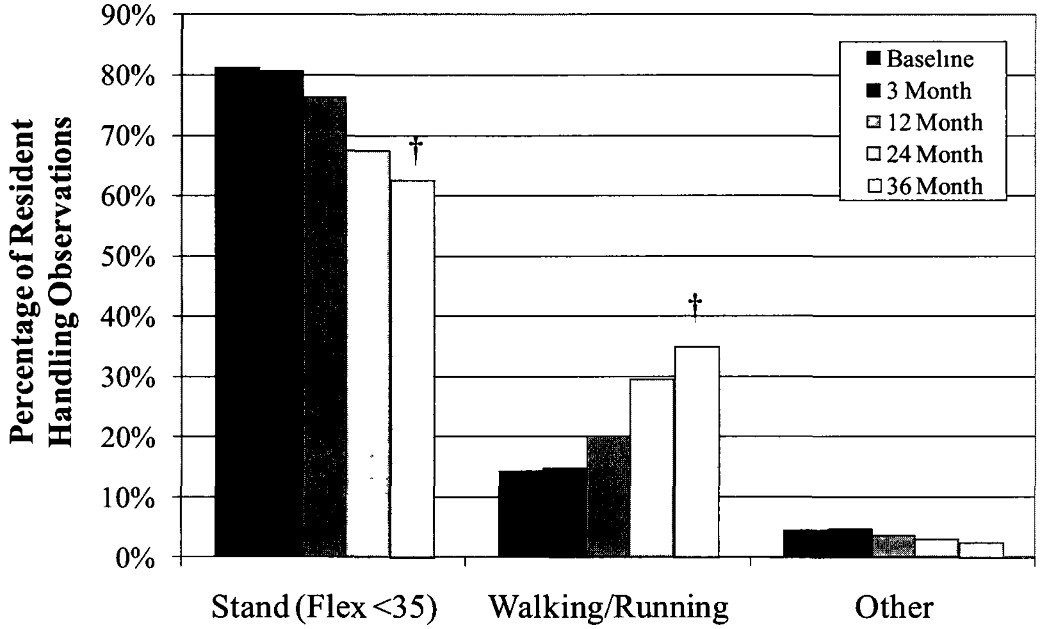


**Figure 2.9: Changes in Leg Action While Resident Handling***

* Resident Handling includes manual and mechanically assisted Ambulation Assist, Reposition, Transfer and Transport

† $p < 0.001$ (Cochran-Armitage test of trend)

## 2.4 DISCUSSION

Almost 99,000 observations from a convenience sample of nursing assistants demonstrated increased equipment use following a SRHP intervention, with improvements in resident handling activities and body postures. Three years of follow-up data were collected to allow enough time for changes in exposures to occur. Observations were made in a real-time work place setting with a method that generates percentages of work time spent in pre-determined postures, tasks and activities. Many favorable trends were observed among nursing assistants over three years: equipment use increased; time in resident handling activities decreased (specifically repositioning in the bed or wheelchair); and work was performed with more neutral trunk postures, fewer flexed, lateral bent, or twisted trunk postures, less static standing and more dynamic leg action, and more often with both arms below 60 degrees. Because 50 to 60% of the observations at each time period were collected while nursing assistants perforemed 'heavy' work, this suggests that changes in resident handling activities, equipment use, and postures were not related to the time of day the observations were made.

Nursing assistants were sometimes observed to walk while transferring residents in lifts. Once a resident is raised using a total body lift, the nursing assistant usually has to walk for a short time while pushing the lift in order to position a resident over a wheelchair, commode, or bed. Without the lifting equipment, the nursing assistant would typically transfer a resident while in a standing or shallow squat position. Additionally, nursing assistants are most likely standing in a neutral trunk position while using lifts to transfer residents. The quantitative results indicate that the use of mechanical lifts reduced the need for nursing assistants to work in stressful body postures during resident handling.

Although the observational method used in this study does not output a total measure of mechanical load on the body, the postural analyses demonstrated an increase in neutral trunk posture and decreases in more severely flexed, bent, and twisted postures while resident handling. Additionally, an increase in time observed with the arms lower than 60 degrees was noted after the 24-month follow-up. Neutral postures, such as those observed following the SRHP, minimize loading on the body, including the lumbar spine and shoulders. Nursing assistants were also observed lifting loads less than 10 pounds more frequently and loads greater than 50 pounds less frequently. It is reasonable to assume that the effect of the SRHP on non-neutral postures and lifting led in turn to lower forces on the spine and shoulders. Several laboratory studies have evaluated the load on the body resulting from patient handling tasks and demonstrated the reductions in biomechanical stress on the caregiver that can be achieved with use of mechanical lift devices (Nelson, 2003b; Garg, 1992 (a,b); Zhuang, 1999).

A major finding of this study showed that after three years, nursing assistants use lifting equipment more than 50% of the time while transferring. However, lifting equipment was used only about 12% of the time while repositioning after two years and 6% of the time after three. While this is an increase from about three percent at baseline, this data may indicate that there are some gaps in the current training at the centers. Because nursing assistants use equipment more often for transfers than repositions, they may feel that the use of equipment while transferring is more important than the use of equipment for repositioning. However, handling equipment purchased as part of the

SRHP included slide boards and slipsheets in addition to the lifting equipment. These devices are inexpensive, available at the facilities, and are designed to help reduce stress on the body while performing repositioning.

Results from the 24-month healthcare workers' questionnaire indicated that two-thirds of nursing assistants use resident handling equipment often or always, while results from the observational assessment indicated that equipment was used for about 57% of transfers. The difference in self-reported and observed equipment use may have related to workers' responses for reasons equipment was not used including unavailability of devices, residents' dislike of the equipment, the perception that the devices were not necessary, and not having enough time. The difference may also be due to nursing assistants' perceptions of the necessity of using equipment on the basis of individual resident acuity.

A 2003 study by Nelson (2003b) evaluated interventions in patient handling tasks, and also reported some reasons why patient lifts were not used, such as, "extra time required, lack of accessibility or availability, and difficulty using and storing." These reasons are similar to the major reasons nursing assistants reported for not using equipment in this study.

Retrieval of necessary equipment for performing resident handling has been reported by others as one reason contributing to the perceived increase in time for performing mechanically assisted lifting. However, in this study the amount of time spent retrieving and replacing equipment declined over time.

### 2.4.1 Limitations and Strengths of This Study

One of the main limitations of this study is related to the population of ergonomic observations. The data consists of a convenience sample focusing on nursing assistants. Due to facility access limitations and the difficulties experienced in gaining consent from individuals within the study population, this selection process was the only method used in this study, though the research team made a concerted effort to recruit nursing employees across the full range of units, patient populations, and seniority levels in each facility. A random sample of individuals might have better ensured a representative population. However, the demographics of observed workers corresponded fairly well to the total study population and a large sample of observation moments was collected at each time period, which helped provide an extensive exposure profile for nursing assistants. Additionally, an attempt to observe the same workers on follow-up visits was made, to standardize for any possible differences in work technique.

Another weakness is the possibility for the "Hawthorne effect," which occurs when employees who are being observed work differently simply because they are being observed. While this could not be ruled out, it is unlikely that it could explain away the exposure trends observed in this study. Overall, it was observed that resident handling equipment was used frequently at the study facilities, including by employees who were not under formal observation. Furthermore, lifting equipment was not always used for every transfer. In addition, the frequency of observed equipment usage while resident handling was actually lower than the nursing assistants' self-reported usage during resident handling activities. This suggests that the Hawthorne effect probably did not play a significant role in the observed changes, because it would presumably have produced a bias in the direction of more usage, rather than less, and more so among workers whose activities were being recorded. In addition, it seems unlikely that workers could have known to adjust their body postures, or to do so intentionally, purely as an artifact of being observed.

The load weight categories of 'ten to 50 pounds' and 'greater than 50 pounds' are wide intervals for manual handling and may result in loss of sensitivity to real changes in weight in hands in the workplace. However, the way the categories were defined made it easier for observers to visually judge manual handling activities in a timely manner, since data were collected at 60 second intervals.

It is possible that some misclassification of exposures was made due to observer error. Observer error may result from the boundary lines of postures, such as that between moderate and severe flexion. However, as part of the protocol, observers were trained to underestimate postures in the case of boundary line uncertainty. Additionally, all observers attained IRR consisting of a minimum of 80% agreement and kappa scores of at least 0.6 in all variable categories prior to officially collecting data for the study. By ensuring high IRR for all observers, the amount of random and systematic error in the recording of observational data was limited and probably would not have affected internal comparisons.

## 2.5 CONCLUSIONS AND RECOMMENDATIONS

Many SRHP interventions in healthcare have focused on nurses in hospitals; fewer studies have examined the long-term care sector. Since nursing assistants perform the majority of the resident handling in nursing homes, they stand to benefit the most from this type of intervention. This study demonstrated decreased time spent manually handling residents, increased neutral trunk postures while transferring and repositioning, decreased flexed, twisted, and laterally bent postures while transferring and repositioning, and decreased lifting of loads greater than fifty pounds three years following the intervention.

Most SRHP intervention studies have reported findings based on questionnaire responses or administrative data such as injury rates and workers' compensation claims. Future analyses examining injury rates and workers' compensation claims at the centers should provide a more descriptive picture of the overall benefits from the increased use of resident handling equipment.

Analyses in this study also suggest the need for additional training in the centers on other types of handling equipment aside from total body lifts and sit-stand lifts. Slide boards and slipsheets are useful tools for eliminating stress on the body during lateral repositions. Considering that repositioning activities occur about twice as often as transferring activities, nursing assistants could benefit from increased usage of these devices.

Several states have passed safe patient handling legislation in recent years. Although this is a step in the right direction, the laws are not comprehensive enough to adequately protect all healthcare workers. Some of these laws cover hospitals only, and most do not have a detailed plan for purchasing and maintaining handling equipment. Results from this intervention demonstrate benefits to nursing assistants in nursing homes in terms of reduced postural and manual handling loads resulting from increased use of handling equipment. In 2009, a bill was introduced in the Senate and House of Representatives directing the Secretary of Labor to issue an occupational health and safety standard to reduce injuries to healthcare workers involved in patient handling tasks. If passed, the standard would protect workers in all types of healthcare facilities by requiring the purchase, use, and maintenance of handling equipment. Programs such as the SRHP evaluated in this study would be required to ensure maximum health and safety benefits to all healthcare workers.

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# CHAPTER III: A PHYSICAL WORKLOAD INDEX TO EVALUATE A SAFE RESIDENT HANDLING PROGRAM FOR CLINICAL STAFF IN NURSING HOMES

## 3.1 INTRODUCTION

Manual resident handling performed by healthcare workers in nursing homes leads to increased lumbar loading, resulting in musculoskeletal disorders including low-back injuries. According to the Centers for Disease Control and Prevention's National Nursing Home Survey of 2004-2005, the second leading cause of injuries to nursing assistants was back injuries (Jones, 2009). Physical exposures for nursing assistants, particularly those in nursing homes, often far exceed those of registered nurses (RNs) and licensed practical nurses (LPNs) (Boyer, 2008). Nursing assistants perform the majority of direct care in nursing homes, which results in physical exposures including trunk flexion and heavy manual handling which may increase their rates of work-related low-back injuries.

A 1998 review of 42 studies on low back pain among nursing jobs reported relationships between low-back pain and physical stressors such as lifts, transfers, 'save the patient' situations, awkward work postures, static standing, and working as a nursing assistant as opposed to a registered nurse (Lagerström, 1998). A major finding of this review was that, in nursing homes, nursing assistants had a higher prevalence of work-related low back problems than nurses, and that higher physical exposures likely played a role.

### 3.1.1 Biomechanical Assessment of Clinical Work

Biomechanical modeling can be a useful method for examining a set of categorical exposures and is often valuable for examining the effects of multiple exposures. Modeling of the low back has been used in laboratory settings to examine ergonomic exposures such as the physical workload of healthcare workers through the use of static and dynamic models that incorporate patient care tasks including transferring and repositioning with and without the use of mechanical lifting equipment (Marras, 1999; Skotte, 2002; Garg, 1992a; Garg, 1992b; Zhuang, 1999). Compressive forces on the lumbar spine are typically used as measures of biomechanical loading.

A German study of nursing home workers reported on construction of an index of physical workload (Klimmer, Hollmann et al., 1998). A total of 610 nursing home employees (physical care, psychosocial care, and housekeeping) were asked to complete a questionnaire regarding physical exposures at work, and the frequencies of postures and manual handling were self-reported using a five-point Likert scale ranging from 'never' to 'very often' (Appendix C). A biomechanical model of lumbar loading on the L5/S1 disc (Jager, 1991) was used to develop weighting factors for each of fifteen postures and manual handling activities (Appendix D). The weights used in the index were computed by subtracting the standard compressive force of the spine from the compressive force of the spine in the specified posture. Standard compressive forces were assigned to the four identified postures (neutral trunk, standing, sitting, and both arms below shoulder height) which resulted in the lowest calculated compressive forces on L5/S1. The weighted frequencies were then combined for an overall estimate of lumbar load for each job group.

A follow-up validation study of 455 of the original employees in physical care/nursing, services jobs, social work, and management was also conducted (Hollmann, Klimmer et al., 1999). Both studies found that nursing staff had the highest index of physical workload compared to the other occupations. Musculoskeletal symptoms on the questionnaire were found to be significantly related to the index of physical workload.

Klimmer revisited the 1998 study of nursing home workers in 2005, comparing the index to another self-reported measure of physical workload on the same population of workers. In 2006, Janowitz et al. modified the index for use as part of an ergonomics assessment tool for hospitals, and in 2008, Nabe-Nielsen et al. used the index as part of a hospital questionnaire comparing two self-reported measures of work demands. In all of these studies, the inputs for frequency of postures and manual handling activities were self-reported information.

Hollmann's conclusions recommended further testing of the index using data on physical workload such as that garnered by observational methods, and a response to the study suggested that "…these approaches, based on self-reported data, can only yield rather crude estimates of biomechanical load (Burdorf, 1999)." Biomechanical evaluations of healthcare work are typically carried out in laboratory settings; however, modification of the index of physical workload using data that represents real-time workloads in an actual nursing home setting would be beneficial and would provide more insight into the actual physical workload of nursing assistants.

In this study, a nursing home corporation's Safe Resident Handling Program (SRHP) was evaluated using a biomechanical model to compute a physical workload index (PWI) for nursing assistants, based on the work of Klimmer and Hollmann. The model contained inputs reflecting the frequencies of postures and manual handling activities resulting from direct ergonomic observations collected using the PATH method (Buchholz, 1996), and biomechanical weighting factors that corresponded to the observational variables. The physical workload index was used to describe physical workload both overall and while performing resident handling. The physical workload of nursing assistants was compared to that of nurses (LPNs and RNs) both before and after an ergonomics intervention in the nursing homes where the work was observed.

## 3.2 METHODS

A large nursing home corporation introduced a SRHP that included resident assessment, the purchasing of resident handling equipment and training on its use, along with policies and procedures for equipment use and maintenance. This prospective study of ten of the nursing facilities included ergonomic observations of clinical nursing staff at baseline, 3-month, 12-month, 24-month, and 36-month follow-up periods. Ergonomic observations were collected on handheld PDAs by 12 observers, using a modification of the PATH method (Buchholz, 1996) that incorporated postures, resident handling activities, and resident handling equipment specific to healthcare workers' jobs. This direct observational method was used to collect information on ergonomic exposures at fixed 60 second intervals. Demographic information of the observed population of nurses and nursing assistants was collected on coversheets, which are standardized forms of supplemental data collected following ergonomic observations. Detailed descriptions of the intervention process and study design, ergonomic exposure assessment method, and data management, were reported on in Chapter II of this dissertation.

As described in the series of steps below, the PWI summed the contributions of compressive forces resulting from 17 combinations of postures and manual handling actions to the overall load on the L5/S1 joint. Each of the 17 terms in the index equation consisted of a weighting factor and a score. The index was calculated using Microsoft Excel at baseline, 3-month follow-up, 12-month follow-up, 24-month follow-up, and 36-month follow-up in order to evaluate the Safe Resident Handling intervention.

### 3.2.1 Weighting Factors

The posture/manual handling combinations were weighted by subtracting the standard compressive force of the spine from the compressive force of the spine at the given combination of posture and manual handling action. The University of Michigan's Three Dimensional Static Strength Prediction Program (3DSSPP) was utilized to determine the compressive forces on L5/S1 based on an average female with a height of 63.6 inches and a weight of 160.3 pounds. Body segments (trunk, arm, and leg) were positioned based on angles determined in the PATH healthcare workers template (Appendix A) to determine compressive forces on L5/S1. The standard compressive force was assigned to the neutral standing posture where arms were at the sides and no load was handled, which resulted in the lowest calculated compressive forces on the L5/S1 (55 pounds or 24.95 kilograms of compressive force).

### 3.2.2 Scores

Before summing the compressive forces resulting from the 17 model inputs, each was first multiplied by a scoring factor. A scoring method was developed to reflect actual frequencies of PATH variables collected over the first shift (7:00 am to 3:00 pm) at nursing homes. The observed frequencies of variables, determined using SAS 9.2, were placed on a continuous scale from 0 to 1. An example of the scoring method for trunk posture is in Table 3.1.

**Table 3.1: Example of Scoring Method for Trunk Posture**

| Nursing Assistant Trunk Posture While Resident Handling (Baseline) | Frequency of Resident Handling Observations | New Trunk Posture Score |
|---|---|---|
| Neutral (< 20°) | 30.50% | 0.305 |
| Moderate Flexion (> 20° - < 45°) | 29.80% | 0.298 |
| Severe Flex (> 45°) | 18.70% | 0.187 |
| Lateral Bent/Twist (Trunk Neutral) | 7.80% | 0.078 |
| Lateral Bent/Twist (Trunk Flexed > 20°) | 12.90% | 0.129 |

### 3.2.3 Posture and Manual Handling Inputs

The PATH method for collecting ergonomic observations resulted in 18 categorical variables relating to exposures including trunk, arm, and leg postures, as well as manual handling (Tables 2-5). Each model input is identified with an alpha-numeric abbreviation. The weight in hands categories for manual handling actions were used to create two inputs each. Weights carried with an upright or neutral trunk are identified by Wu1 – Wu3, and weights carried with an inclined or flexed trunk are identified by Wi1 – Wi3.

**Table 3.2: Trunk Postures**

| Model Input | Postures From PATH Method |
|---|---|
| T1 | Neutral (Trunk Flexed < 20°) |
| T2 | Moderate Flexion (Trunk Flexed ≥ 20° to < 45°) |
| T3 | Severe Flexion (Trunk Flexed ≥ 45°) |
| T4 | Lateral Bent/Twisted - Neutral (Trunk Flexed < 20°) |
| T5 | Lateral Bent/Twisted - Flexed (Trunk Flexed ≥ 20°) |

**Table 3.3: Arm Postures**

| Model Input | Postures From PATH Method |
|---|---|
| A1 | Both Arms < 60° |
| A2 | 1 Arm Raised ≥ 60° |
| A3 | 2 Arms Raised ≥ 60° |

**Table 3.4: Leg Postures**

| Model Input | Postures From PATH Method |
|---|---|
| L1 | Sitting |
| L2 | Standing |
| L3 | Shallow Squat (Knees Bent > 35° to < 80°) |
| L4 | Kneeling (One or Both Knees) |
| L5 | Walking |
| L6 | Deep Squat (Knees Bent ≥ 80°) |
| L7 | Lunge (1 Knee Bent > 35°) |

**Table 3.5: Manual Handling Actions**

| Model Input | Manual Handling From PATH Method |
|---|---|
| Wu1/Wi1 | < 10 Pounds (< 4 55 Kilograms) |
| Wu1/Wi2 | ≥ 10 Pounds to ≤ 50 Pounds (≥ 4 55 to ≤ 22 68 |
| Wu1/Wi3 | > 50 Pounds (> 22 68 Kilograms) |

Midpoints of body angles and weight in hands were used as inputs in the 3DSSPP. For example, moderate trunk flexion in the PATH template refers to the range from 20° to 45° of forward flexion. In this case, an angle of 32.5° of forward flexion was used to calculate the compressive force on the L5/S1 joint. The midpoints of the loads handled were distributed bilaterally in the 3DSSP program. For the trunk postures severe flexion and lateral bent/twist flexed, upper endpoints were not specified in the PATH template. In some instances, observers in the field witnessed extreme forward flexion (up to 120°); thus midpoints were calculated based on this endpoint.

The postures in the PATH template are associated with specific body angles, except for standing, sitting, and walking. Neutral standing and sitting were included in the 3DSSPP's pre-set postures feature. For the walking posture, hip flexion-extension angles and knee flexion-extension angles were determined by consulting literature on human gait analysis (Kadaba, et al. 1989). Hip and knee angles were interpolated from a figure (Appendix E) depicting an average six-meter gait cycle for 40 healthy subjects. Angles representing 20%, 40%, 60%, 80%, and 100% of the gait cycle were included in the 3DSSPP analysis. Additionally, several postures included multiple possibilities for observational classification including 'Lateral Bent or Twisted – Neutral,' 'Lateral Bent or Twisted – Flexed,' and 'Kneeling (One or Both Knees).' In these cases, each posture option was entered into the 3DSSPP, and the compressive forces on L5/S1 were averaged. Body segment angles and weight in hands inputs for the 3DSSPP calculations are contained in Appendix F.

The weight in hands category, 'less than ten pounds,' includes observations where manual handling did not take place. A large portion of the observations of all job titles fall into this category. In order to consider the percentage of time where no load was handled, PATH tasks (direct care tasks, medical tasks, administrative tasks, and other tasks) were stratified by job title and those with weight in hands less than ten pounds were identified. Based on observer knowledge of the tasks, it was determined that when 'less than ten pounds' was coded for weight in hands it was likely that no load at all was being handled during the following tasks: diligent watch, feeding, resident/family counsel, give meds, med prep/mix, other medical, vital signs, computer, meet/train, other admin, paper, phone, break, and universal precaution. The frequency of observations with no load in the hands was much higher for nurses than for nursing assistants, and for nursing assistants no load in the hands occurred more frequently when the trunk was in neutral posture than ın flexıon (Tables 3.6 and 3.7).

**Table 3.6: Percentage of Observations with No Load Handled (Neutral Trunk)**

| Neutral Trunk | % Observations Where Load is Likely 0 lbs | | | | |
|---|---|---|---|---|---|
| | Baseline | 3-Month | 12-Month | 24-Month | 36-Month |
| Nursing Assistant | 40 54% | 43 47% | 47 02% | 43 92% | 61 78% |
| Nursing Assistant - RH | 2 64% | 3 45% | 3 67% | 1 38% | 0 75% |
| Nurse | 91 13% | 87 30% | 87 81% | 88 44% | 93 44% |

**Table 3.7: Percentage of Observations with No Load Handled (Flexed Trunk)**

| Flexed Trunk | % Observations Where Load is Likely 0 lbs | | | | |
|---|---|---|---|---|---|
| | Baseline | 3-Month | 12-Month | 24-Month | 36-Month |
| Nursing Assistant | 26 09% | 17 09% | 18 79% | 17 10% | 22 87% |
| Nursing Assistant - RH | 1 55% | 8 94% | 2 11% | 2.78% | 0 30% |
| Nurse | 90.45% | 67 43% | 78 71% | 79 05% | 90 91% |

The compressive forces on L5/S1 for the Wu1 and Wi1 inputs were calculated for neutral and flexed trunks with no load handled and with a five pound load handled, which is the midpoint of 'less than ten pounds.' The compressive forces were then weighted according to the percentage of observations where no load was handled.

Following the design of the existing index, four postures (neutral trunk, standing, sitting, and both arms below 60°) with low compressive forces on the L5/S1 were omitted from the model. Postures retained in the final model include T2 – T5, A2 – A3, and L3 – L7. The weighted compressive forces were converted from pounds to kiloNewtons for model inputs. The final equation used for calculating the PWI was as follows:

$$\text{PWI} = \sum_{i=2}^{5} W_{Ti} * S_{Ti} + \sum_{j=2}^{3} W_{Aj} * S_{Aj} + \sum_{k=3}^{7} W_{Lk} * S_{Lk} + \sum_{l=1}^{3} W_{Wul} * S_{Wul} + \sum_{m=1}^{3} W_{Wim} * S_{Wim}$$

The PWI was calculated for nursing assistants using both the total number of observations and also with observations restricted to resident handling observations only. Because LPNs and RNs were witnessed performing resident handling activities for less than 3% of the collected observations, data for these job titles were pooled to create a PWI for nurses.

## 3.3 RESULTS

For all time periods, the observed population predominantly consisted of female nursing assistants. In general, nurses were more often White than nursing assistants, and a larger proportion of nursing assistants were of Hispanic ethnicity compared to nurses (Table 3.8).

**Table 3.8: Population Demographics**

| | Baseline | 3-Month | 12-Month | 24-Month | 36-Month |
|---|---|---|---|---|---|
| *Number of Observation Periods* | | | | | |
| Nursing Assistant | 60 | 56 | 100 | 88 | 57 |
| Nurse | 13 | 8 | 23 | 14 | 1 |
| *Number of Observation Moments* | | | | | |
| Nursing Assistant | 11,408 | 8,474 | 17,738 | 21,141 | 17,365 |
| Nursing Assistant (Resident Handling) | 1,473 | 1,252 | 1,604 | 1,823 | 1,933 |
| Nurse | 1,160 | 1,846 | 2,841 | 2,624 | 178 |
| *Sex (% Female)* | | | | | |
| Nursing Assistant | 75% | 84% | 94% | 94% | 93% |
| Nurse | 100% | 88% | 96% | 100% | 100% |
| *Mean Tenure (years)* | | | | | |
| Nursing Assistant | 4.75 | 4.24 | 4.00 | 4.45 | 4.50 |
| Nurse | 6.44 | 4.22 | 6.11 | 3.03 | 4.00 |
| *Race/Ethnicity* | | | | | |
| Nursing Assistant | | | | | |
| White | 31% | 39% | 27% | 30% | 40% |
| Black | 69% | 61% | 66% | 61% | 32% |
| Asian | 0% | 0% | 0% | 2% | 3% |
| Latino | 0% | 0% | 7% | 7% | 25% |
| Hispanic | 0% | 0% | 8% | 8% | 25% |
| Nurse | | | | | |
| White | 38% | 63% | 78% | 57% | 100% |
| Black | 62% | 38% | 22% | 29% | 0% |
| Asian | 0% | 0% | 0% | 7% | 0% |
| Latino | 0% | 0% | 0% | 7% | 0% |
| Hispanic | 0% | 0% | 0% | 7% | 0% |

### 3.3.1 Weighting Factors

The compressive forces on L5/S1 for the weighting factors in the index were computed using the 3DSSPP (Tables 9-13).

**Table 3.9: Compressive Forces on L5/S1 and Weighting Factors Resulting from Trunk Postures**

| Input | Trunk Angle | Definition | Midpoint Angle | Compressive Force on L5/S1 (lbs) | Average Force (lbs) | Weighting Factor |
|---|---|---|---|---|---|---|
| T2 | Moderate Flexion | 20°- 45° | 32 5° | 316 | - | 1 16 |
| T3 | Severe Flexion | > 45° | 82 5° * | 444 | - | 1 73 |
| T4 | Lateral Bent/ Twist Neutral ** | 20° bent or 45° twist | - | 140 † | 144.5 | 0 40 |
| | | | - | 149 †† | | |
| T5 | Lateral Bent/ Twist Flexed | > 20° flexed and 20° bent | 70° § | 440 † | 441.0 | 1 72 |
| | | | | 442 †† | | |

* 82.5° is the midpoint between 45° and 120°
** Flexion midpoint is 10° (between 0° & 20°)
† 20° of lateral bending
†† 45° of axial rotation
§ 70° is the midpoint between 20° and 120°

**Table 3.10: Compressive Forces on L5/S1 and Weighting Factors Resulting from Arm Postures**

| Input | Arm Angle | Definition | Midpoint Angle | Compressive Force on L5/S1 (lbs) | Weighting Factor |
|---|---|---|---|---|---|
| A2 | 1 Arms > 60° | > 60° | 120° * | 90 | 0 16 |
| A3 | 2 Arms > 60° | > 60° | 120° * | 125 | 0 31 |

* 120° is the midpoint between 60° & 180°

**Table 3.11: Compressive Forces on L5/S1 and Weighting Factors Resulting from Leg Postures**

| Input | Leg Action | Definition | Midpoint or Interpolated Angles | Compressive Force on L5/S1 (lbs) | Average Force (lbs) |
|---|---|---|---|---|---|
| L3 | Shallow Squat | 35°- 80° | 57 5° | 58 | - |
| L4 | Kneeling | 1 Knee | - | 61 | 61 |
| | | 2 Knees | - | 61 | |
| L5 | Walking/ Running | 20% Gait Cylce | 17° (Hip), 14° (Knee) † | 56 | 70 |
| | | 40% Gait Cylce | -6° (Hip), 5° (Knee) † | 73 | |
| | | 60% Gait Cylce | -4° (Hip), 39° (Knee) † | 74 | |
| | | 80% Gait Cylce | 27° (Hip), 36° (Knee) † | 73 | |
| | | 100% Gait Cylce | 31° (Hip), 5° (Knee) † | 74 | |
| L6 | Deep Squat | > 80° | 85° †† | 80 | - |
| L7 | Lunge | 35°- 90° | 67 5° | 56 | - |

* Input angles for knee on ground
† Hip and knee angles were interpolated from a publication reporting on human gait (Kadaba, 1989)
†† 85° is the midpoint between 80° & 90°

**Table 3.12: Compressive Forces on L5/S1 and Weighting Factors Resulting from Lifting Loads with an Upright Trunk**

| Input | Weight in Hands With Upright Trunk | Definition | Midpoint Weight | Compressive Force on L5/S1 (lbs) | Weighting Factor |
|---|---|---|---|---|---|
| Wu1 | Less Than 10 Pounds | 0-10 lbs | 5 Pounds (2 5 lbs/hand) | 159 | 0 44 * |
| | | | | | 0 46 † |
| | | | | | 0 42 †† |
| Wu2 | 10 to 50 Pounds | 10-50 lbs | 30 Pounds (15 lbs/hand) | 210 | 0 69 |
| Wu3 | Greater Than 50 Pounds | 50-150 lbs | 100 Pounds (50 lbs/hand) | 353 | 1 33 |

* Range of weighting factors for 5 time points for nursing assistants
† Range of weighting factors for 5 time points for nursing assistants while resident handling
†† Range of weighting factors for 5 time points for nurses

**Table 3.13: Compressive Forces on L5/S1 and Weighting Factors Resulting from Lifting Loads with a Flexed Trunk**

| Input | Weight in Hands With Inclined Trunk | Definition | Midpoint Weight | Compressive Force on L5/S1 (lbs) | Average Force (lbs) | Weighting Factor |
|---|---|---|---|---|---|---|
| Wi1 | Less Than 10 Pounds | Moderate Flexion * | 5 Pounds (2 5 lbs/hand) | 339 | 464 | 1 65 -1 71 ** 1 76 - 1 82 § 1 22 - 1 37 §§ |
| | | Severe Flexion † | | 509 | | |
| | | Lateral Bent Flexed †† | | 503 | | |
| | | Lateral Twist Flexed †† | | 505 | | |
| Wi2 | 10 to 50 Pounds | Moderate Flexion * | 30 Pounds (15 lbs/hand) | 449 | 585.25 | 2 36 |
| | | Severe Flexion † | | 637 | | |
| | | Lateral Bent Flexed †† | | 626 | | |
| | | Lateral Twist Flexed †† | | 629 | | |
| Wi3 | Greater Than 50 Pounds | Moderate Flexion * | 100 Pounds (50 lbs/hand) | 734 | 956.25 | 4 01 |
| | | Severe Flexion † | | 1051 | | |
| | | Lateral Bent Flexed †† | | 1018 | | |
| | | Lateral Twist Flexed †† | | 1022 | | |

* Flexion midpoint is 32.5°
† Flexion midpoint is 82.5°
†† Flexion midpoint is 70°
** Range of weighting factors for 5 time points for nursing assistants
§ Range of weighting factors for 5 time points for nursing assistants while resident handling
§§ Range of weighting factors for 5 time points for nurses

### 3.3.2 Scores

The observed frequencies of trunk, arm, and leg postures and manual handling activities were used as scoring factors in the PWI, and are listed in Tables 3.14-3.16.

**Table 3.14: Observed Frequencies of Postures and Manual Handling for Nursing Assistants**

| | Index Inputs | Nursing Assistants | | | | |
|---|---|---|---|---|---|---|
| | | Baseline | 3 Month | 12 Month | 24 Month | 36 Month |
| T2 | Moderate Flexion | 15 49% | 14.12% | 15 43% | 12.94% | 8 13% |
| T3 | Severe Flexion | 6 86% | 7 21% | 4 79% | 3 48% | 7 12% |
| T4 | Lateral Bent/Twist Neutral | 6 88% | 6 97% | 4 07% | 3.46% | 1 72% |
| T5 | Lateral Bent/Twist Flexed | 4 50% | 6 19% | 2 73% | 2 17% | 2 27% |
| A2 | 1 Arm > 60° | 19.00% | 19 18% | 13.70% | 13 02% | 8 33% |
| A3 | Both Arms > 60° | 13 28% | 15.94% | 11 25% | 8 62% | 6 04% |
| L3 | Shallow Squat | 0 30% | 0.44% | 0 42% | 0 48% | 0 24% |
| L4 | Kneeling (1 or Both) | 0.17% | 0 33% | 0 12% | 0 07% | 0 29% |
| L5 | Walking | 23 69% | 28.98% | 23 42% | 25 64% | 28.74% |
| L6 | Deep Squat | 0 99% | 0 73% | 0 69% | 0 62% | 0 93% |
| L7 | Lunge | 0.10% | 0 23% | 0 35% | 0 31% | 0 13% |
| Wu1 | < 10 Pounds (Upright) | 63 33% | 62 44% | 70 28% | 75 15% | 77 02% |
| Wu2 | 10-50 Pounds (Upright) | 2 54% | 2 75% | 2 49% | 2 53% | 3 45% |
| Wu3 | > 50 Pounds (Upright) | 0 22% | 0.12% | 0 12% | 0 10% | 0 26% |
| Wi1 | < 10 Pounds (Inclined) | 21 60% | 20 21% | 19 37% | 15 97% | 15 70% |
| Wi2 | 10-50 Pounds (Inclined) | 4 18% | 5 66% | 3 12% | 2 45% | 1 56% |
| Wi3 | > 50 Pounds (Inclined) | 1 00% | 1 58% | 0 34% | 0 16% | 0 14% |

**Table 3.15: Observed Frequencies of Postures and Manual Handling for Nursing Assistants While Resident Handling**

| | Index Inputs | Nursing Assistants (Resident Handling) | | | | |
|---|---|---|---|---|---|---|
| | | Baseline | 3 Month | 12 Month | 24 Month | 36 Month |
| T2 | Moderate Flexion | 30 27% | 30.88% | 36 57% | 28 78% | 15 03% |
| T3 | Severe Flexion | 18 10% | 17 68% | 12 42% | 8 38% | 11 13% |
| T4 | Lateral Bent/Twist Neutral | 7 76% | 7 44% | 4 45% | 3 97% | 1 90% |
| T5 | Lateral Bent/Twist Flexed | 12.59% | 16 40% | 6 52% | 4 13% | 5 01% |
| A2 | 1 Arm > 60° | 33 29% | 34.38% | 22 54% | 18 75% | 11 52% |
| A3 | Both Arms > 60° | 28 57% | 33 81% | 34 65% | 27 52% | 13 90% |
| L3 | Shallow Squat | 1 29% | 1 12% | 0 81% | 1 05% | 0 63% |
| L4 | Kneeling (1 or Both) | 0.48% | 0 96% | 0 19% | 0 33% | 0 37% |
| L5 | Walking | 14 69% | 14 24% | 19 55% | 29 64% | 34 93% |
| L6 | Deep Squat | 1 90% | 2 08% | 1 50% | 0 77% | 0 74% |
| L7 | Lunge | 0 27% | 0 24% | 0.63% | 0 39% | 0 47% |
| Wu1 | < 10 Pounds (Upright) | 18 42% | 18 57% | 24 23% | 36 16% | 42.72% |
| Wu2 | 10-50 Pounds (Upright) | 10 98% | 7 93% | 14 38% | 17 14% | 22 73% |
| Wu3 | > 50 Pounds (Upright) | 1 43% | 0.72% | 1 13% | 1.05% | 1 48% |
| Wi1 | < 10 Pounds (Inclined) | 26 67% | 24 24% | 23 86% | 15 91% | 17 48% |
| Wi2 | 10-50 Pounds (Inclined) | 27 01% | 30 56% | 28 30% | 23 67% | 12 30% |
| Wi3 | > 50 Pounds (Inclined) | 7 30% | 10 08% | 3 19% | 1 65% | 1 15% |

**Table 3.16: Observed Frequencies of Postures and Manual Handling for Nurses**

| | Index Inputs | Nurses | | | | |
|---|---|---|---|---|---|---|
| | | Baseline | 3 Month | 12 Month | 24 Month | 36 Month |
| T2 | Moderate Flexion | 9.07% | 10.69% | 11.84% | 10.12% | 7.34% |
| T3 | Severe Flexion | 4.75% | 3.47% | 4.27% | 1.85% | 6.78% |
| T4 | Lateral Bent/Twist Neutral | 4.75% | 6.89% | 4.45% | 3.20% | 2.82% |
| T5 | Lateral Bent/Twist Flexed | 1.94% | 2.97% | 2.48% | 0.69% | 0.56% |
| A2 | 1 Arm > 60° | 13.49% | 18.38% | 16.47% | 13.85% | 9.55% |
| A3 | Both Arms > 60° | 5.11% | 12.09% | 9.64% | 7.27% | 5.06% |
| L3 | Shallow Squat | 0.18% | 0.11% | 0.39% | 0.43% | 0.00% |
| L4 | Kneeling (1 or Both) | 0.00% | 0.11% | 0.11% | 0.19% | 0.00% |
| L5 | Walking | 16.90% | 16.70% | 12.85% | 14.26% | 9.55% |
| L6 | Deep Squat | 0.88% | 0.22% | 0.79% | 0.50% | 0.00% |
| L7 | Lunge | 0.00% | 0.00% | 0.43% | 0.19% | 0.00% |
| Wu1 | < 10 Pounds (Upright) | 77.80% | 74.80% | 75.38% | 82.93% | 81.36% |
| Wu2 | 10-50 Pounds (Upright) | 1.41% | 1.01% | 1.44% | 1.04% | 0.56% |
| Wu3 | > 50 Pounds (Upright) | 0.18% | 0.11% | 0.00% | 0.08% | 0.56% |
| Wi1 | < 10 Pounds (Inclined) | 14.84% | 14.76% | 17.22% | 12.19% | 13.48% |
| Wi2 | 10-50 Pounds (Inclined) | 0.70% | 1.79% | 1.33% | 0.46% | 1.12% |
| Wi3 | > 50 Pounds (Inclined) | 0.18% | 0.56% | 0.00% | 0.04% | 0.00% |

### 3.3.3 Physical Workload Index

The weighting factors multiplied by the scores for each posture combination were summed to calculate the PWI at baseline and for four follow-up periods for nurses, nursing assistants, and nursing assistants while resident handling (Figure 3.1).

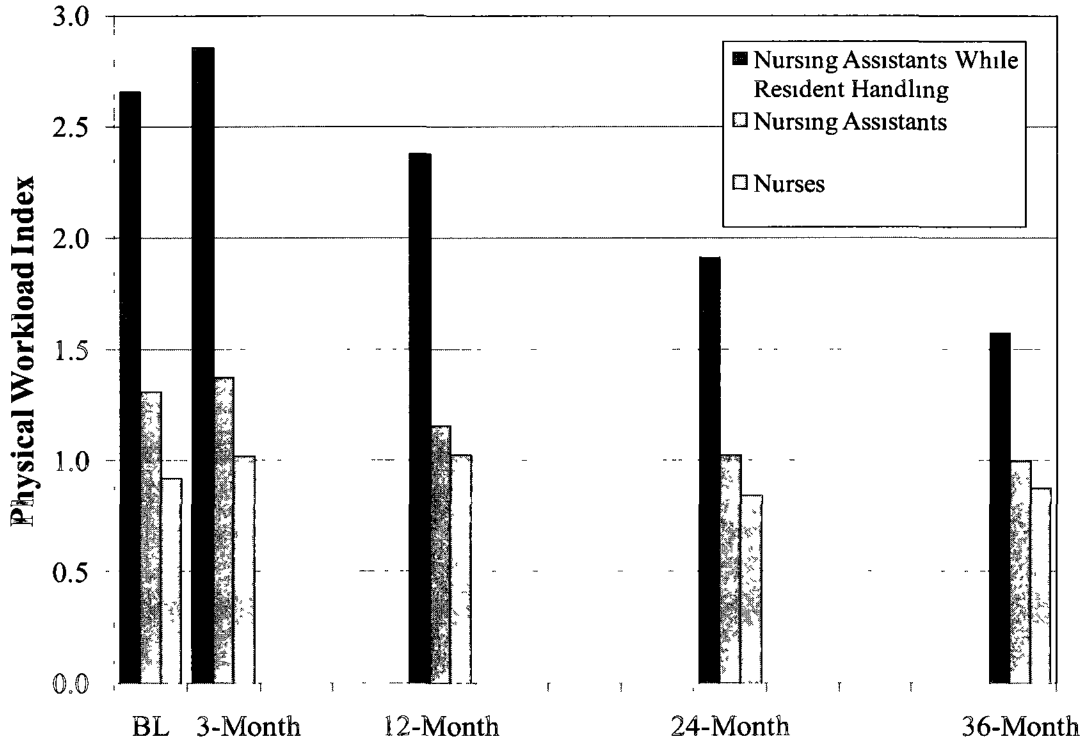


**Figure 3.1: Physical Workload Index for Nurses, Nursing Assistants, and Nursing Assistants While Resident Handling**

In general, nursing assistants had a much higher PWI than nurses, especially while the assistants were handling residents. The physical workload consistently increased slightly at the 3-month follow-up survey, followed by a declining trend through both the 12 and 24-month follow-ups. At the 36-month follow-up, the index for nurses seemed to level off, while the workload indices continued to decrease for nursing assistants, even while performing resident handling. By the end of the 36-month follow-up, the index had decreased by 24.2% for nursing assistants, by 40.9% for nursing assistants while resident handling, and by 2.5% for nurses.

## 3.4 DISCUSSION

In this large observational study of nursing home direct care staff, nursing assistants had a much higher combined physical workload (from postural load and weight in hands) than did nurses. By 36 months after implementation of the "Safe Resident Handling" program, the PWI decreased for nurses, nursing assistants, and nursing assistants while resident handling only. Although a slight decrease was observed over the 36-month follow-up, the PWI for nurses did not vary much. For nursing assistants, both overall and while resident handling only, the workload increased slightly at three months and then decreased steadily at the 12, 24, and 36-month observation periods. This is naturally consistent with the trends in observed frequencies of body postures and manual handling when they were examined individually in Chapter II.

Hollmann et al. originally used the index to differentiate between job titles solely based on self-reported physical workload (1999). Although the job categories are different in this study, the resulting index did differentiate between nursing assistants and nurses based on their observed physical workload.

The use of resident handling equipment has been shown to reduce compressive forces on the lumbar spine in laboratory studies. For example, static biomechanical evaluations of five manual patient transferring tasks and three mechanical transfer devices showed that the compressive forces at L5/S1 were reduced when using mechanical devices to perform wheelchair-to-showerchair and showerchair-to-wheelchair transfers (Garg et al., 1992 a,b). Zhuang et al. (1999) investigated the effects of transfer methods and resident weight using force platforms and a three-dimensional biomechanical model; lifting devices significantly reduced low-back compressive forces for nine nursing assistants. A biomechanical assessment, with ground reaction forces and hand reaction forces as input variables in a linked segment model, showed higher compressive forces on the lumbar spine (but not shear forces) in manual versus mechanically-assisted patient handling and repositioning (OHSAH, 2006).

Typically, output from PATH exposure assessment results in frequencies of time spent in observed postures and activities. A review of 30 observational methods for assessing biomechanical exposures reported that PATH addresses exposure levels only, and that output from the PATH method provides no association with MSDs (Takala, 2010). In 2006, Janowitz et al. decided against using the PATH method for ergonomic exposure assessment in hospital settings, due to the lack of an output summary score that could be used in multilevel modeling. By pairing the frequencies of PATH exposures with biomechanical modeling of the lumbar spine to create the PWI, the type of output score that could be useful to musculoskeletal researchers is now available.

### 3.4.1 Limitations and Strengths of This Study

When biomechanical models have been used to evaluate healthcare work, they typically use inputs gathered from controlled laboratory studies using cooperative 'patients,' which may not represent real life working situations, thus underestimating the actual physical stress on the body. The prior uses of the PWI (Klimmer, 1998; Hollmann, 1999; Klimmer, 2005; Janowitz, 2006; Nabe-Nielson, 2008) were based on self-reported frequencies of postures and manual handling activities. In contrast to these methods, this study utilized observational postural and manual handling data collected at work sites which was more objective than self-reported information and laboratory studies.

However, there are some limitations to the biomechanical model used in this study. It is a static model and does not estimate the contributions due to dynamic activities often performed by healthcare workers. When working with the 3DSSPP, some assumptions were made regarding inputs for body postures, weight in hands, and anthropometry. The arms were input as straight at the elbow and the trunk was kept neutral while computing the effects of the leg and arm postures, and the leg angles were input as straight at the hip and knee while computing trunk and arm angles. Weight in hands was equally distributed in the right and left hands and applied vertically downwards. These assumptions may result in an underestimate of the compressive force on the lumbar spine, however these assumptions were held over the five time periods pre- and post-intervention and reductions in the overall PWI were observed for all job categories. Anthropometry for a $50^{th}$ percentile female was used for computations, so the index results may be different for males. Because the observed populations of both nurses and nursing assistants were primarily female, this assumption was justifiable.

The midpoints of body angles and weight in hands were used in the 3DSSPP to calculate compressive forces on the L5/S1 for each posture and manual handling combination. If it were possible, the most appropriate inputs for the 3DSSPP would be the median joint angle and load lifted for each combination. However, this type of information cannot be determined from the PATH datasets, thus midpoints were used for all calculations. Monte Carlo simulation or bootstrapping techniques, which has been utilized in other studies (Tak, Yuan, 2006), could be used to estimate distributions (and medians could then be calculated), of postures and weight in hands for each combination, but with thousands of observation moments already collected these types of methods were unnecessary.

Based on observer knowledge, the median values of trunk postures such as 'severe flexion' and 'lateral bent/twist flexed' may be lower than midpoints used for calculating the PWI. Because moment arms about the trunk increase as flexion increases to 90°, using midpoints for 'severe flexion' and 'lateral bent/twist flexed' that are close to 90° may somewhat overestimate the weighting factors for these categories, if their true median values are closer to the categories' lower endpoints. Since these median values were held constant over the five time periods and across job titles, bias between survey periods or job groups is unlikely.

The manner in which the weight in hands categories were defined in the PATH template made visual judgment of handled loads easier for observers to categorize in a 60 second time interval. However, 'ten to 50 pounds' and 'greater than 50 pounds' are wide intervals for categorizing manual handling activities and may have resulted in a loss of sensitivity to actual changes in loads handled in the workplace leading to an underestimate of mechanical loading on the lumbar spine due to manual handling at each time period.

At the 36-month follow-up, only one nurse was observed, resulting in a much smaller sample size than the other time periods. With more data for this time point, the resulting index may have been different. However, nurses spend considerably less time performing resident handling activities when compared to nursing assistants, and have infrequent contact with lifting equipment. Therefore it is unlikely that the SRHP would have much impact on the physical workload of nurses, and it is doubtful that the PWI for the 36-month time period would change much.

## 3.5 CONCLUSIONS AND RECOMMENDATIONS

The method used in this study demonstrated differences in physical exposures between clinical job titles; and also across time periods, indicating benefits resulting from the SRHP for both the nursing assistants and nurses. There are many potential applications for the PWI in the scope of this study with healthcare workers. Variability between individuals could be examined using their actual anthropometric measurements and frequencies of postures and manual handling activities. The index could also be used to analyze direct care tasks to determine the highest risk tasks performed by healthcare workers, so further individual interventions could be considered. Additionally, further examination of the PWI could provide insight into threshold levels of physical exposures; for example, how much would the PWI have to decrease for nursing assistants' jobs to be considered "safe?" In the future, the pairing of PATH frequencies and biomechanical modeling of the lumbar spine could also be applied to other industries in order to better understand physical exposures in the workplace.

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# CHAPTER IV: EXPLANATORY FACTORS FOR DIFFERENCES AMONG NURSING HOMES IN PHYSICAL WORKLOAD AND THE USE OF HANDLING EQUIPMENT

## 4.1 INTRODUCTION

Safe patient handling programs in healthcare settings are crucial for reducing musculoskeletal injuries to healthcare workers (Collins, 2006). A 2003 review (Hignett, 2003) of patient handling interventions reported that multifaceted interventions typically reduce risk factors related to patient handling activities more successfully than single factor and training-only interventions. Common components of multifaceted interventions included patient assessment, the introduction of patient handling devices, written policies for effective equipment use, and training on patient handling procedures. Evaluations of patient handling interventions in various healthcare settings have been found to promote reductions in forces on the lumbar spine (Nelson, 2003), back injuries (Engkvist, 2006), workers' compensation claims and lost injury days (Park RM, 2009; Engkvist, 2006; Nelson, 2006; Collins, 2004), OSHA 200 log incidents (Collins, 2004; Evanoff, 2003), self-reported injury rates (Collins, 2004), and claim costs (Park RM, 2009; Nelson, 2006).

To date, little research has been conducted into variability of the success of Safe Resident Handling Programs (SRHPs) among healthcare centers. However, several studies have reported on factors that benefit or hinder the effectiveness of SRHPs, such as staffing levels, turnover, resident acuity, equipment factors, organizational factors, and relationships with co-workers.

Availability of staff was identified as an important factor for successful interventions in several studies. A recent study (Park, 2009) evaluated the effects of varying resident handling interventions in all nursing homes in Ohio. Inadequate resident-to-staff ratio was found to be a risk factor for musculoskeletal injuries. Additionally, Trinkoff (2005) reported that reductions in workers' compensation claim rates at nursing homes in Ohio were associated with increasing hours of staff time available per resident, and Enkvist (2007) reported on obstacles to successful interventions identified by hospital nurses, including a lack of time and trained staff.

Employee turnover has also been reported to hinder intervention benefits. Rockefeller (2002) reported on the negative effects of administrative turnover on ergonomic interventions in nursing homes in Washington State.

Resident acuity was identified in some studies as a factor that could hamper effective SRHPs. Park (2009) reported an association between lower resident acuity and increased risk for musculoskeletal injuries. Another study (Enkvist, 2007) identified residents with dementia as a possible barrier to the successful implementation of SRHPs in hospitals.

A systematic review of patient handling intervention studies reported on individual and environmental barriers and facilitators of interventions in varied healthcare settings (Koppelaar, 2009). One of the most commonly identified environmental barriers was convenience and easy accessibility of equipment. Hunter (2010) identified misplaced or lost equipment as a barrier to successful SRHP implementation, and Enkvist (2007) reported lack of equipment to be an identified obstacle for SRHP intervention.

Park (2009) suggested that intervention implementation is more feasible in facilities where organizational factors such as ample equipment purchases and fewer changes in facility ownership are present.

Relationships with co-workers was identified in several studies as an important factor for the success of SRHPs. Good working relationships between supervisors and co-workers were recognized as important factors for nursing home staffs' well-being in general (Schaefer, 1996). One study (Koppelaar, 2009) reported that a supportive management climate was a facilitator for successful programs. Poor relationships with co-workers were reported as an obstacle to intervention success (Enkvist, 2007).

Further research regarding predictors of effective SRHPs is necessary to identify additional factors hindering effectiveness in order to more successfully promote the implementation of multifaceted patient handling interventions. It would be useful to examine individual, environmental, and psychosocial factors over time, including baseline pre-intervention measurements, in order to better measure the direction of associations between the factors and efficacy of the SRHP.

The goal of this study was to examine possible explanations for differences in the efficacy of a SRHP intervention in five nursing homes, measured in three ways. The SRHP was company-instituted and incorporated resident assessment, the purchase of resident handling equipment, employee training, and policies for equipment use and maintenance. Changes in equipment use while resident handling in addition to changes in a physical workload index (PWI) for nursing assistants, both overall and while handling residents, were examined over a two-year period following SRHP implementation. Questionnaires, administrative data, employee satisfaction surveys, and staff exit interviews following the collection of ergonomic observations were all sources of variables that could potentially explain differences among centers in outcome measures.

## 4.2 METHODS

This prospective study of five nursing homes included ergonomic observations of nursing assistants at baseline (the week of the department heads' meeting to begin SRHP implementation) and at 3-month, 12-month, and 24-month follow-up periods. A modification of the PATH method (Buchholz, 1996) was used to make ergonomic observations. This version incorporated resident handling activities and handling equipment along with postures and tasks specific to the healthcare industry (Appendix A). Data were collected by 12 observers using handheld PDAs at fixed 60-second intervals (observation moments). Systematic post-observation exit interviews with participants were conducted and this information was recorded on "coversheets" (Appendix B), summarizing these supplemental data for each person-shift in a standardized format. The intervention process, study design, ergonomic exposure assessment method, and data management were reported on in detail in Chapter II of this dissertation.

A PWI was calculated by summing the contributions of compressive forces on the L5/S1 joint resulting from 17 combinations of postures and manual handling actions. Each of the 17 terms in the index equation consisted of a posture combination, weighted by subtracting the standard compressive force of the spine from the compressive force of the spine at the given combination, and a score based on the frequencies of PATH variables. Chapter III of this dissertation further describes the procedures for calculating the PWI.

A questionnaire focusing on general health, musculoskeletal symptoms, psychosocial risk factors, workplace factors, and demographic information was distributed by the investigators to all clinical staff members in each facility where job observations were made at each of the four time periods. Chapter II details the types of information obtained by these questionnaires.

Additionally, administrative data for the study period were made available by the corporation. Administrative data included information such as employee and administrative turnover for the study years and percentage of agency staff for each facility at each time period.

Employee satisfaction surveys, available to employees in all job categories, were designed by a third-party research company, "My InnerView," (2008) and administered locally at each facility. Survey results were made available to researchers by the nursing home corporation. The survey was developed so employers in the nursing home sector can better understand important factors related to their employees' job satisfaction. Employees mailed in surveys to report on global job satisfaction, work environment, training, supervision, management, and demographics. These data were provided to the investigators for the years 2005 through 2009. For one center, results from the employee satisfaction survey were available only at the 12-month and 24-month follow-ups (2008 and 2009). Results from the remaining centers were available for all time periods (2006 to 2008).

### 4.2.1 Outcome Measures

Changes in equipment use while resident handling and changes in the PWI, both overall and while resident handling, were used to examine the efficacy of the SRHP. Values for each outcome measure were calculated for each of the five facilities. To ensure that variation in sample sizes did not affect the calculation of outcome measures, standard errors were used to calculate confidence intervals for the percentages of equipment use while resident handling and the overall percentage of observation moments for each facility at each time period.

#### *4.2.1.1 Equipment Use While Resident Handling*

Observational data included use of resident handling equipment consisting of gait belts, slideboards, slipsheets, slings, sit/stand lifts and total body lifts. Resident handling activities were assisting with ambulation, repositioning, transferring, and transporting. For all resident handling activities, the frequency of equipment use was calculated for each facility at each time period. Linear regression was used to fit slopes across the data points (0 months, 3 months, 12 months, and 24 months) in order to best represent the changes in equipment use at each time period for each facility. Cochran-Armitage tests for trend were calculated (Agresti, 2002). All data analysis was performed with SAS 9.2.

#### *4.2.1.2 Physical Workload Index*

For each time period at each facility, the PWI was calculated for nursing assistants, both overall and while handling residents only. Slopes for the PWI, both overall and while resident handling, were determined for each facility using linear regression in order to examine the changes in PWI over time.

### 4.2.2 Explanatory Factors

Candidate explanatory factors for inclusion in this study were selected based on first-hand experience of collecting data in the five nursing homes. Insight into interpersonal and work environment factors that might help explain differences in outcome measures between facilities informed the selection of variables which were available from questionnaire responses, administrative data, employee satisfaction surveys, and coversheets (Table 4.1). Some of the factors were collected at the facility level and others were collected from individuals and then converted to summary statistics by facility.

**Table 4.1: Explanatory Factors and Data Sources**

| Data Source | Explanatory Factors |
|---|---|
| Investigators: Questionnaires | Co-worker Support |
| | Supervisor Support |
| Company: Administrative Data | % Rehabilitation Population |
| | % Dementia Beds |
| | Baseline Equipment Usage |
| | Wellness Program |
| | Administrator Turnover |
| | Director of Nursing Turnover |
| | Nursing Assistant Turnover |
| | % Agency Staff |
| Company: Employee Satisfaction Surveys | Recommendation for Job |
| | Safety of Workplace |
| | Adequacy of Equipment & Supplies |
| | Quality of Teamwork |
| | Staff-to-Staff Communication |
| Investigators: Observation Coversheets | Was today a typical day? |
| | Were there any obstacles to getting your work done on time today? |
| | Was there any broken or missing equipment today? |
| | Was the unit understaffed today? |
| | Did you feel any time pressure today? |

*4.2.2.1 Factors from Questionnaire Responses*

At each survey, the questionnaire included two questions each about co-worker support ("The people I work with take a personal interest in me" and "The people I work with can be relied on when I need help") and supervisor support ("My supervisor is helpful in getting the job done" and "My supervisor pays attention to what I am saying"). The responses to these questions were reported using a four-point Likert scale ranging from 'strongly disagree' to 'strongly agree.' The responses were averaged for each pair of questions. Percent change from baseline values was calculated for each facility (24-month – baseline/baseline).

***4.2.2.2 Environmental Factors from Administrative Data***

Information regarding turnover by job type was provided by the nursing home corporation; turnover of nursing assistants, administrators, and directors of nursing (DONs) was calculated for each facility. Yearly turnover data for nursing assistants was used to calculate percent change from baseline values for each facility (24-month – baseline/baseline).

The percentages of nursing assistant shifts filled by agency staff were estimated by the investigators for the week of the survey, based on staffing sheets provided by the facilities at the times of data collection. Typically, agency staff was hired to fill shifts when facilities were understaffed. Percent change from baseline agency staffing levels was calculated for each facility (24-month – baseline/baseline).

Administrators and wellness program champions at the facilities were surveyed to confirm information regarding wellness program activities. Two of the five facilities did not provide feedback, so it was assumed that wellness programs were not established at those locations.

Factors describing the case-mix of residents, including 'percent rehabilitation beds' and 'percent dementia beds,' were extracted from investigators' field notes describing unit types and resident censuses.

Levels of baseline equipment use for each facility (0 to 2) were determined by comparing frequencies of PATH observations with field notes recounting types and frequencies of handling equipment observed. Equipment was present, though not observed in use, in all facilities at baseline. Makes and models, as well as quantities, were not necessarily the same as the equipment purchased for the SRHP.

#### *4.2.2.3 Factors from Employee Satisfaction Surveys*

Five questions were chosen as potential explanatory factors: "Rate this facility on the safety of the workplace," "Rate this facility on the adequacy of equipment and supplies to do your job," "Rate this facility on how your co-workers work together as a team," "Rate this facility on staff-to-staff communication," and "What is your recommendation of this facility as a place to work?" A four-point Likert scale ranging from 'poor' to 'excellent' was used to rate responses for each item. Using only responses from nursing assistants at each center, the mean value and percentage of 'poor' responses for each question were calculated for each of the study years (2006 to 2008 for four facilities and 2007 to 2009 for one). Percent change from baseline values for both mean survey responses and percent 'poor' responses was calculated for each facility (24-month – baseline/baseline).

#### *4.2.2.4 Factors from Coversheet Data*

Demographic information was compiled for the individuals observed. Additionally, five questions were chosen from the investigators' observation coversheets as potential explanatory variables. At each survey, the center percentage of 'yes' responses were calculated for these questions asked at the end of the observed shift: "Was today a typical day?" "Were there any obstacles to getting your work done on time today?" "Was there any broken or missing equipment today?" and "Was the unit understaffed today?" Additionally, the percentage of 'never' responses was calculated for "Did you feel time pressure today?" Percent change from baseline responses was calculated for each facility (24-month – baseline/baseline).

### 4.2.3 Domains for Explanatory Factors

Explanatory factors from the four data sources were further organized by domain to better classify their relationships with outcome measures. The domains examined in this analysis were facility characteristics, equipment factors, staffing factors, turnover, personal work factors, and interpersonal relationships.

### 4.2.4 Correlation Coefficients

Spearman correlation coefficients (SAS 9.2) were computed between the outcome variables (slope of equipment use while resident handling over time, slope of the PWI over time, and slope of the PWI while resident handling over time) and all candidate explanatory and demographic variables.

## 4.3 RESULTS

Between three and 21 individual workers were observed at each time period at each facility (mean 12.7, SD 3.9). This resulted in a range of 160 to 4323 observation moments (mean 2807, SD = 1088) per facility per time period, which included 31 to 324 resident handling observation moments (mean 171.3, SD 83.9) (Table 4.2).

**Table 4.2: Data Collection – Observation Periods and Observation Moments**

| Facility | Observation Periods | | | | Observation Moments | | | | Observation Moments (RH) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F0 | F1 | F2 | F3 | F0 | F1 | F2 | F3 | F0 | F1 | F2 | F3 |
| Center A | 13 | 14 | 14 | 12 | 2884 | 4323 | 3466 | 3033 | 206 | 286 | 305 | 149 |
| Center B | 3 | 13 | 21 | 14 | 160 | 3425 | 3354 | 3603 | 38 | 110 | 181 | 143 |
| Center C | 12 | 10 | 16 | 8 | 2400 | 2392 | 3442 | 1892 | 271 | 245 | 127 | 120 |
| Center D | 14 | 10 | 15 | 15 | 3916 | 1788 | 4117 | 2989 | 324 | 214 | 139 | 31 |
| Center E | 9 | 8 | 18 | 14 | 1012 | 1397 | 2992 | 3547 | 76 | 111 | 180 | 170 |

At all facilities, the study populations were predominantly female; however, more men were observed at Center D and Center E than at the other three centers (Table 4.3). Mean job tenure of the observed workers ranged from about two years to about six years. The observed workers at Center D had the lowest mean job tenure, while those at Center E had the highest. The observed population at Center A was much more likely to be White and Centers C and D were more likely to be Black compared to the other centers. No observed workers were Asian or of Latino/Hispanic ethnicity.

**Table 4.3: Demographic Information for Observed Nursing Home Workers, by Facility**

| | Center A | Center B | Center C | Center D | Center E |
|---|---|---|---|---|---|
| *n (Includes 4 time periods)* | 53 | 51 | 46 | 54 | 49 |
| *Sex (Mean Females)* | 91% | 100% | 91% | 83% | 75% |
| *Mean Tenure (Years)* | 5 4 | 4.7 | 3 6 | 2.1 | 6 2 |
| *Race* | | | | | |
| White | 98% | 35% | 3% | 0% | 21% |
| Black | 2% | 65% | 97% | 100% | 79% |

### 4.3.1 Safe Resident Handling Program Outcomes

#### *4.3.1.1 Equipment Use While Resident Handling*

Three centers had almost no equipment use at baseline, while two did have equipment in use. Confidence intervals indicated that there was a small amount of variation at baseline, thus differences at the centers was unlikely (Table 4.4). Confidence intervals were similar among centers for the other time periods, demonstrating minimal differences.

**Table 4.4: Equipment Use While Resident Handling – Proportion of Work Time Observed, Standard Errors, and Confidence Intervals**

| Equipment Use While Resident Handling | | Center A | Center B | Center C | Center D | Center E |
|---|---|---|---|---|---|---|
| Baseline | Proportion | 21.6% | 0.1% | 16.3% | 2.6% | 0.1% |
| | Standard Error | 2 4% | 0.6% | 2.1% | 0.6% | 0.4% |
| | Confidence Interval | 19.2-24.0 | 0-0.007 | 14.1-18.4 | 2 0-3.3 | 0-0.005 |
| 3-Month | Proportion | 21 6% | 4.2% | 18 6% | 3 6% | 7 4% |
| | Standard Error | 3 5% | 0.9% | 2 1% | 1 3% | 2 2% |
| | Confidence Interval | 18.1-25.1 | 3.3-5.1 | 16.5-20 7 | 2.4-4.9 | 5.3-9.6 |
| 12-Month | Proportion | 31.5% | 12.3% | 15.8% | 10.8% | 20.5% |
| | Standard Error | 2.7% | 1.8% | 2.0% | 1.8% | 2.3% |
| | Confidence Interval | 28.8-34.1 | 10.5-14.0 | 13.8-17.8 | 9.1-12.6 | 18.1-22 8 |
| 24-Month | Proportion | 20 6% | 21 7% | 37.3% | 18.0% | 19.0% |
| | Standard Error | 2.5% | 2.7% | 3 8% | 3.1% | 2 3% |
| | Confidence Interval | 18.0-23 1 | 19.0-24.4 | 33.5-41.2 | 14.9-21 1 | 16.8-21.3 |

In four centers, equipment use increased markedly by the end of the 24-month follow-up (Cochran-Armitage p-values < 0.005 in Centers B, C, and D) (Figure 4.1).

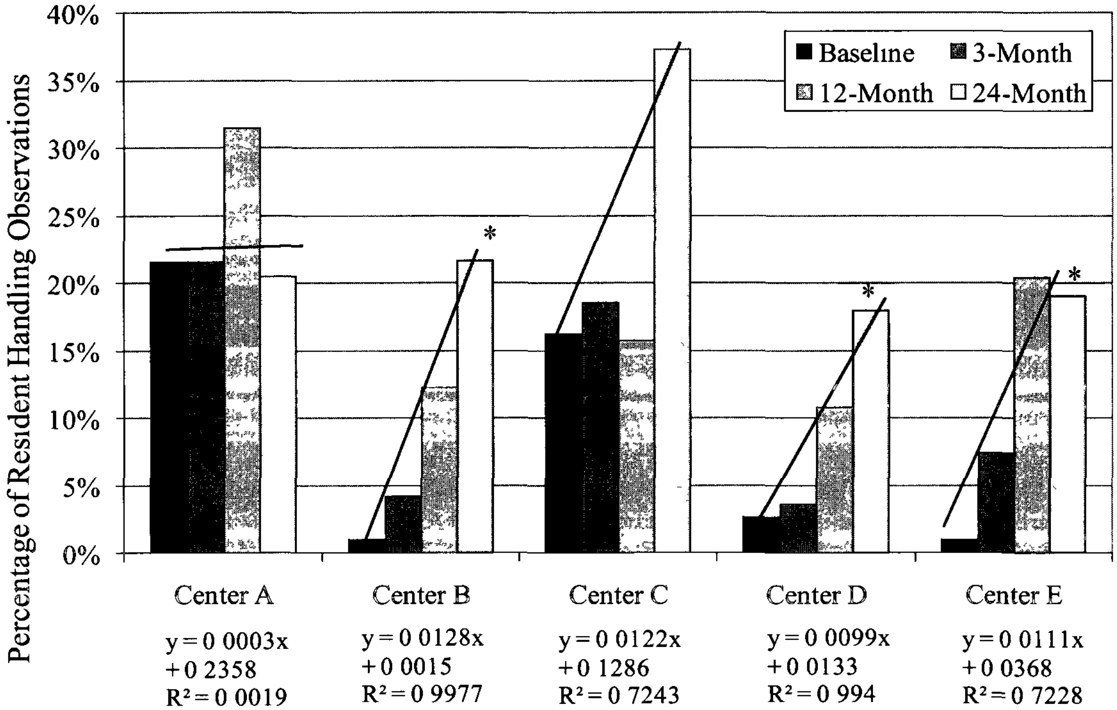



**Figure 4.1: Equipment Use† While Resident Handling†† by Facility**

* $p < 0.005$ (Cochran-Armitage test of trend)

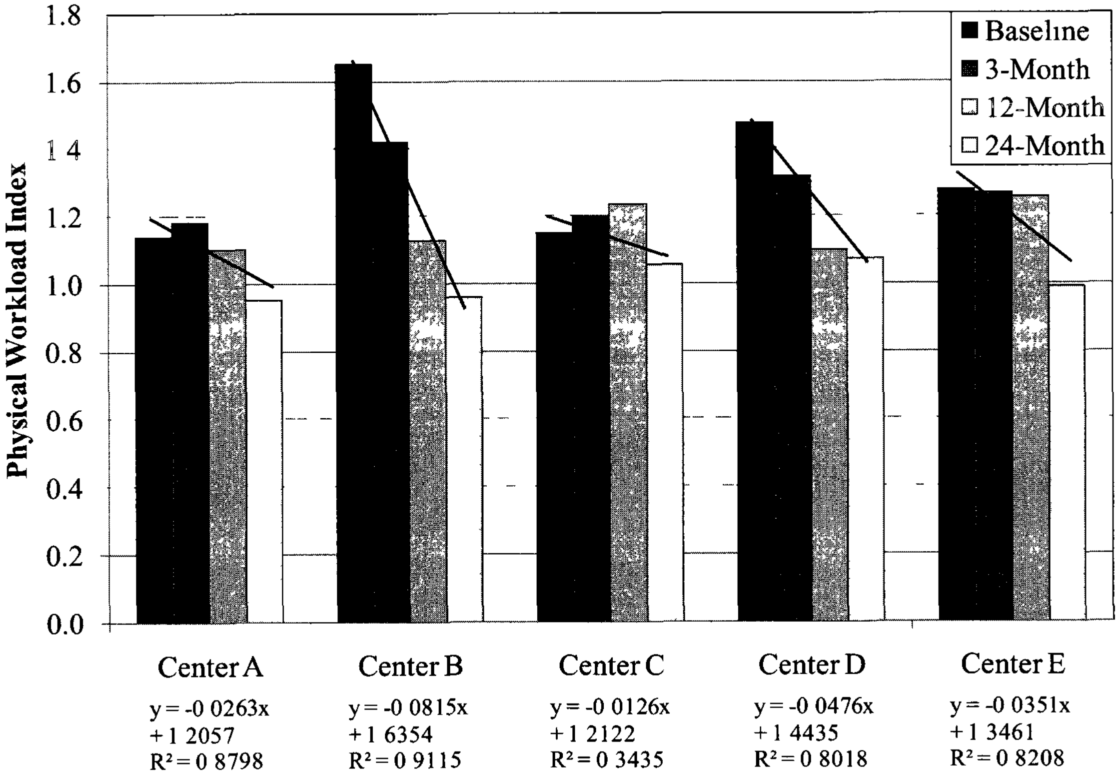
† Equipment includes Total Body Lifts, Sit-Stand Lifts, Slings, Slideboards, Slipsheets, and Gait-belts

†† Resident Handling includes manual and mechanically assisted Ambulation Assist, Reposition, Transfer and Transport

By the end of the follow-up period, nursing aides in all centers were observed using equipment for at least 18% of resident handling observations. A slight net decrease in equipment use was observed at Center A by the end of 24 months, although there had been a large increase at 12 months. Workers in Center B showed the steepest increase in equipment use of all the centers.

#### *4.3.1.2 Physical Workload Index*

Reductions in both the PWI and the PWI while resident handling were observed for all facilities (Figures 4.2 and 4.3). For all centers, post- to pre-intervention ratios for PWI scores ranged from 0.58 to 0.92. Center B had the steepest negative slope indicating the largest decrease in the PWI for the two years of follow-up, while Centers A and C experienced the weakest downward trends, relating to the smallest improvements in the PWI.




**<u>Figure 4.2: Physical Workload Index for Nursing Assistants by Facility</u>**

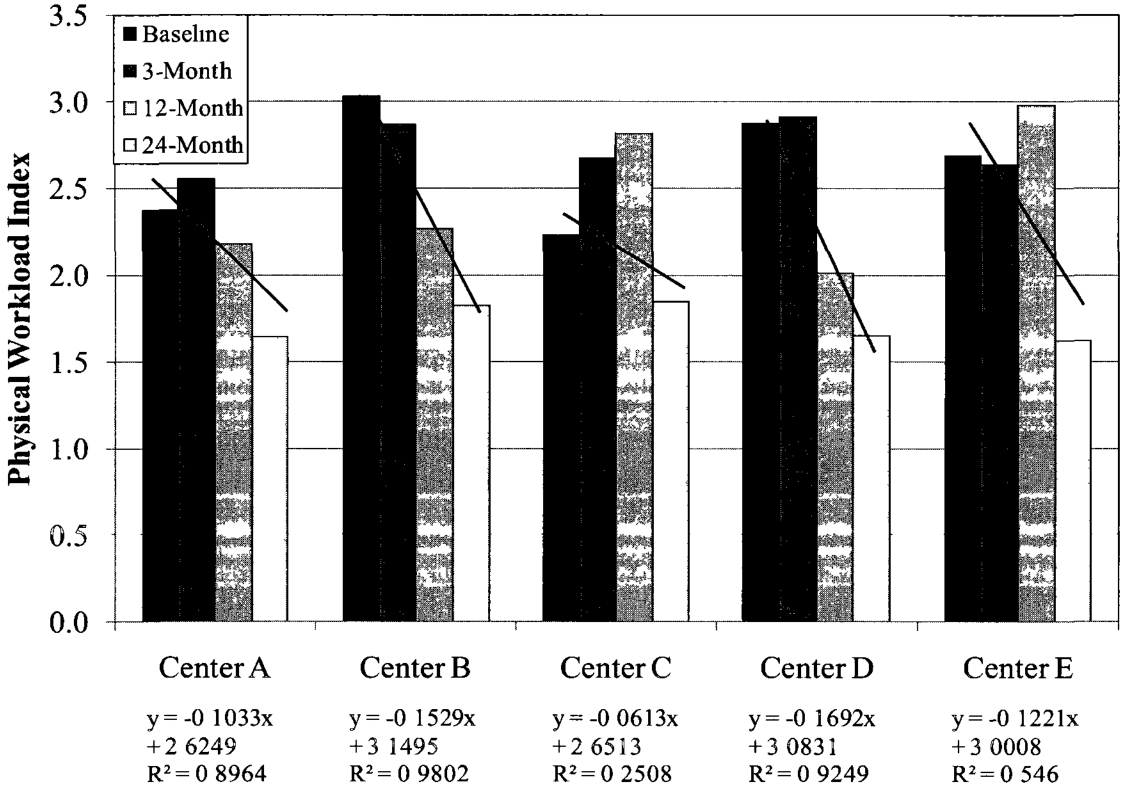



**Figure 4.3: Physical Workload Index for Nursing Assistants While Resident Handling by Facility**

Post- to pre-intervention ratios for PWI scores while resident handling ranged from 0.57 to 0.83. Centers B and D had the steepest negative slopes for the PWI while resident handling, and Centers A and C experienced the weakest negative slopes for the PWI while resident handling over two years.

## 4.3.2 Center Characteristics in Relation to SRHP Effectiveness

Variation in potential explanatory factors was observed among centers (Table 4.5).

**Table 4.5: Summary of Center-Specific Explanatory Factors and Outcome Measures**

| | Data Source | Outcome Variables | Center A | Center B | Center C | Center D | Center E |
|---|---|---|---|---|---|---|---|
| | Observational Data | Slope of Physical Workload Index | -0 0263 | -0 0815 | -0 0126 | -0 0476 | -0 0351 |
| | | Slope of Physical Workload Index While RH | -0 1033 | -0 1529 | -0 0613 | -0 1692 | -0 1221 |
| | | Slope of Equipment Use While RH | 0 0003 | 0 0132 | 0 0122 | 0 0099 | 0 0115 |
| **Domain** | **Data Source** | **Explanatory Factors** | **Center A** | **Center B** | **Center C** | **Center D** | **Center E** |
| Facility Characteristics | Administrative Data | Rehab Population (% Beds) | 31 0% | 22 5% | 48 6% | 26 2% | 14 0% |
| | | Dementia Population (% Beds) | 0% | 0% | 0% | 26 2% | 11 2% |
| | | Wellness Program | Yes | Yes | No | No | No |
| Equipment Factors | Administrative Data | Level of Baseline Equipment Usage While Resident Handling | 2 | 0 | 2 | 1 | 0 |
| | Employee Satisfaction Surveys | Change in Mean Adequacy of Supplies & Equipment | -8% | 55% | -3% | 39% | 18% |
| | | Change in %'Poor' Adequacy of Supplies & Equipment | -36% | -53% | 123% | -22% | -57% |
| Staffing Factors | Administrative Data | Change in Agency Staffing | 1567% | -46% | 0% | 69% | -1% |
| | Coversheets | Change in Observed Understaffed Shifts | 1567% | -97% | 50% | -88% | -57% |
| Turnover | Administrative Data | Change in Nursing Assistant Turnover | 27% | -78% | -57% | -57% | 42% |
| | | Total Administrator Turnover | 1 | 3 | 0 | 2 | 1 |
| | | Total DON Turnover | 1 | 4 | 3 | 4 | 3 |
| Personal Work Factors | Employee Satisfaction Surveys | Change in Mean Recommendation for Job | -41% | 303% | 14% | 41% | -16% |
| | | Change in %'Poor' Recommendation for Job | - | -73% | 67% | -52% | 98% |
| | Coversheets | Change in Obstacles to Getting Work Done on Time | 160% | -79% | -40% | 4% | 140% |
| | | Change in Never Feeling Time Pressure | -96% | 1329% | 313% | -67% | 320% |
| Interpersonal Relationships | Questionnaires | Change in Supervisor Support | -18% | -7% | -12% | 2% | -5% |
| | Employee Satisfaction Surveys | Change in Mean Staff-to-Staff Communication | -36% | 161% | -3% | 34% | -22% |
| | | Change in %'Poor' Staff-to-Staff Communication | 27% | -50% | 59% | -31% | 24% |
| | | Change in %'Poor' Quality of Teamwork | -16% | 30% | -34% | 160% | - |

Center B was the facility with the steepest slope for equipment use while resident handling and the steepest negative slope for the PWI. This center also had favorable conditions in terms of nursing assistant turnover, the use of agency staff to fill shifts, recommendation for job, adequacy of equipment & supplies, staff-to-staff communication, 'never' feeling time pressure, shifts with obstacles to getting work done on time, and understaffing. The weakest slope for equipment use while resident handling along with a weak slope for the PWI were observed at Center A, where negative changes in these same explanatory factors occurred.

#### *4.3.2.1 Explanatory Factors*

Factors from the questionnaire responses, administrative data, employee satisfaction surveys, and coversheets that were correlated with outcome measures are listed in Table 4.6. The demographic variables of the observed population including gender (mean female), race (% White), and mean tenure were not significantly correlated with any of the outcome measures.

**Table 4.6: Selected Correlation Coefficients for Explanatory Factors and Program Outcome Measures (Spearman Tests)**

| | Explanatory Factor | Slope for Equipment Use While Resident Handling | Slope for the Physical Workload Index | Slope for the Physical Workload Index While Resident Handling |
|---|---|---|---|---|
| **Facility Characteristics** | Rehab Population | - | 0 70 (p = 0 188) | - |
| | Dementia Population | - | - | -0 67, (p = 0 215) |
| **Equipment Factors** | Levels of Baseline Use of Handling Equipment | - | 0 79 (p = 0 111) | - |
| | Decrease in Mean Adequacy of Supplies and Equipment | - | -0 90 (p = 0 037) | -0 80 (p = 0 104) |
| **Staffing Factors** | Decrease in the Percentage of Agency Staff Used | -0 90 (p = 0 037) | - | - |
| | Increase in Understaffing on Observation Day | - | 0 90 (p = 0 037) | 0 80 (p = 0 104) |
| **Turnover** | Decrease in Nursing Assistant Turnover | -0 70 (p = 0 188) | - | - |
| | Total Director of Nursing Turnover | 0 88 (p = 0 051) | - | - |
| | Total Administrator Turnover | - | -0 97 (p = 0 005) | -0 87 (p = 0 054) |
| **Personal Work Factors** | Change in Mean Recommendation for Job | 0 70 (p = 0 188) | -0 70 (p = 0 188) | - |
| | Decrease in % 'Poor' Responses to Recommendation for Job | - | -0 80 (p = 0 200) | - |
| | Decrease in Obstacles to Getting Work Done on Time | -0 90 (p = 0 037) | - | - |
| | Increase in Never Feeling Time Pressure | 0 90 (p = 0 037) | - | - |
| **Interpersonal Relationships** | Increase in Supervisor Support | - | - | 0 80 (p = 0 104) |
| | Change in Mean Staff-to-Staff Communication | 0 70 (p = 0 188) | -0 70 (p = 0 188) | - |
| | Increase in % 'Poor' Responses to Staff-to-Staff Communication | - | 1 0 (p = <0 0001) | 0 90 (p = 0 037) |
| | Increase in % 'Poor' Responses to Quality of Teamwork | - | 0 80 (p = 0 200) | 1 0 (p = <0 0001) |

Explanatory factors from the turnover and personal work factors domains were more highly correlated with the outcome measuring the slope of equipment use while resident handling, while the slope of the PWI was more correlated with explanatory factors from the facility characteristics, equipment factors, and interpersonal relationships domains.

***4.3.2.2 Facility Characteristics***

*4.3.2.2.1 Resident Case-Mix*

Small slopes for the PWI, representing less change in physical workload, were associated with increases in the percentage of rehabilitation beds in a facility (correlation coefficient = 0.70, p = 0.188; Table 4.6). Centers A and C, with the weakest negative slopes for both the PWI and the PWI while resident handling, had the largest portion of rehabilitation beds of all centers (Table 4.5). Centers D and E, which had the largest dementia populations, had some of the steepest negative slopes for the PWI while resident handling over two years (Table 4.5), although only moderately associated (correlation coefficient = -0.67, p = 0.215; Table 4.6).

*4.3.2.2.2 Wellness Programs*

Patterns in the increase of equipment use while resident handling and the decrease in the PWI based on wellness program were not observed. Centers A and B were the only facilities with wellness program activities. Center A experienced the smallest change in equipment use while resident handling while Center B experienced the strongest increase. The second lowest decrease in the PWI over time was observed at Center A and the largest decrease was at Center B (Table 4.5).

***4.3.2.3 Equipment Factors***

*4.3.2.3.1 Access to Handling Equipment at Baseline*

Smaller slopes for the PWI were moderately associated with increases in the level of equipment used for resident handling at baseline (correlation coefficient = 0.79, p = 0.111; Table 4.6). Centers A and C, the two facilities observed using the most equipment while resident handling at baseline, had the weakest negative slopes for PWI overall and while resident handling only (Table 4.5).

*4.3.2.3.2 Adequacy of Supplies and Equipment*

The decrease in mean adequacy of equipment and supplies was significantly correlated with slopes decreasing in magnitude for the PWI (-0.90, p = 0.037; Table 4.6) (Figure 4.4), and associated with slopes decreasing in magnitude for the PWI while resident handling (correlation coefficient = -0.80, p = 0.104; Table 4.6).

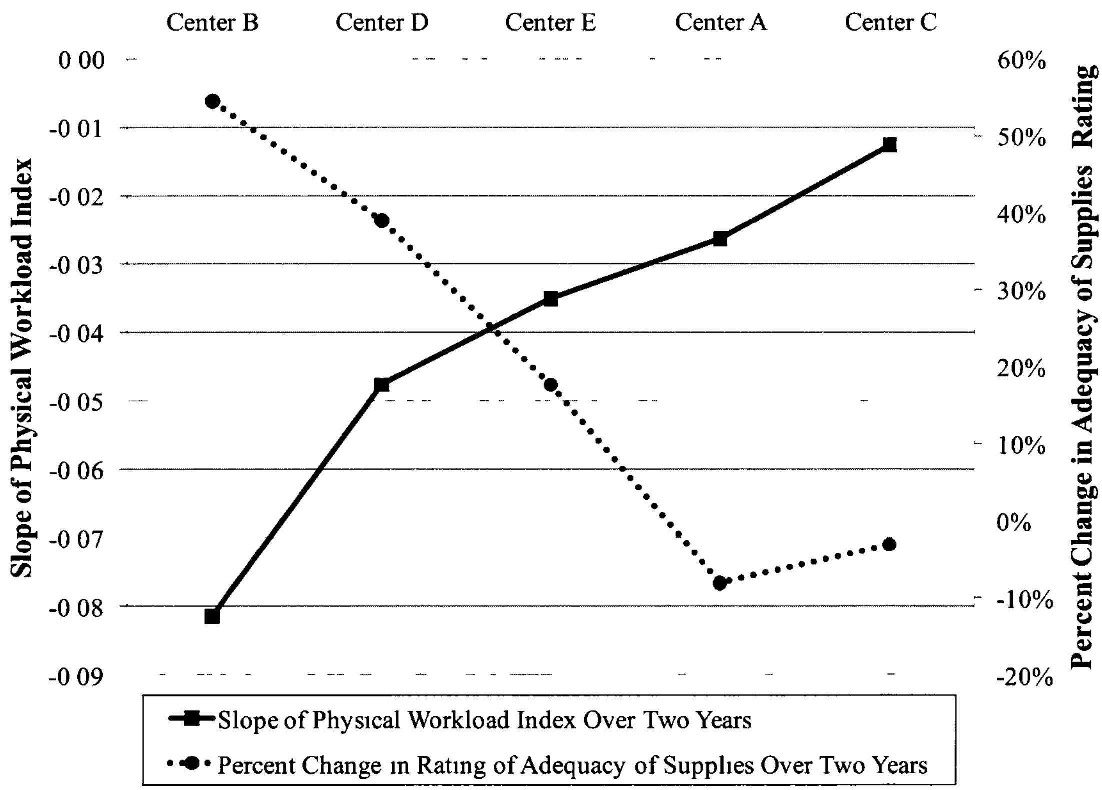



**Figure 4.4: Slope for Physical Workload Index vs. Percent Change in Perceived Adequacy of Supplies and Equipment**

The facility with the steepest slope for equipment use while resident handling and the steepest negative slope for the PWI (Center B) had the largest increases in mean adequacy of equipment and supplies and decreases in the percentage of 'poor' responses to this question. Conversely, Center A, the facility with the weakest slope for equipment use while resident handling and a weak negative slope for the PWI had the largest decrease in adequacy of equipment and supplies and an increase in the percentage of 'poor' responses to this question.

***4.3.2.4 Staffing Factors***

*4.3 2.4.1 Agency Staff*

An increasing slope for equipment use while resident handling was significantly correlated with a decrease in the percentage of agency staff used to fill shifts (-0.90, p = 0.037; Table 4.6). The only facility with an increase in the use of agency staff was Center A, where the weakest slope was observed for equipment use while resident handling over time (Table 4.5).

*4.3.2.4.2 Understaffing*

Increases in the percentage of observed understaffed shifts were significantly correlated with slopes decreasing in magnitude for the PWI (0.90, = 0.037; Table 4.6), and associated with slopes decreasing in magnitude for the PWI while resident handling (correlation coefficient = 0.80, p = 0.104, Table 4.6). Center B had the largest decrease in reported understaffing compared to the other centers (Table 4.5).

#### *4.3.2.5 Turnover*

*4.3.2.5.1 Nursing Assistant Turnover*

Increasing slopes for equipment use while resident handling were associated with a decrease in turnover of nursing assistants over two years (correlation coefficient = -0.70, p = 0.188; Table 4.6). Center A experienced an increase in nursing assistant turnover over two years, and Center B, with the steepest positive slope for equipment use while resident handling had the largest decrease in nursing assistant turnover (Table 4.5).

*4.3.2.5.2 Administrative Turnover*

In general, higher turnover of DONs was correlated with slopes increasing in magnitude for equipment use while resident handling (0.88, p = 0.051; Table 4.6), and higher administrator turnover corresponded to weaker negative slopes for the PWI (correlation coefficient = -0.97, p = 0.005; Table 4.6) (Figure 4.5) and the PWI while resident handling (correlation coefficient = -0.87, p = 0.054; Table 4.6).

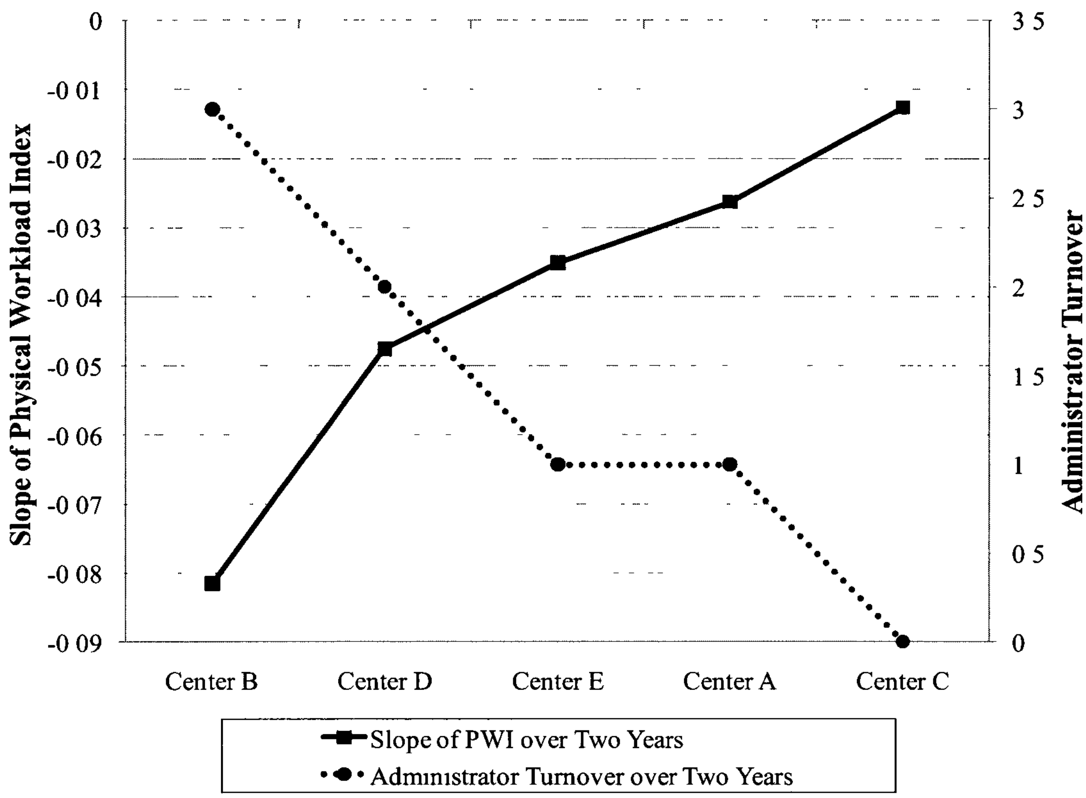



**Figure 4.5: Slope for Physical Workload Index vs. Administrator Turnover**

### *4.3.2.6 Personal Work Factors*

#### 4.3.2.6.1 Job Satisfaction

Increases in mean rating of "would recommend this job" were associated with increasing slopes for equipment use while resident handling (correlation coefficient = 0.70, p = 0.188; Table 4.6) and slopes decreasing in magnitude for the PWI (correlation coefficient = 0.70, p = 0.188; Table 4.6). The largest increase in mean recommendation for job was at Center B, the facility with the steepest slope for equipment use while resident handling and the steepest negative slope for the PWI. The facility with the weakest slope for equipment use while resident handling and a weak negative slope for the PWI (Center A), had the largest decrease in mean recommendation for job (Table 4.5).

Decreases in the percentage of 'poor' ratings for the same survey question were also associated with weaker slopes for the PWI (correlation coefficient = 0.70, p = 0.188; Table 4.6). Center B had the largest decrease in the percentage of 'poor' responses to this question, and Center A had the largest increase in the percentage of 'poor' responses for "would recommend this job."

#### *4.3.2.6.2 Obstacles to Getting Work Done on Time*

The increasing slopes for equipment use while resident handling were significantly correlated with a decrease in the percentage of work shifts involving obstacles to getting work done on time (-0.90, p = 0.037; Table 4.6).

Centers B and C were the two facilities with the steepest slopes for equipment use while resident handling over time, and they had the largest decreases in reported obstacles to getting work done on time. In addition to this, Center A, the facility with the weakest slope for equipment use and second weakest slope for the PWI, had the largest increases in obstacles to getting work done on time.

#### *4.3.2.6.3 Time Pressure*

In general, as the slopes for equipment use while resident handling over time became weaker, nursing assistants reported 'never' feeling time pressure less frequently (correlation coefficient = 0.90, p = 0.037; Table 4.6) (Figure 4.6).

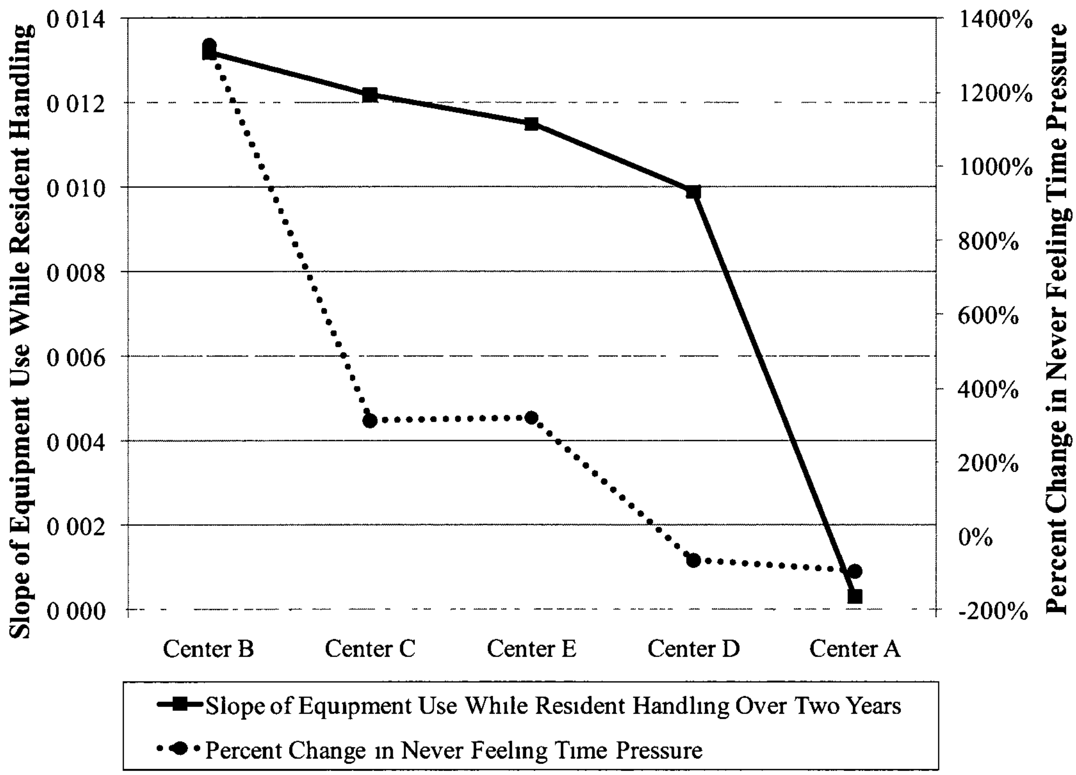



**Figure 4.6: Equipment Use While Resident Handling vs. Percent Change in Never Feeling Time Pressure**

The facility with the weakest slope for equipment use and second weakest slope for the PWI (Center A) had the largest decrease in 'never' feeling time pressure.

#### ***4.3.2.7 Interpersonal Relationships***

*4.3.2.7.1 Supervisor Support*

Weaker slopes for the PWI while resident handling were associated with increases in the percentage of supervisor support (correlation coefficient = 0.80, p = 0.104; Table 4.6). Center D, with the steepest negative slope for the PWI while resident handling (i.e., reduced physical workload), had the highest mean perceived supervisor support compared to the other facilities (Figure 4.7). Supervisor support scored highest for

Center D at each time period except baseline, and this was the only facility that reported increased supervisor support at the 24-month follow-up.

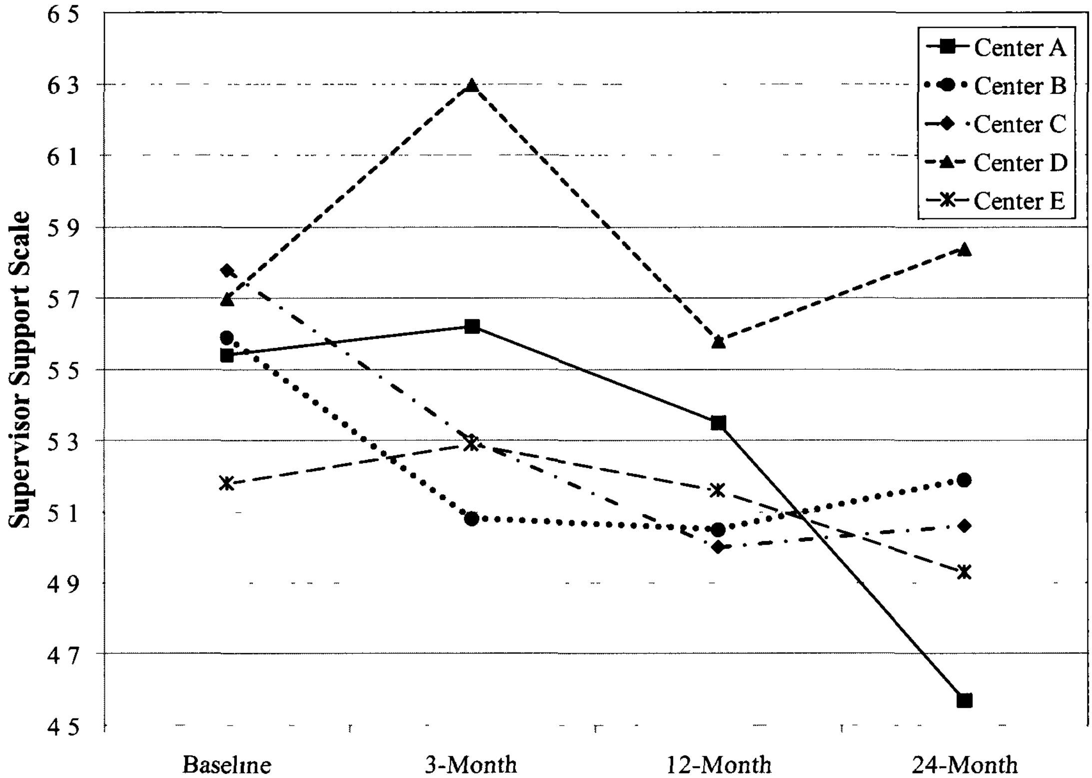



**Figure 4.7: Workers' Assessment of Supervisor Support over Time**

Center A, which had the smallest change in equipment use while resident handling and the second smallest change in the PWI, also had the largest decrease in perceived supervisor support over the 24-month follow-up (Table 4.5).

*4.3.2.7.2 Staff-to-Staff Communication*

As change in mean staff-to-staff communication decreased, the magnitude of the slope for the PWI decreased (correlation coefficient = -0.70, p = 0.188; Table 4.6) (Figure 4.8). In addition, increases in the percentage of 'poor' responses for staff-to-staff communication were significantly correlated with the slopes decreasing in magnitude for the PWI (1.0, $p < 0.0001$; Table 4.6) and the PWI while resident handling (0.90, $p = 0.037$; Table 4.6).

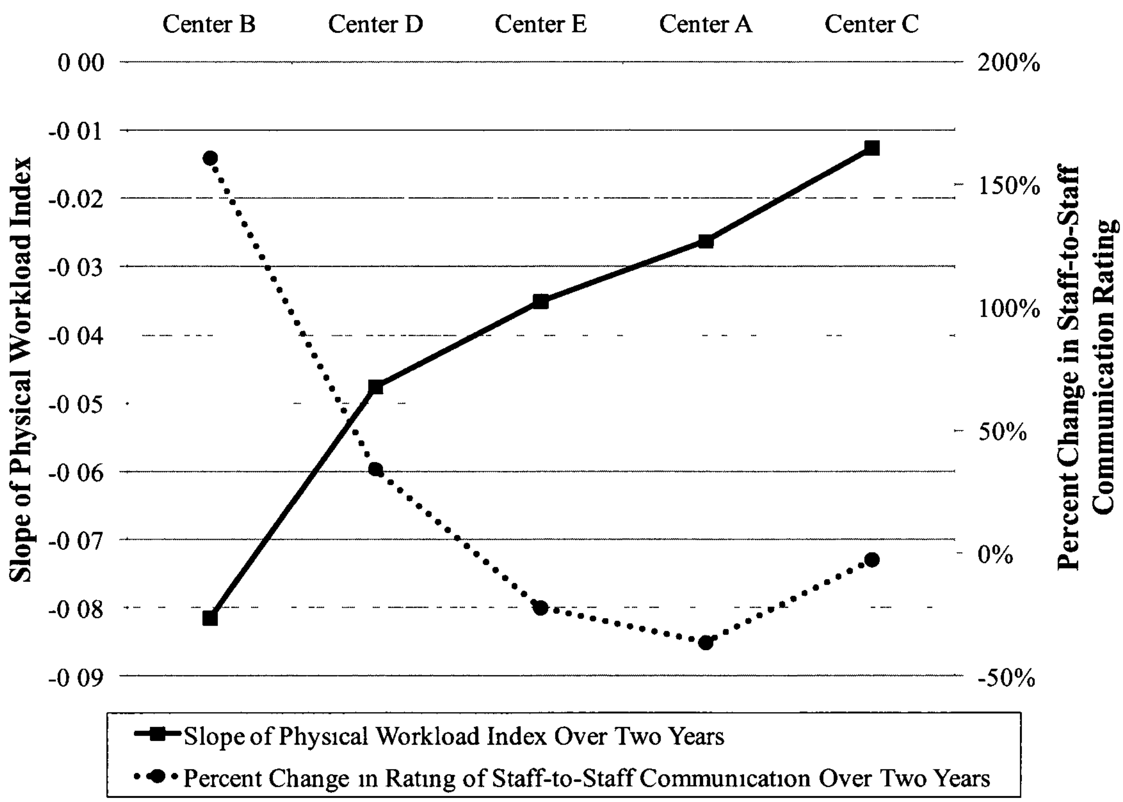



**Figure 4.8: Slope for Physical Workload Index vs. Percent Change in Perceived Staff-to-Staff Communication**

Center B, the facility with the steepest slope for equipment use while resident handling and the steepest negative slope for the PWI, had the largest increase in staff-to-staff communication and a corresponding decrease in the percentage of 'poor' responses to this question (Table 4.5). The largest decrease in staff-to-staff communication occurred at Center A, the facility with the weakest slope for equipment use while resident handling and a weak negative slope for the PWI. An increase in the percentage of 'poor' responses to this survey question was also reported at Center A (Table 4.5).

*4.3.2.7.3 Quality of Teamwork*

Increases in the percentage of 'poor' ratings for quality of teamwork were associated with weaker slopes for the PWI (correlation coefficient = 0.80, $p = 0.20$; Table 4.6), and significantly correlated with weaker slopes for the PWI while resident handling (1.0, $p < 0.0001$; Table 4.6). The facility with a weak negative slope for the PWI and the weakest slope for equipment use while resident handling over time (Center A) had an increase in the percentage of 'poor' responses to the quality of teamwork survey question. Additionally the largest decrease in mean quality of teamwork occurred at this facility (Table 4.5).

## 4.4 DISCUSSION

By the end of two years, all the facilities experienced decreases in the PWI and the PWI while resident handling and all facilities excluding Center A had more equipment use while resident handling compared to baseline. There were noticeable differences in these outcomes among facilities, however.

When considering the outcome measures, it appears that increasing equipment use influenced decreases in the PWI, as expected. In this study, it appears that more positive outcome measures were associated with positive changes in many explanatory factors such as nursing assistant turnover, the use of agency staff to fill shifts, recommendation for job, adequacy of equipment & supplies, staff-to-staff communication, 'never' feeling time pressure, shifts with obstacles to getting work done on time, and understaffing. Less positive outcome measures were associated with negative changes in these same explanatory factors.

The slope for equipment use while resident handling was related to more explanatory factors from the turnover and personal work factors domains, and the slope for the PWI was correlated with more explanatory factors from the facility characteristics, equipment factors, and interpersonal relationships domains. First-hand experience offered insight into the domains of explanatory factors associated with the outcome measures.

For example, when considering facility characteristics such as the rehabilitation populations in facilities which change frequently and result in changes in resident acuity and more variability in the day-to-day workload of nursing assistants. Rehabilitation units also have a high priority on getting patients moving on their own. The characteristics of this type of resident population affect the amount of handling equipment used which in turn affects physical workload.

Equipment factors such as high levels of baseline equipment usage would generally produce a population of nursing assistants already accustomed to safe resident handling practices, and the adequacy of supplies and equipment directly relates to the frequency of equipment used while resident handling and, in turn, the physical workload. In this study, centers with minimal observed baseline equipment use benefited the most from the intervention. These centers had steeper increases in equipment use while resident handling and decreases in physical workload.

Understaffed shifts leads to fewer workers to care for residents and the possibility of either not having enough staff or the lack of time to properly use equipment for transferring residents. Another staffing factor, the percentage of shifts staffed by agency nursing assistants, results in knowledge gaps, and regular employees must spend time reviewing care procedures for each resident. Extra time spent with agency staff may result in lack of time to properly use equipment.

Turnover of nursing assistants can lead to gaps in training and may result in less frequent effective use of handling equipment and a higher physical workload. Lower administrator turnover could hypothetically provide a higher level of management commitment to SRHPs which would, in turn, encourage increased use of equipment. In this study, however, higher administrator turnover rates were actually associated with slopes increasing in magnitude for the PWI. An explanation for this outcome is unclear.

The personal work factor, increased recommendation for the job, indicates more supportive work environments where equipment use would potentially be promoted.

Additionally, fewer obstacles to getting work done on time and never feeling time pressure may result in more time to properly use equipment.

Interpersonal relationships such as higher levels of perceived supervisor support suggest a higher level of management commitment to the SRHP or to employee well-being in general, influencing nursing assistants to use equipment more frequently to reduce their physical workload. Higher ratings of staff-to-staff communication and quality of teamwork could also result in more supportive work environments, more effective use of available equipment, and reduced physical workload.

To date, few studies have examined the impact of factors affecting successful SRHP interventions. Although most studies have not quantified determinants of effective safe resident handling programs, they have identified some barriers to success, including adequate staffing (Garg, 1992) and staff turnover rates (Li, 2004; Peterson, 2004; Charney, 2006). In this study, understaffing of shifts was strongly correlated with the PWI both overall and while resident handling. Nursing assistant turnover was associated with equipment use while resident handling, and the largest decrease in nursing assistant turnover was observed where equipment use increased the most and the PWI decreased the most. The largest increase in nursing assistant turnover was observed where equipment use increased the least and the change in the PWI was weaker. Decreasing totals of administrator turnover were correlated with slopes decreasing in magnitude for the PWI, and increasing totals of DON turnover were correlated with slopes increasing in magnitude for equipment use while resident handling. This direction of these correlations was unexpected, and future investigations should address this result.

### 4.4.1 Limitations and Strengths of This Study

In this study regression modeling was not an appropriate method for data analysis because of the small sample of facilities, so the effects of the explanatory factors could not be quantified. Computing correlation coefficients is useful for examining relationships, although statistical power was very limited.

Although these data were all longitudinal, there was no way to determine the temporal direction of the observed associations because both dependent and independent variables were measured over the same time period. For example, increase in equipment use was highly correlated with a decrease in obstacles to getting work done on time and with an increase in the percentage of 'never' feeling time pressure. It could be argued that these explanatory factors are either a cause or an effect of the increased use of handling equipment. A future analysis of these outcome measures on the individual level should help quantify the effects of explanatory factors through regression modeling.

The ergonomic observations were collected from a convenience sample focused on nursing assistants. A random sample of individuals might have been a more representative population, however convenience sampling was the only method used for recruiting participants in this study due to difficulties gaining individuals' consent and facility access limitations. The research team made every attempt to recruit nursing assistants across all types of units, patient populations, and seniority levels at each facility. Additionally, to standardize for any possible differences in work technique, the research team attempted to observe the same workers at each follow-up visit.

The response rates for the employee satisfaction survey varied among centers and across time periods, and it is possible that selection bias exists in this data source. The possibility of information bias in this data source also exists, since the investigators have no way of knowing how confidentiality was guaranteed to those completing the survey. If confidentiality was not properly insured, workers may have felt obligated to report socially acceptable answers on the survey. However, 'poor' ratings were reported at each time period for each of the five questions examined in this study, so it appears that honest responses were reported and this form of information bias is unlikely.

Selection bias and information bias are unlikely in the data collected in the questionnaire distributed by the investigators. Workers' responses were kept confidential and high response rates among centers and over time were recorded, indicating a low likelihood of bias in this data source.

Information bias resulting from observed workers providing socially acceptable answers to coversheet questions is unlikely as well. Observed employees usually develop a rapport with observers by the end of a work day resulting in honest replies. Additionally, responses to questions regarding understaffing and broken equipment, for example, can be verified by the investigators making the observations.

At baseline, few observation moments were collected at Center B due to logistical externalities, but narrow confidence intervals for the percentages of resident handling observations at each time period indicate that the variation in number of observation moments did not affect the outcome measures much.

Wellness program information was not provided for two of the five facilities, thus it was assumed that those facilities did not participate in wellness activities. It is possible, however, that the facilities have wellness programs which could change the outcome of that analysis. The opportunity to follow up with these facilities regarding wellness activities has been presented, though the results of the wellness program analysis suggest that the presence of a wellness program does not affect the outcome measures since it was observed that the two facilities with wellness programs experienced opposing results for outcome measures and some explanatory factors.

Currently there is not much literature on the topic of factors that affect SRHP effectiveness, so we relied on our own observations and information we learned from the staff. It is probable that there are other explanatory factors with higher correlations to the outcome measures. However the investigation of the explanatory factors in this study was not unsystematic; rather, it was informed by first-hand experience while conducting ergonomic observations in all of the facilities. This type of experience provided insight into the domains of explanatory factors that were associated with the outcome measures of interest.

A strength of this study is that the data were collected longitudinally. The only other study to examine factors impacting SRHPs was cross-sectional (Koppelaar, 2010) resulting in temporal ambiguity. Additionally, the observational method for collecting data allowed for systematic quantification of exposures in non-routinized jobs, and the large samples of observation moments collected at baseline and each follow-up period which helped create an extensive exposure profile for nursing assistants.

Because this study analyzed data from multiple work places within a single company, assessments across facilities were more comparable than centers owned by different companies. Information from the different sources was collected systematically across centers, reducing variability in data collection methods and reporting.

The mixed methods approach used in this study produced robust results. Because multiple data sources were used, the results were not solely dependent on one source of information such as worker self-report or administrative data.

**4.4.2 Conclusions**

Few studies have attempted to quantify the effects of factors that predict successful SRHP interventions. This study reported significant correlations between the outcome measures of equipment use while resident handling and the PWI with explanatory factors including the percentage of agency staff used to fill shifts, work shifts involving obstacles to getting work done on time, the percentage of 'never' feeling time pressure, adequacy of supplies and equipment, the percentage of 'poor' ratings for quality of teamwork, the percentage of 'poor' ratings for staff-to-staff communication, and the percentage of observed understaffed shifts.

In a future study expanding on this analysis, regression modeling could be used to examine the relationship between the outcome measures and explanatory factors on the individual level. There are 47 nursing assistants who were observed on at least two of the four time periods that could be part of the study population. Slopes for equipment use while resident handling and the PWI over time could be calculated and used as outcome measures. Data from questionnaires and coversheets are available for each individual at each time period, and explanatory factors from administrative data and employee satisfaction surveys could remain on the group level.

Factors that were highly correlated with the outcome measures in this study could become the basis for regression modeling. Many other factors from questionnaire responses and various sources of administrative data could also be considered for analysis including resident/staff ratios, resident mobility, psychosocial work exposures, self-rated health, health behaviors, internal locus of control, health self-efficacy, history of back pain, injuries, or surgery, job satisfaction, and organizational support for employee health.

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# CHAPTER V: CONCLUSIONS

## 5.1 OBJECTIVES

The overall aim of this dissertation was to evaluate the effects of a Safe Resident Handling Program (SRHP) on a population of nursing assistants and nurses in a series of nursing homes. Ergonomic exposures were collected at a pre-intervention baseline period and then three months, 12 months, 24 months and 36 months post-intervention in order to assess postures, manual handling activities and equipment use and calculate a physical workload index. These measures were used to evaluate the efficacy of the SRHP for nursing assistants overall and later by facility. Data from employee questionnaires, administrative data, employee satisfaction surveys, and post-observation exit interviews with observed employees were used to augment the analyses of observational data.

## 5.2 ACCOMPLISHMENTS

This dissertation demonstrated many benefits resulting from the implementation of a safe resident handling program. Analysis of observational data of nursing assistants while performing resident handling indicated decreased time spent in resident handling activities and increased use of resident handling equipment. The occurrence of neutral trunk postures had more than doubled, while flexed, twisted, and laterally bent postures decreased and the lifting of loads greater than fifty pounds decreased by the end of the follow-up period. Trends, both statistically significant as well as important in magnitude, were observed for decreased time spent resident handling, increased equipment use while resident handling, increased neutral trunk posture, increased incidence of working with arms below 60°, decreased static standing, and decreased handling loads greater than 50 pounds.

The physical workload decreased over the three years of follow-up for nurses and for nursing assistants both overall and specifically while resident handling. The Physical Workload Index (PWI) showed marked differences between scores for nurses and nursing assistants (0.91 vs. 1.31 at baseline). The index decreased by 24.2% for nursing assistants, by 40.9% for nursing assistants while resident handling, and by 2.5% for nurses by the end of the 36-month follow-up. At baseline, the PWI score for nursing assistants while resident handling was twice as high as their overall PWI score, but by the end of the follow-up, the resident handling PWI score was only about 50% larger than their overall PWI score.

This dissertation also examined the efficacy of the SRHP on a facility level by measuring changes in the PWI and in equipment use while resident handling. By the end of the follow-up period, the overall PWI as well as the PWI while resident handling had decreased for all facilities, and all facilities excluding one were using more equipment while resident handling compared to the baseline observations. However, the degree of improvement was not the same in all five centers. Positive changes in many explanatory factors appeared at the facility with the most positive outcome measures; the facility with the least positive outcome measures experienced negative changes in the same explanatory factors. Of the explanatory factors gathered from questionnaire responses, administrative data, employee satisfaction surveys, and coversheets, significant correlations related to the outcome measures included the percentage of agency staff used to fill shifts, work shifts involving obstacles to getting work done on time, the percentage of 'never' feeling time pressure, adequacy of supplies and equipment, the percentage of 'poor' ratings for quality of teamwork, the percentage of 'poor' ratings for staff-to-staff communication, and the percentage of observed understaffed shifts.

Together, the three studies presented successful reductions in harmful ergonomic exposures of nursing personnel following the SRHP and then examined explanatory factors for overall program success on the facility level. The first two studies examined overall changes in the physical exposures of nursing personnel. The study focusing on the Physical Workload Index utilized findings from the ergonomic exposure study in order to complete calculations for the PWI for nursing assistants and nurses. The third study in this dissertation used results from both of the previous studies as outcome measures for SRHP interventions. Equipment use while resident handling (results from the first study) and the PWI for nursing assistants (results from the second study) were used to measure the success of the SRHP at each facility.

**5.2.1 Limitations and Strengths of This Dissertation**

One of the main limitations of this dissertation is associated with the collection of ergonomic observations. The data was collected from a convenience sample of nursing assistants, due to facility access restrictions and obstacles involved with gaining workers' consent. Although a random sample of workers may have ensured a more representative population, the research team attempted to recruit employees working in different types of units and with different resident populations at each facility. Additionally, researchers attempted to observe the same workers at each follow-up period, to standardize for possible differences in work practices.

It is possible that some observer error may have led to misclassification of exposures. All observers, however, were required to attain IRR of at least 80% agreement and kappa scores of at least 0.6 in all variable categories prior to officially collecting data in order to limit the amount of random and systematic error due to observation.

Some assumptions were made concerning inputs for body postures, weight in hands, and anthropometry for the biomechanical model in the second study, which may have resulted in an underestimate of the compressive force on the L5/S1 joint. However, these assumptions were held for each of the five time periods pre- and post-intervention and reductions in the overall PWI occurred for all job categories examined. Additionally, the weight in hands categories of 'ten to 50 pounds' and 'greater than 50 pounds' consist of wide intervals and categorization of manual handling activities in this manner may have led to a loss of sensitivity to actual changes in weight in hands and an underestimate of compressive forces on the lumbar spine.

The median values of the trunk postures 'severe flexion' and 'lateral bent/twist flexed' may be lower than the midpoints that were used for calculating the PWI. The weighting factors for these categories may be somewhat overestimated, since moment arms about the trunk increase as flexion increases to 90°. The median values were held constant for calculations over the five time periods and across job titles, so bias between survey periods or job groups was unlikely.

A small sample of facilities was used for analysis in the third study of this dissertation, thus the effects of the explanatory factors could not be quantified. Additionally, although these data were all longitudinal, there was no way to determine the temporal direction of the observed associations because both dependent and independent variables were measured over the same time period.

The possibility for information bias and selection bias in the employee satisfaction survey data exists due to uncertainties in data collection strategies by a third party company as well as varied response rates among centers and across time periods. However, the possibility for selection bias and information bias in questionnaire, coversheet, and administrative data is unlikely.

To date, much of the research on SRHP interventions has focused on nurses in hospitals. Typically, these investigations have evaluated programs by examining injury and workers' compensation data or self-reported information. This dissertation, however, evaluated a SRHP focusing primarily on the outcomes of nursing assistants in nursing homes through the analysis of ergonomic observations of real-time workplace settings pre- and post-SRHP. This dissertation also utilized a three year follow-up period for post-intervention evaluation, while many prior studies have relied on shorter follow-ups.

The findings from this dissertation also quantified physical workload of nursing assistants with a biomechanical model based on direct observations. Prior biomechanical studies of lifting devices have been conducted in controlled laboratory settings with cooperative 'patients.' This type of evaluation does not consider the unpredictable nature of healthcare work, which can include much heavier residents, resistant or combative residents, space constraints, broken or missing equipment, uncooperative co-workers, and time pressure as well as many other variables. Direct observations of workers in nursing home settings capture more information regarding the variable nature of clinical work, particularly resident handling, and present a more informative picture about the actual physical workload of nursing home personnel.

The combination of observational data with compressive forces on the lumbar spine results in the PWI, which provides an output measure for the categorical PATH data which previously did not exist. This type of output measure may make the PATH method more marketable to other researchers in the future. The use of the PWI could easily be expanded to evaluate physical workload in many other occupational settings as well.

This was one of the first studies that attempted to identify factors associated with successful SRHPs. Since data was collected from work places within a single company, evaluations across facilities in this study are more comparable than facilities owned by different companies. The mixed methods approach used in this dissertation identified potential factors from multiple data sources, based on insight gained from interacting with nursing home personnel while conducting ergonomic observations. Information from the data sources was collected systematically across centers, thus limiting variability in data collection methods and reporting. Although the sample of facilities examined was small, explanatory factors identified in this dissertation should enhance the understanding of successful program implementation and motivate future investigations into this research area.

## 5.3 FUTURE RECOMMENDATIONS

### 5.3.1 Recommendations for Research

The sustainability of SRHPs is a topic that has not been reported on much in the literature. The studies in this dissertation utilized a 36-month follow-up which is longer than many studies; however long-term success should be further evaluated, particularly since the management of the SRHP has now been handed off from the third-party training company to the individual facilities. In the future, the success of these programs may differ from facility to facility even more than what has currently been reported on.

Many SRHP intervention studies have reported findings based on administrative data such as injury rates and workers' compensation claims. Future analyses comparing the changes in observed ergonomic exposures with changes in injury rates and workers' compensation claims at the centers would provide a more complete descriptive picture of the overall benefits from the increased use of resident handling equipment.

Rather than concentrating on all resident handling observations which include transporting and assisting with ambulation, future investigations of the observational data could focus more on repositioning and transferring observations. These two activities should benefit most from the SRHP since they require the use of lifting equipment. The need for additional training in the centers on other types of handling equipment is evident, particularly for repositioning since it accounts for about twice as much time as transferring. Nursing assistants could benefit from increased training for the usage of slide boards and slipsheets which are useful tools for eliminating stress on the body during lateral repositions.

Additional applications of the PWI could also be investigated in the future. Questionnaire responses regarding musculoskeletal symptoms could be examined to investigate possible relationships with the PWI. The PWI could be calculated for repositioning and transferring observations to determine the efficacy of the SRHP on these two resident handling activities. The index could be used for analysis of direct care tasks to determine the highest risk tasks performed by nursing assistants, so individual interventions could be considered. On the facility level, the PWI could be examined to determine which postures and manual handling activities contributed most to the index score for each facility so specific trainings and interventions could be planned.

Future investigations of the efficacy of the SRHP on the individual level would expand the understanding of individual differences, and could improve strategies for implementing interventions and training. To examine variability between individuals the PWI could be calculated using their anthropometric measurements and frequencies of postures and manual handling activities.

A future study utilizing regression modeling could examine the relationship for individuals between the outcome measures of the PWI as well as equipment use while resident handling and the explanatory factors identified from questionnaires, administrative data, employee satisfaction surveys, and coversheets. A total of 47 nursing assistants were observed on at least two of the four time periods and could be included in this investigation. Data from questionnaires and coversheets are available for each individual at each time period, and slopes for equipment use while resident handling over time and the PWI over time could be calculated and used as outcome measures. The explanatory factors that were highly correlated with the outcome measures in this dissertation could first be considered in the regression analysis, and additional factors from questionnaire responses and various sources of administrative data could also be considered.

This suggested future research would complement the findings of this dissertation and further explore the effects of the SRHP on the ergonomic exposures of nursing assistants. Outcomes from additional research would have the potential to improve the quality of the work environment for all healthcare workers.

**5.3.1 Recommendations for Practice**

The results from this dissertation have many implications for the long term care sector. Many benefits were associated with the SRHP. The less severe trunk, arm, and leg postures along with lighter loads handled and a reduced overall physical workload post-intervention result in reduced loading on the musculoskeletal system including the lumbar spine, shoulders and knees, leading to possible injury reduction for nursing personnel. Additionally, several factors were identified as being beneficial or detrimental to the success of the SRHP.

The nursing home industry could benefit from reviewing the explanatory factors for the implementation of a successful SRHP identified in this dissertation. Ensuring adequate staffing levels alone could affect positive changes in many of the identified factors, as well as the outcome measures. For example, facilities with less understaffing, generally relied on less frequent use of agency staffing, and saw less turnover of nursing assistants. These facilities also had improvements in mean staff-to-staff communication and job satisfaction over time. The facilities with the least understaffing also had the largest increases in equipment use while resident handling over time and the largest decreases in the PWI over time. If a conscious effort was made to assuring adequate staffing levels at facilities, the long term care sector could experience great success in implementing SRHPs, thus reducing injuries and providing safer work environments for nursing home personnel.

# APPENDIX A: PATH TEMPLATE

**PATH Resident Handling and Environment of Care Template (60 seconds)**

| Worker Number: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Worker | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Trunk Angle** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Neutral <20 | | | | | | | | | | |
| Mod Flex ≥20 - <45 | | | | | | | | | | |
| Severe Flex ≥45 | | | | | | | | | | |
| Lat Bent/Twist Neutral | | | | | | | | | | |
| Lat Bent/Twist Flexed | | | | | | | | | | |
| Bent Backwards >10 | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Leg Action** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Stand (flex <35) | | | | | | | | | | |
| Walking/Running | | | | | | | | | | |
| Sitting | | | | | | | | | | |
| Lunge (1 knee ≥35) | | | | | | | | | | |
| Kneeling (1 or both) | | | | | | | | | | |
| Shallow Squat (kn's >35 <80) | | | | | | | | | | |
| Deep Squat (both kn's ≥80) | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Arm Angle** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Both arms <60 | | | | | | | | | | |
| 1 arm ≥60 | | | | | | | | | | |
| 2 arms ≥60 | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Weight in Hands (lbs)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| < 10 lbs | | | | | | | | | | |
| ≥10 - <50 lbs | | | | | | | | | | |
| ≥50 - <150 lbs | | | | | | | | | | |
| ≥150 lbs | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Manual Handling** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No MH | | | | | | | | | | |
| 1 hand | | | | | | | | | | |
| 2 hands | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Manual Handling Action** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No MH | | | | | | | | | | |
| Carry/Hold | | | | | | | | | | |
| Push/Pull/Drag | | | | | | | | | | |
| Lift/Lower | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Resident Handling Activity** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No RH | | | | | | | | | | |
| Reposition | | | | | | | | | | |
| Transfer | | | | | | | | | | |
| Ambulation Assist | | | | | | | | | | |
| Transport | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Team Handling** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No RH | | | | | | | | | | |
| Yes | | | | | | | | | | |
| No | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Resident Status** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No RH | | | | | | | | | | |
| Independent | | | | | | | | | | |
| Partial Assist | | | | | | | | | | |
| Total Assist | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Resident Compliance** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No RH | | | | | | | | | | |
| Compliant | | | | | | | | | | |
| Resistant | | | | | | | | | | |
| Combative | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |

| **Handling Equipment** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| No RH Equip | | | | | | | | | | |
| Gait Belt | | | | | | | | | | |
| Slide Board | | | | | | | | | | |
| Slipsheet | | | | | | | | | | |
| Sit/Stand Lift | | | | | | | | | | |
| Total Body Lift | | | | | | | | | | |
| Other Device | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Other Equipment** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No Other Equip | | | | | | | | | | |
| Walker | | | | | | | | | | |
| Geriatric Chair | | | | | | | | | | |
| Shower Chair | | | | | | | | | | |
| Wheelchair | | | | | | | | | | |
| Stretcher/Bed | | | | | | | | | | |
| Med Cart | | | | | | | | | | |
| Other Cart | | | | | | | | | | |
| IV Pump | | | | | | | | | | |
| Other Misc Equip | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Direct Care Tasks** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No Direct Care | | | | | | | | | | |
| Dress/Undress | | | | | | | | | | |
| Feeding | | | | | | | | | | |
| Bath/Groom | | | | | | | | | | |
| Toileting | | | | | | | | | | |
| Resident Handling | | | | | | | | | | |
| Patient/Family Counsel | | | | | | | | | | |
| Diligent Watch | | | | | | | | | | |
| Other Care | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Medical Tasks** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No Medical | | | | | | | | | | |
| Vital Signs | | | | | | | | | | |
| Med Prep/mix | | | | | | | | | | |
| Give Meds | | | | | | | | | | |
| Wound Care | | | | | | | | | | |
| Other Medical | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Admin Tasks** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No Admin | | | | | | | | | | |
| Paper | | | | | | | | | | |
| Computer | | | | | | | | | | |
| Meet/Train | | | | | | | | | | |
| Phone | | | | | | | | | | |
| Other Admin | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Other Tasks** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| No Other | | | | | | | | | | |
| Housekeeping | | | | | | | | | | |
| Food Prep/Deliver | | | | | | | | | | |
| Retrieve/Replace Equip | | | | | | | | | | |
| Universal Precaution | | | | | | | | | | |
| Break | | | | | | | | | | |
| Other Misc Tasks | | | | | | | | | | |
| **Work Area** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Bedroom | | | | | | | | | | |
| Bathroom | | | | | | | | | | |
| Shower Room | | | | | | | | | | |
| Dining Area | | | | | | | | | | |
| Common Area | | | | | | | | | | |
| Common Hallway | | | | | | | | | | |
| Linen/Supply Closet | | | | | | | | | | |
| Nursing Station | | | | | | | | | | |
| Rehab Room | | | | | | | | | | |
| Office | | | | | | | | | | |
| Other Area | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |
| **Space Contstraints** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Unrestricted | | | | | | | | | | |
| Restricted | | | | | | | | | | |
| Not Obs/Not Sure | | | | | | | | | | |

| | |
|---|---|
| Analyst: | |
| Date: | |
| Job Title: | |
| Facility | |
| Start Time | |
| End Time | |

# APPENDIX B: PATH COVERSHEET

# "PRO-CARE" Project Cover Sheet

**Pre-Observation Data**

**REPEAT Individual** ○ YES ○ NO

If YES,
*prior observation dates:* ☐☐ / ☐☐ / ☐☐☐☐

☐☐ / ☐☐ / ☐☐☐☐

☐☐ / ☐☐ / ☐☐☐☐

**PATH Template Name:** ☐☐☐ **PDA Name*** e.g. PEAT 1 ☐☐☐☐☐

**PATH Template Version:** ○ 1.6 ○ 1.7 ○ 1.8 ○ 1.9

**1. Descriptive Data (Observer)**

Date ☐☐ / ☐☐ / ☐☐☐☐ Business Unit # ☐☐☐☐☐

Facility: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Analyst Initials: ☐☐ Analyst ID ☐☐ Department ○ Staff Nursing ○ Mngmnt/Admin

Area ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Unit: ○ Long Term Care ○ Dementia/Homestead ○ Acute/Sub-acute Care/REF ○ Assisted Living

Job Title ○ CNA/GNA ○ CMA ○ LPN ○ RN ○ Unit Coordinator

First Observation Start Time ☐☐ : ☐☐ ○ AM ○ PM First Observation End Time: ☐☐ : ☐☐ ○ AM ○ PM

Second Observation Start Time: ☐☐ : ☐☐ ○ AM ○ PM Second Observation End Time ☐☐ : ☐☐ ○ AM ○ PM

Comments: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Strong/noticeable odors upon arrival in the work area. ○ YES ○ NO

Housekeeping

| ☐ Poor | ☐ Fair | ☐ Good | ☐ Very Good |
|---|---|---|---|
| dirty and poor storage of materials | housekeeping is fair; some clutter on pedestrian traffic routes | neat and orderly; some clutter but generally contained | well controlled storage and cleanliness |

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# "PRO-CARE" Project Cover Sheet

## 2. Shift Information (Supervisor)

Shift start time [ ][ ]:[ ][ ] O AM O PM    End time [ ][ ]:[ ][ ] O AM O PM

Days per week [ ] Days    Shift: O Day O Evening O Night

Comments: [ ]

## 3. Staffing Conditions

a) Unit Staffing by job title

| | Scheduled | Actual | | Scheduled | Actual |
|---|---|---|---|---|---|
| CNA/GNA | | | RN | | |
| CMA | | | Unit Manager | | |
| LPN | | | Other | | |

b) Number of residents [ ]

c) Anyone on restricted duty/light duty from same job title? O YES O NO

Comments [ ]

f) Any broken or missing equipment that affected the workday? O YES O NO

Comments [ ]

## 4. Worker Observed

First name [ ]    Worker ID [ ]

Last name [ ]

Sex: O Male O Female    Race: [ ]    Latino: O YES O NO O DK

# of years or months on this job: Years [ ] Months [ ]

A few descriptors: hair color/style, clothes, height, build, etc [ ]

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# "PRO-CARE" Project Cover Sheet

**Post Observation Data**

**5. Static Posture(s)**

How often did the employee perform tasks that required static posture of long duration?

***List tasks here:***

| | | | | |
|---|---|---|---|---|
| | O Always | O Often | O Sometimes | O Never |
| | O Always | O Often | O Sometimes | O Never |
| | O Always | O Often | O Sometimes | O Never |
| | O Always | O Often | O Sometimes | O Never |

**Ever Seated:** O YES O NO

A. How often is a backrest used for body support?

O Always O Often O Sometimes O Never O No Backrest

B. How often is a shoulder support or armrest used?

O Always O Often O Sometimes O Never O No Armrests

**Ever Standing:** O YES O NO

A. How often is a floor mat used?

O Always O Often O Sometimes O Never O no floor-mat

B. How often is a foot rest used?

O Always O Often O Sometimes O Never O no footrest

**Work Routinization:**

O (1)Single Routine Task O (2)Multiple Routine Tasks O (3)Single Variable Task O (4)Multiple Tasks, Mixed O (5)Multiple Variable Tasks (no cycle)

**VDU Operation:**

**Does the employee rely on a computer for any part of their daily routine?** O YES O NO

**Responsibility for safety and health of other EMPLOYEES:**

O (9)N/A

O (1)Very limited (worker bears little responsibility for safety of others)

O (2)Limited (Worker responsible for safety of others within narrow limits)

O (3)Average (Worker must maintain periodic vigilance to ensure others are not injured by his/her actions or inattention)

O (4)Significant (Continual care to ensure safety of others; constant vigilance)

O (5)Very Significant (Safety of others depends mainly on the corrective actions of worker)

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# "PRO-CARE" Project Cover Sheet

**Responsibility for safety and health of RESIDENTS:**

- O (9)N/A
- O (1)Very limited (worker bears little responsibility for safety of others)
- O (2)Limited (Worker responsible for safety of others within narrow limits)
- O (3)Average (Worker must maintain periodic vigilance to ensure others are not injured by his/her actions or inattention)
- O (4)Significant (Continual care to ensure safety of others; constant vigilance)
- O (5)Very Significant (Safety of others depends mainly on the corrective actions of worker)

**Resident Handling Equipment:**

**A. Gait Belt:**

- O None Used
- O Single strap belt type without any handles
- O Wide material with vertical handle straps
- O Other (describe)

**B. Slide Board: (check all that apply)**

- O None Used
- O Wood with no handles
- O Hard plastic with poor coupling
- O Hard plastic with good coupling
- O Hard plastic with embedded pivot disc
- O Other

**C. Whole Body Lifts: (check all that apply)**

O None Used O Electronic Controls O Hydraulic Hand Pump

**D. Sit-Stand Device: (check all that apply)**

O None Used O Electronic Controls O Hydraulic Hand Pump

**E. Friction Reducing Devices (slip sheets): If used, were handles present?**

O None Used O Regular sheet O Yes handles present O No handles present

**F. If other resident handling equipment was used, check all that apply:**

- O No other equipment used
- O Inflatable transfer mat used (e.g. "Hover" Mat)
- O Lateral Transfer machine or device used (e.g. "ON3" Machine, Phil-E-Slide friction reducing devices). Specify:

**G. Other unusual equipment**

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# "PRO-CARE" Project Cover Sheet

**Hazard Checklist (check the frequency category that applies)**

| | Always | Often | Sometimes | Never |
|---|---|---|---|---|
| a) Poor IAQ: | O | O | O | O |
| b) Latex gloves used: | O | O | O | O |
| c) Vinyl gloved use: | O | O | O | O |
| d) Other gloves used: | O | O | O | O |
| Other Glove Type: | | | | |
| e) Other PPE: | O | O | O | O |
| Specify: | | | | |
| f) Chem: Hazardous chemicals are used during the shift | O | O | O | O |
| g) Sharps: Use of contaminated needles or other sharps required by task | O | O | O | O |
| h) Cuts: Task requires working with or near sharp objects: | O | O | O | O |
| i) STF: Slip trip and fall hazards, check if slippery (wet) surface, cluttered floors, or if climbing stairs ladders, stools, etc. | O | O | O | O |
| j) Hi-Volt: Potential contact with high voltage sources during job | O | O | O | O |
| k) Burn: Task(s) performed near hot surfaces, objects, or substances (food trays, water, etc) | O | O | O | O |
| l) Mach: Tasks performed in the vicinity of moving parts (such as lifts, beds, or other devices) | O | O | O | O |

## Exit Interview Questions

Were you working under any deadlines during this period? O YES O NO

If Yes, what deadlines

A

B

Do these deadlines happen often? O YES O NO

Tell me more about one of these deadlines

Nature of deadline

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# "PRO-CARE" Project Cover Sheet

**Were there any obstacles to getting your work done on time today?** O YES O NO

If Yes, what was the biggest obstacle?

**Does the workload in this department differ over the course of a week?** O YES O NO

**Does the workload in this department differ from one month to the next?** O YES O NO

**Does the workload in this department differ from this season compard to other times of the year?** O YES O NO

**Was this a typical work day?** O YES O NO

If No, comments from employee.

**Observer comments re: typical work day**

**Rest/recovery time (during this time period only):**

**Check ALL that apply**

O I took formal breaks Total # of minutes=

O I took formal meals Total # of minutes=

O I took informal breaks for a quick sit, chat, etc. Total # of minutes=

O I did not take any formal breaks nor any formal meals

**High Time Pressure:**

O Always O Often O Sometimes O Never

Comment:

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## "PRO-CARE" Project Cover Sheet

Possible comment topics. Teamwork/coworker relationships; supervisory relationships; staffing problems; issues with resident handling equipment; data collection errors; data analysis questions.

**Note 1**

**Note 2**

**Note 3**

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# "PRO-CARE" Project Cover Sheet

Note 4

Note 5

Note 6



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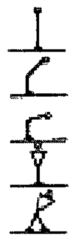
# APPENDIX C: SURVEY ON FREQUENCIES OF PHYSICAL EXPOSURES AT WORK [1]

[1] Hollman, S , Klımmer, F , Schmıdt, K H , Kylıan, H , 1999 Valıdatıon of a questıonnaıre for assessıng physıcal work load Scandınavıan Journal of Work Envıronment and Health, 25(2) 105-114

**Musculoskeletal load due to body posture and strenuous effort during work**

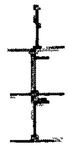
Please estimate, how often you have to work with the body postures displayed below, and how often you have to lift or to carry the weights mentioned below.
Please fill up all lines!

**Trunk**



| | never | seldom | sometimes | often | very often |
|---|---|---|---|---|---|
| straight, upright | | | | | |
| slightly inclined | | | | | |
| strongly inclined | | | | | |
| twisted | | | | | |
| laterally bent | | | | | |

**Arms**



| | never | seldom | sometimes | often | very often |
|---|---|---|---|---|---|
| both arms below shoulder height | | | | | |
| one arm above shoulder height | | | | | |
| both arms above shoulder height | | | | | |

**Legs**

| | never | seldom | sometimes | often | very often |
|---|---|---|---|---|---|
| sitting | | | | | |
| standing | | | | | |
| squatting | | | | | |
| kneeling with one knee or with both | | | | | |
| walking, moving | | | | | |

**Weight, lifted / carried with upright trunk**

| | never | seldom | sometimes | often | very often |
|---|---|---|---|---|---|
| light (up to 10 kg) | | | | | |
| medium (10 - 20 kg) | | | | | |
| heavy (more than 20 kg) | | | | | |

**Weight, lifted / carried with inclined trunk**

| | never | seldom | sometimes | often | very often |
|---|---|---|---|---|---|
| light (up to 10 kg) | | | | | |
| medium (10 - 20 kg) | | | | | |
| heavy (more than 20 kg) | | | | | |

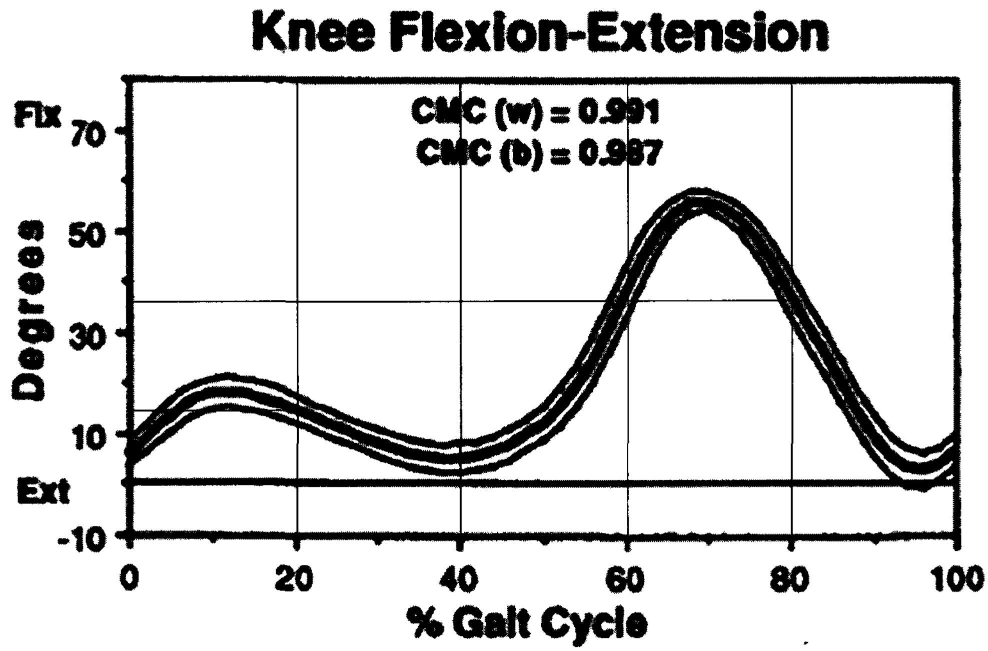
# APPENDIX D: EQUATION FOR BIOMECHANICAL MODEL OF LUMBAR LOADING [2]

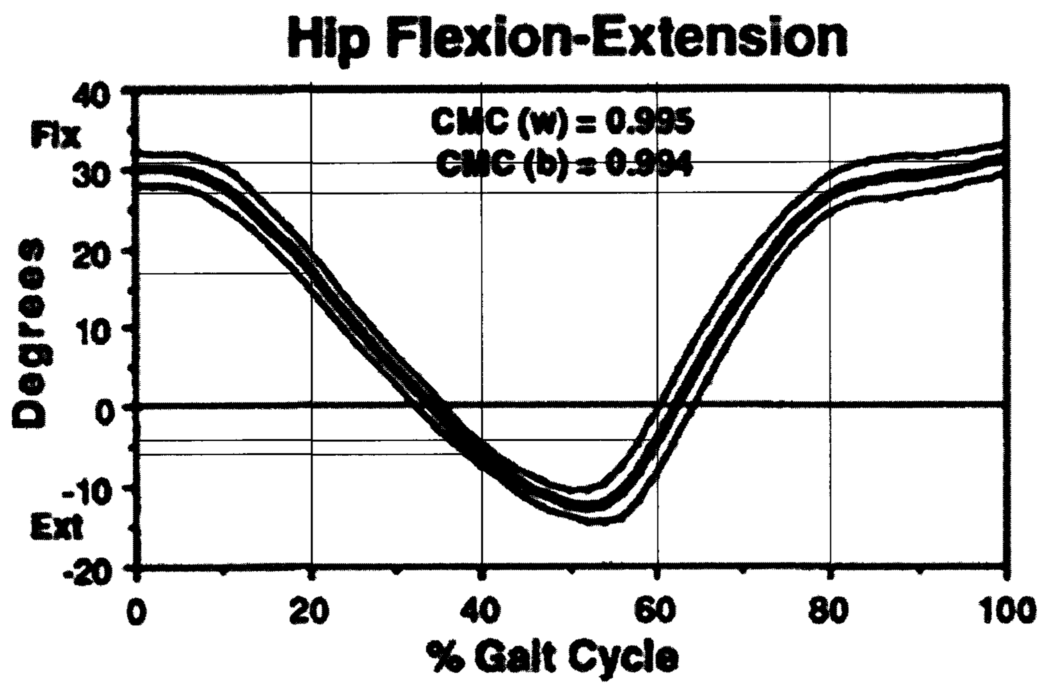
[2] Hollman, S , Klımmer, F , Schmıdt, K H , Kylıan, H , 1999 Valıdatıon of a questıonnaıre for assessıng physıcal work load Scandınavıan Journal of Work Envıronment and Health, 25(2) 105-114

Index of physical work load = 0.974 × score of T2 + 1.104 × score of T3 + 0.068 × score of T4 + 0.173 × score of T5 + 0.157 × score of A2 + 0.314 × score of A3 + 0.405 × score of L3 + 0.152 × score of L4 + 0.152 × score of L5 + 0.549 × score of Wu1 + 1.098 × score of Wu2 + 1.647 × score of Wu3 + 1.777 × score of Wi1 + 2.416 × score of Wi2 + 3.056 × score of Wi3, where T1 = straight, upright (trunk bent 5 degrees forward), T2 = slightly inclined (trunk bent 45 degrees forward), T3 = strongly inclined (trunk bent 75 degrees forward), T4= twisted, T5 = laterally bent, A1= 2 arms below shoulder height, A2 = 1 arm above shoulder height, A3 = 2 arms above shoulder height, L1 = sitting, L2 = standing, L3 = squatting (trunk bent 15 degrees forward), L4 = kneeling with one or both knees, L5 = walking or moving, Wu1-Wu3 = lifting with the trunk upright, and Wi1-Wi3 = lifting with the trunk inclined 60 degrees. The item scores were coded as follows. "never" = 0, "seldom" = 1, "sometimes" = 2, "often" = 3, "very often" = 4.

# APPENDIX E: INTERPOLATED HIP AND KNEE ANGLES FOR WALKING [3]

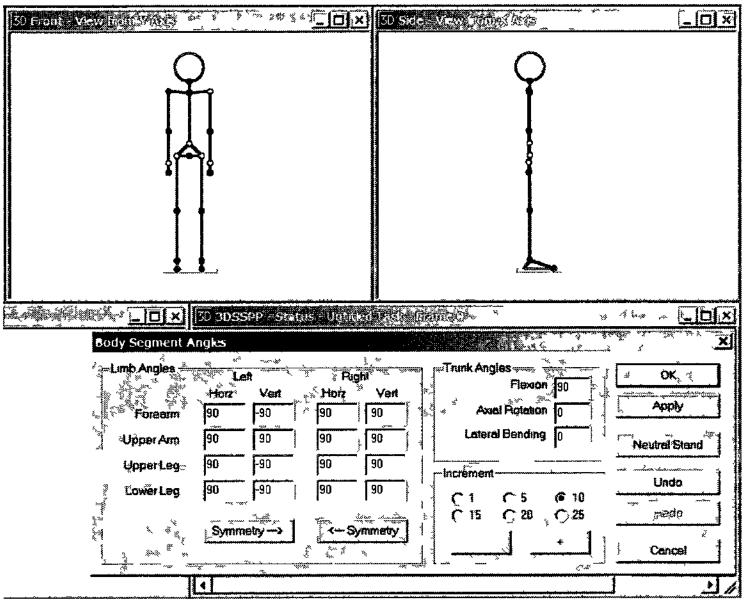
[3] Kadaba, M P , Ramakrıshnan, H K , Wooten, J , Gaıney, G , Gorton, G , Cochran, G V B , 1989 Repeatabılıty of kınematıc, kınetıc, and electromyographıc data ın normal adult gaıt Journal of Orthopaedıc Research, 7(6) 849-860

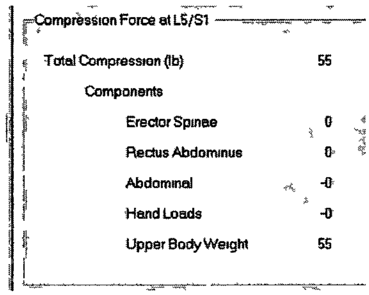

Knee Flexion-Extension
CMC (w) = 0.991
CMC (b) = 0.987
Flx
Ext
Degrees
70
50
30
10
-10
0
20
40
60
80
100
% Gait Cycle


Hip Flexion-Extension
CMC (w) = 0.995
CMC (b) = 0.994
Flx
Ext
Degrees
40
30
20
10
0
-10
-20
0
20
40
60
80
100
% Gait Cycle

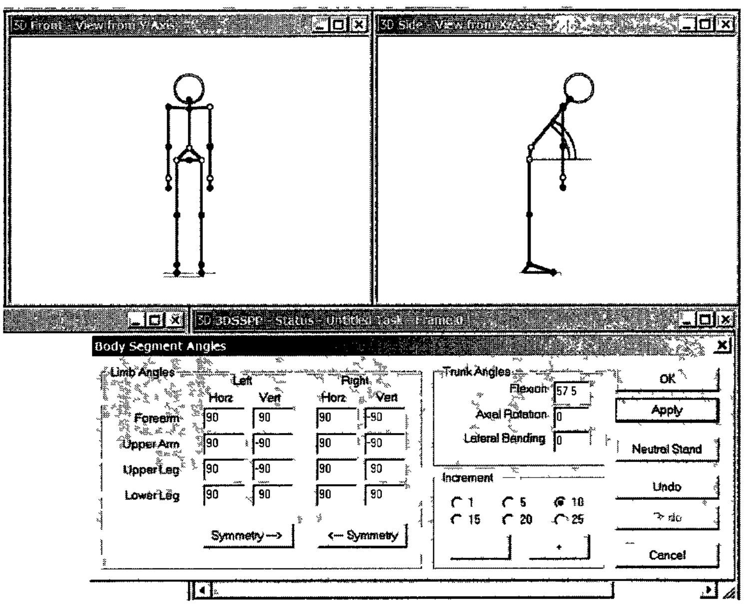
# APPENDIX F: 3DSSPP INPUT AND OUTPUT

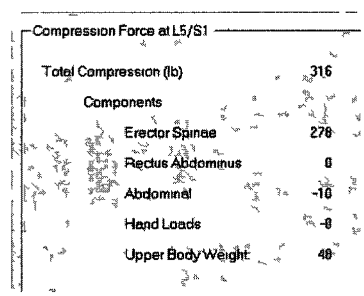
T1: Neutral Stand



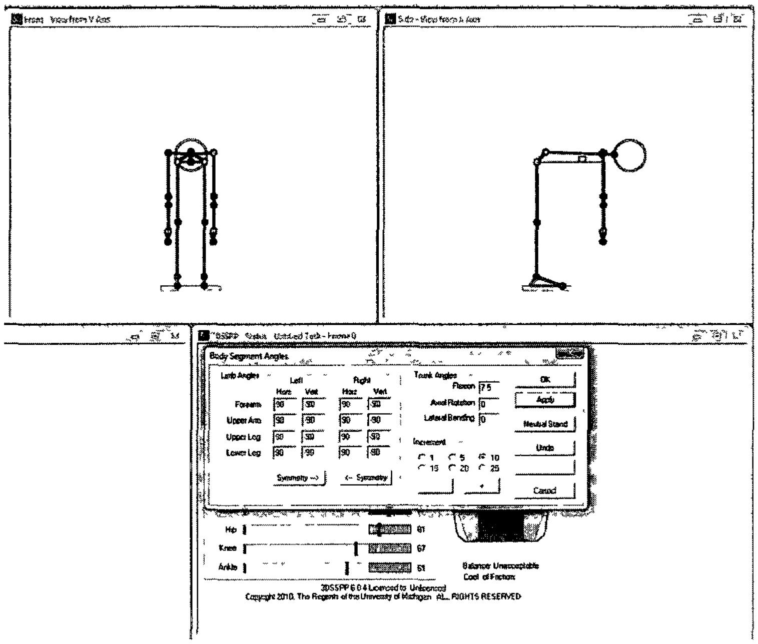



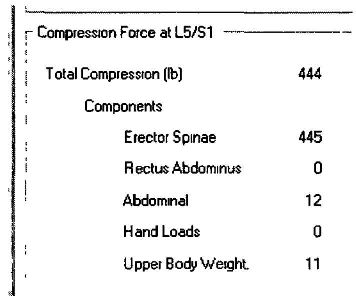

T2: Moderate Flexion



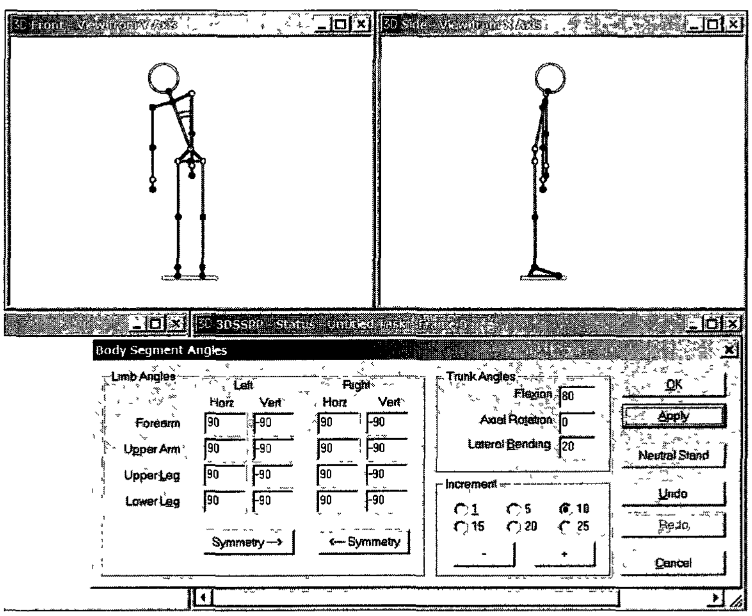



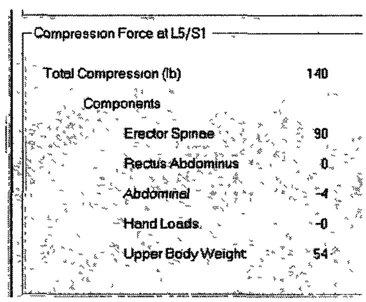
# T3: Severe Flexion



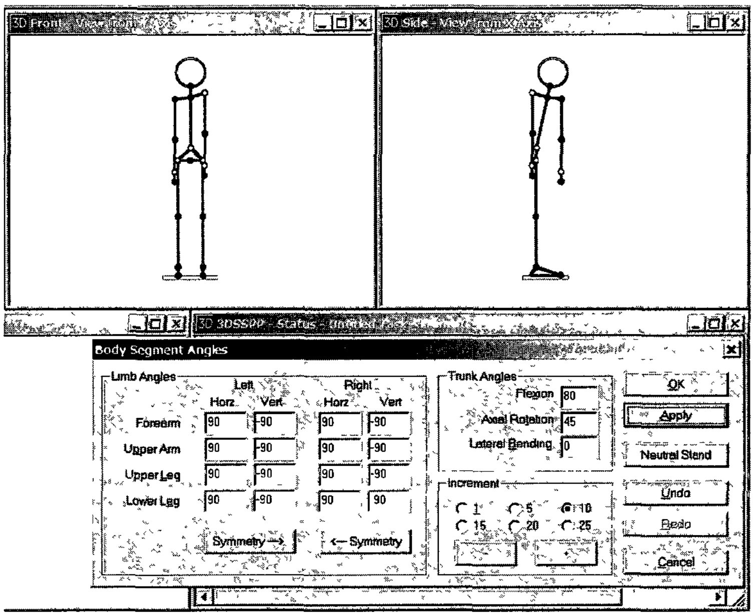


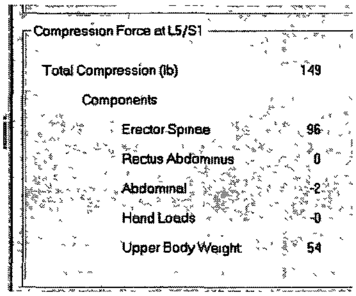

# T4: Lateral Bent/Twist Neutral (Bent)



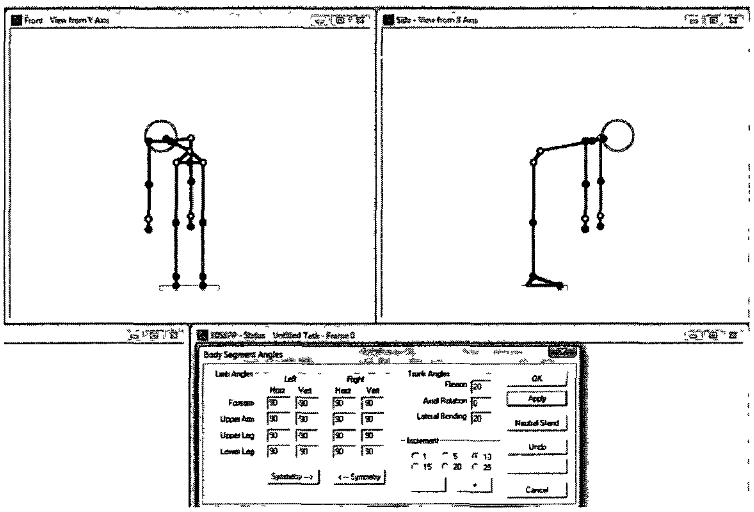



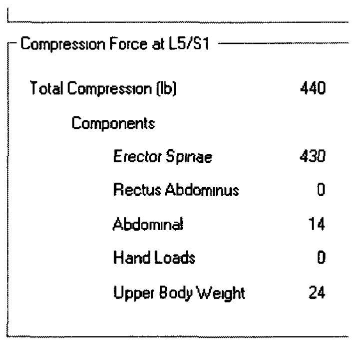
T4: Lateral Bent/Twist Neutral (Twisted)



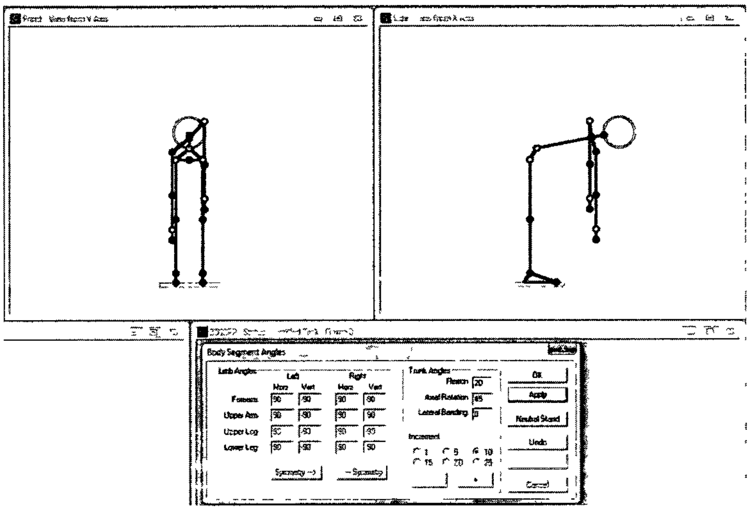


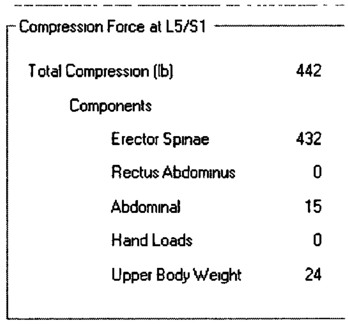

T5: Lateral Bent/Twist Flexed (Bent)



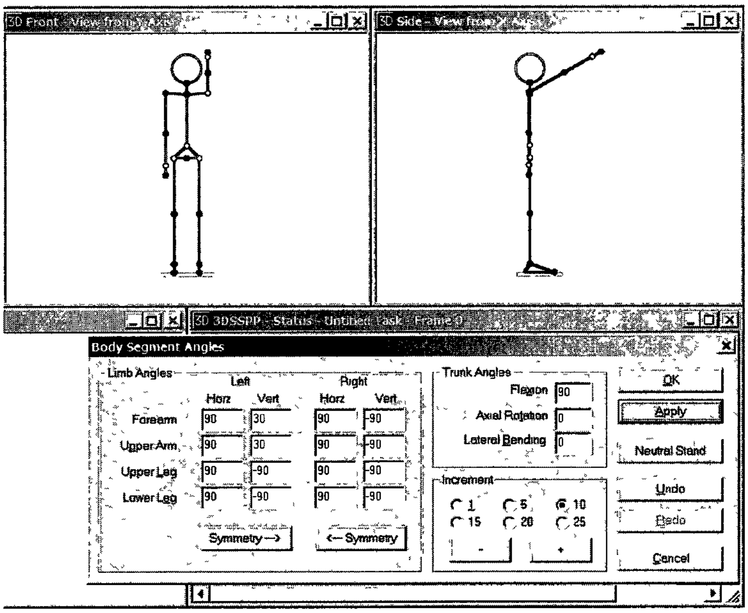


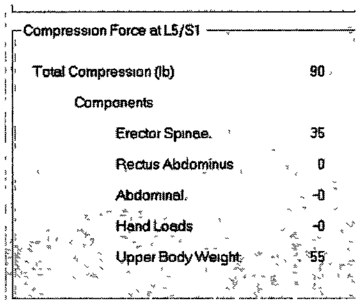
T5: Lateral Bent/Twist Flexed (Twisted)



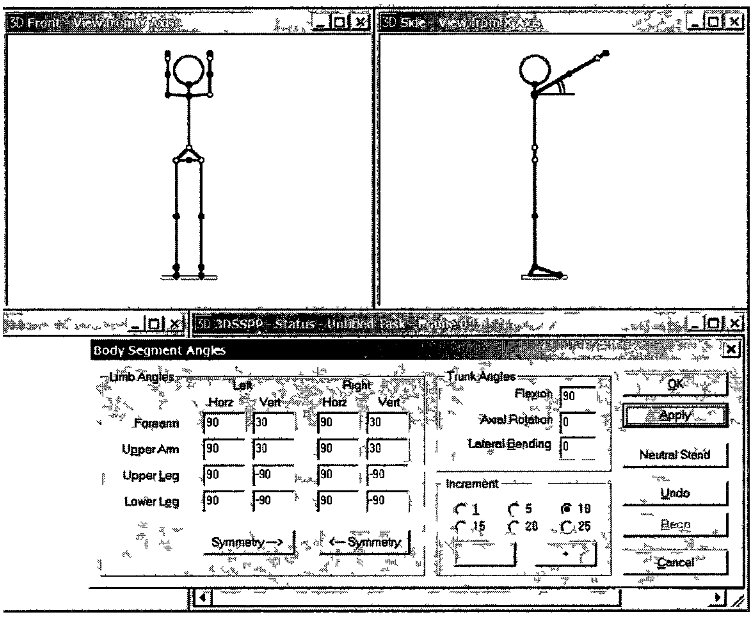


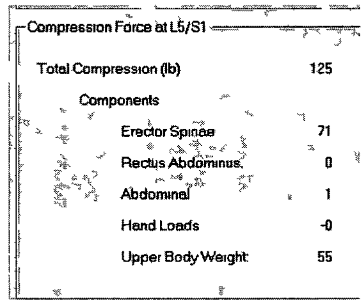

A2: 1 Arm > 60



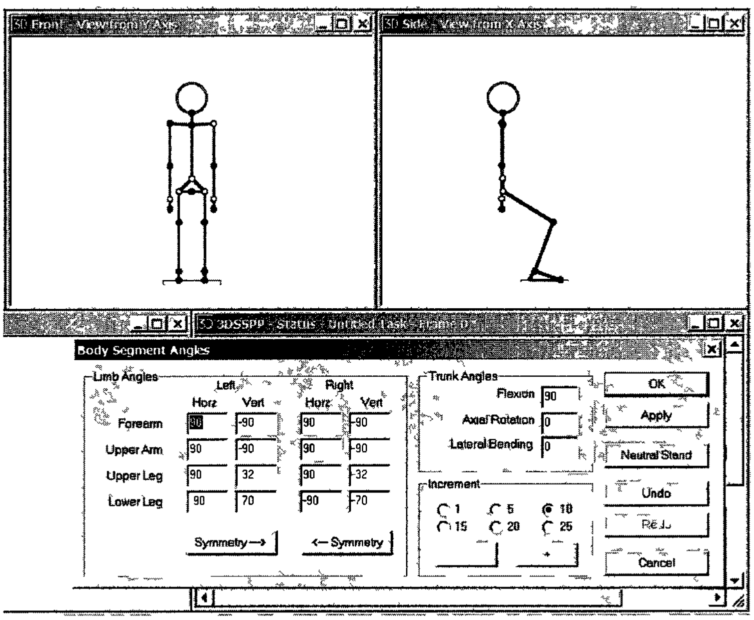



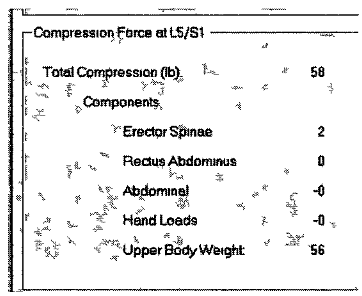
A3: 2 Arms > 60



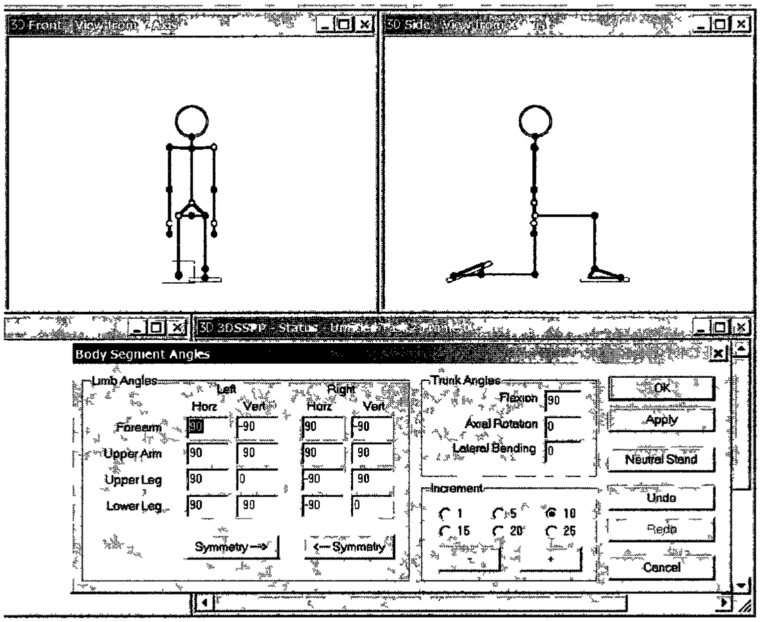


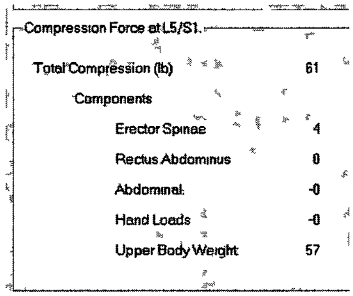

L3: Shallow Squat



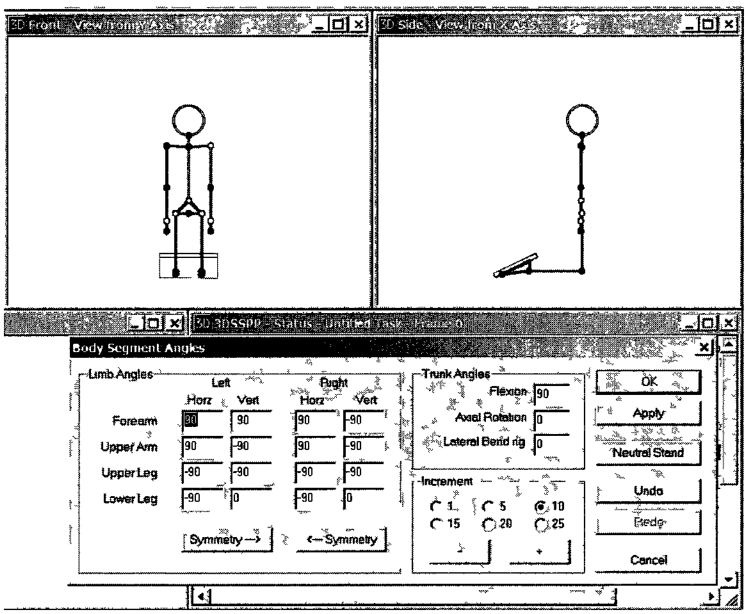


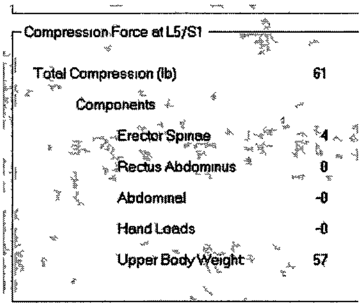
L4: Kneeling (1 Knee)



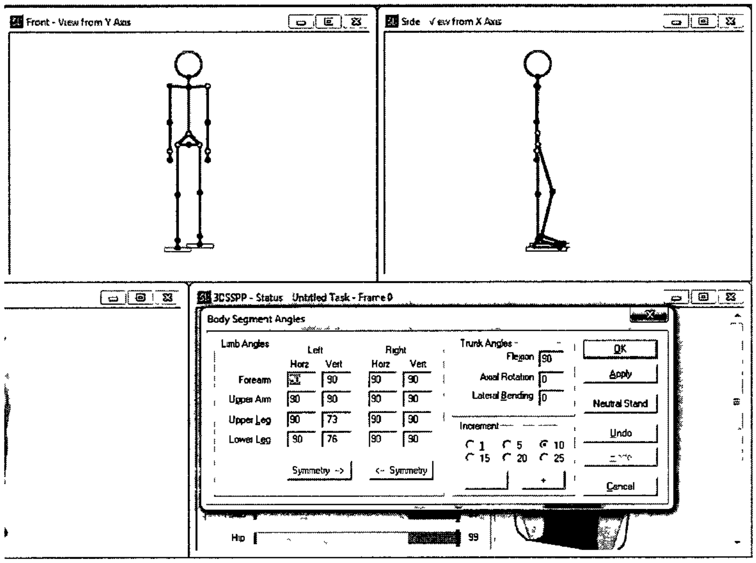




L4· Kneelıng (Both Knees)



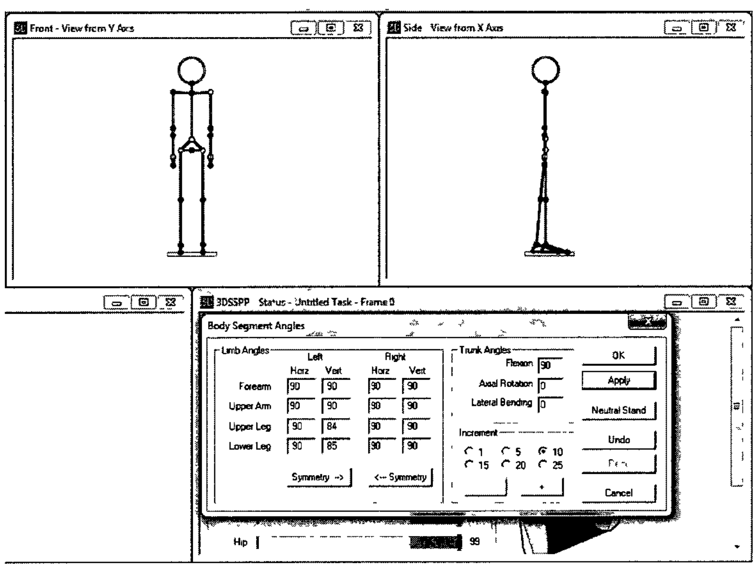



## L5: Walk (Part 1: 20% Gait Cycle)



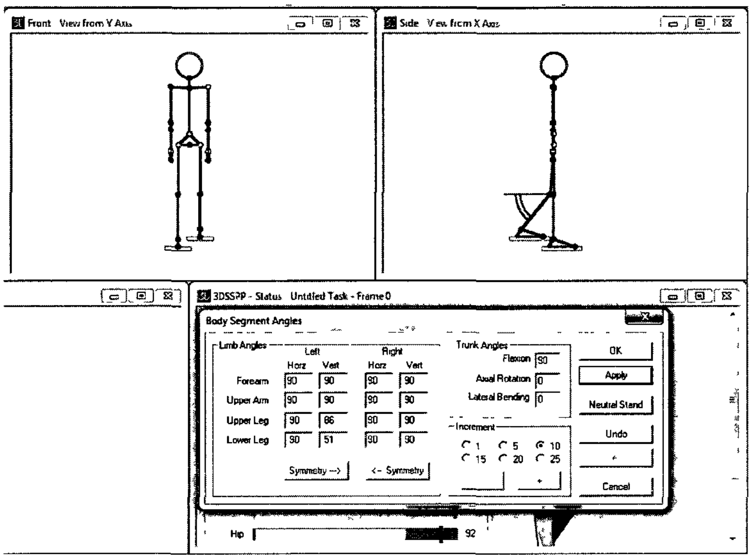

| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 56 |
| Components | |
| Erector Spinae | 0 |
| Rectus Abdominus | 1 |
| Abdominal | 0 |
| Hand Loads | 0 |
| Upper Body Weight | 55 |

## L5: Walk (Part 2: 40% Gait Cycle)




| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 73 |
| Components | |
| Erector Spinae | 0 |
| Rectus Abdominus | 2 |
| Abdominal | 0 |
| Hand Loads | 16 |
| Upper Body Weight | 55 |

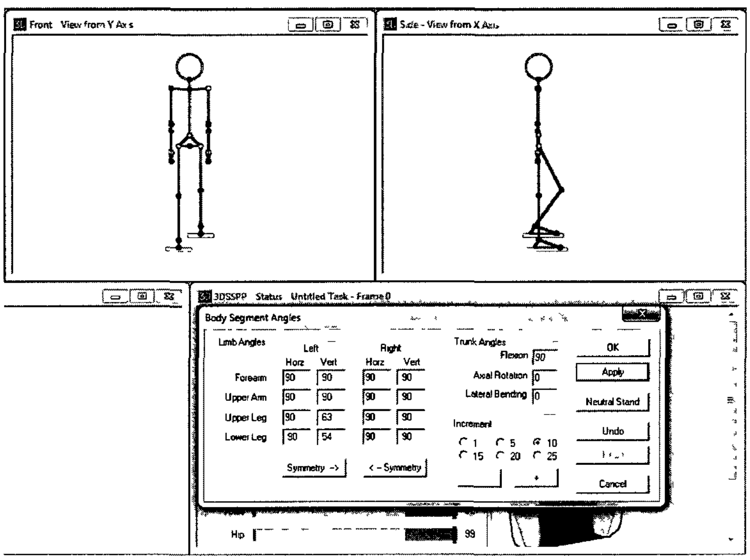
L5: Walk (Part 3: 60% Gait Cycle)




Compression Force at L5/S1

| | |
|---|---|
| Total Compression (lb) | 74 |
| Components | |
| Erector Spinae | 0 |
| Rectus Abdominus | 3 |
| Abdominal | -0 |
| Hand Loads | 15 |
| Upper Body Weight | 55 |

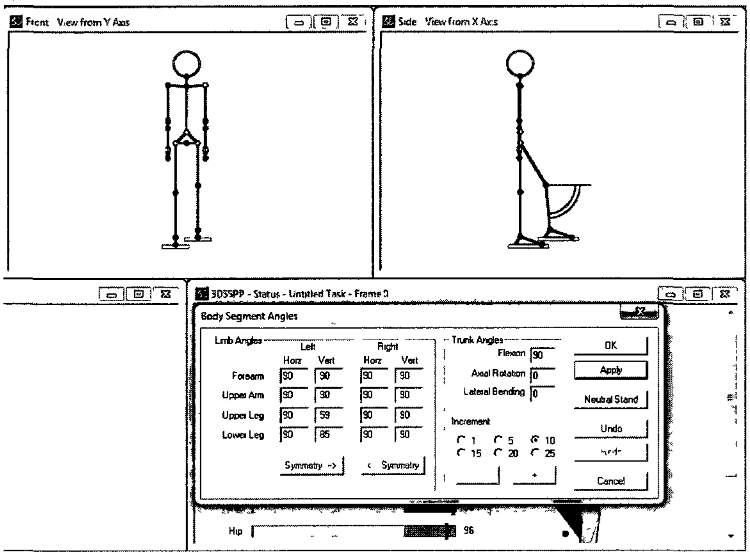
L5: Walk (Part 4: 80% Gait Cycle)




Compression Force at L5/S1

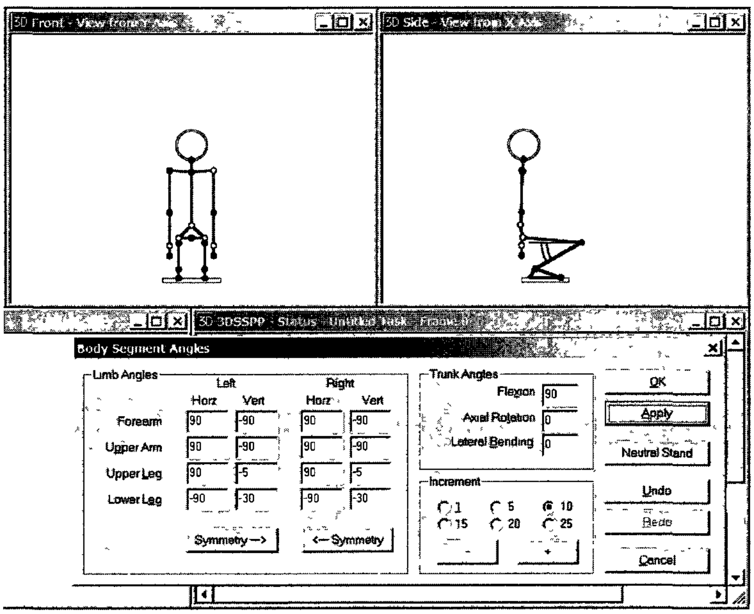
| | |
|---|---|
| Total Compression (lb) | 73 |
| Components | |
| Erector Spinae | 0 |
| Rectus Abdominus | 2 |
| Abdominal | 0 |
| Hand Loads | 16 |
| Upper Body Weight | 55 |

## L5: Walk (Part 5: 100% Gait Cycle)



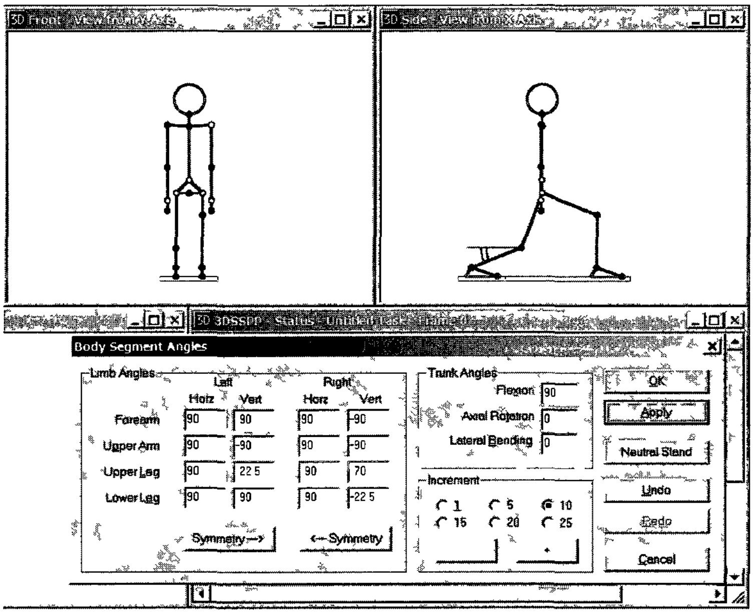

| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 74 |
| Components | |
| Erector Spinae | 0 |
| Rectus Abdominus | 3 |
| Abdominal | 0 |
| Hand Loads | 15 |
| Upper Body Weight | 55 |

## L6: Deep Squat



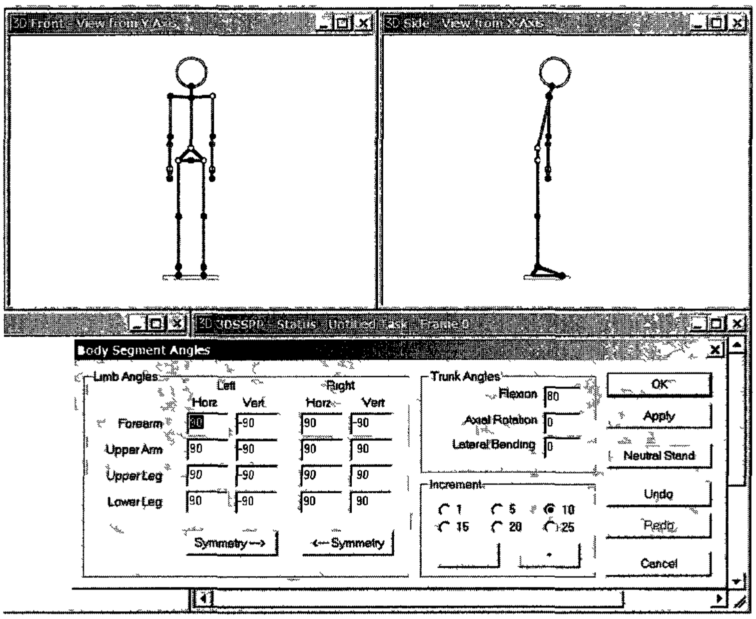

| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 80 |
| Components | |
| Erector Spinae | 18 |
| Rectus Abdominus | 0 |
| Abdominal | -0 |
| Hand Loads | -0 |
| Upper Body Weight | 62 |

## L7· Lunge



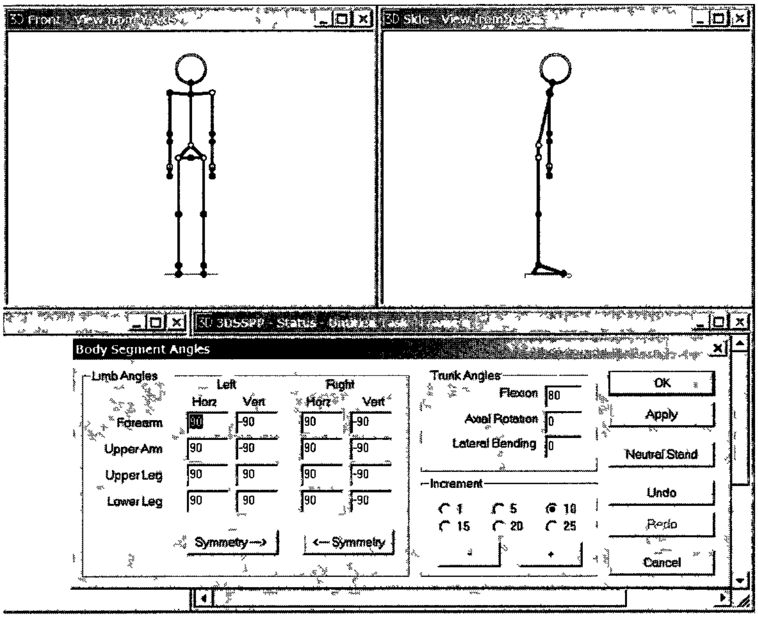

| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb). | 56 |
| Components | |
| Erector Spinae | 1 |
| Rectus Abdominus | 0 |
| Abdominal | -0 |
| Hand Loads | -0 |
| Upper Body Weight | 56 |

## Wu1 Neutral Trunk, Lıftıng <10 lbs

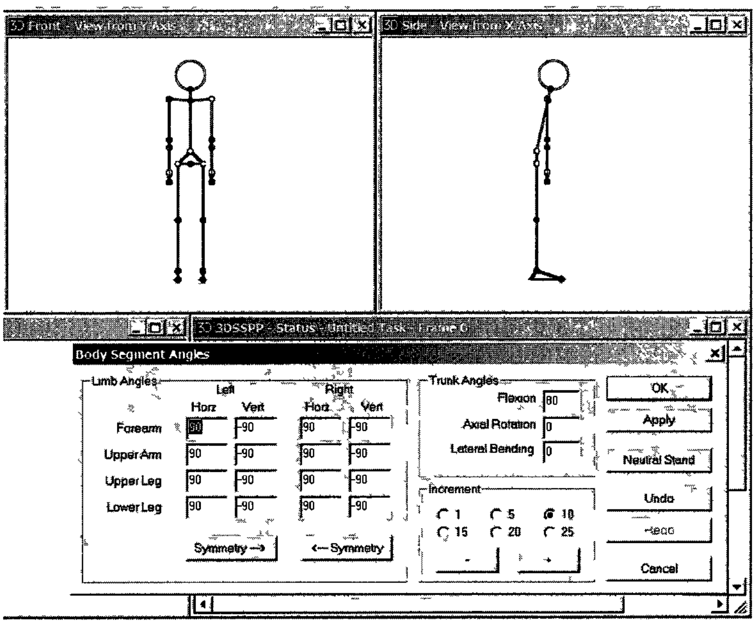



| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 159 |
| Components | |
| Erector Spinae | 102 |
| Rectus Abdominus | 0 |
| Abdominal | 2 |
| Hand Loads | 4 |
| Upper Body Weight | 54 |

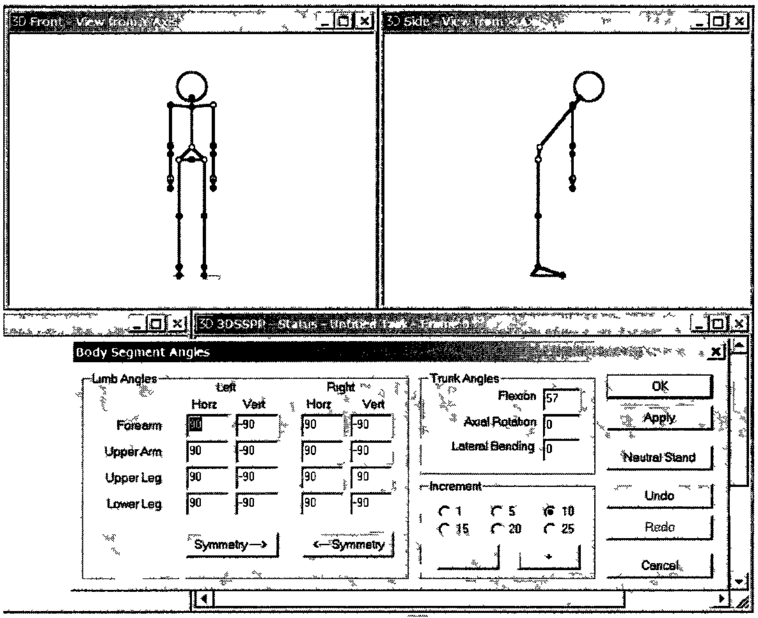
Wu2: Neutral Trunk, Lifting 10-50 lbs




Wu3: Neutral Trunk, Lifting >50 lbs

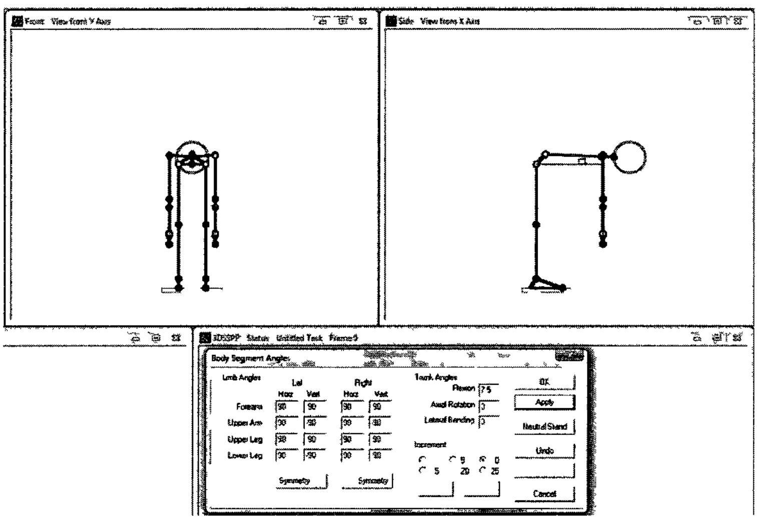


W11 Flexed Trunk, Lifting <10 lbs (Moderate Flexion)



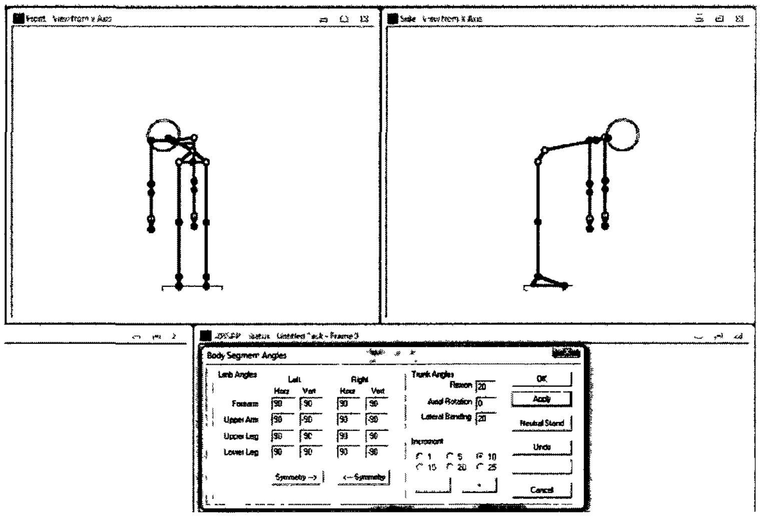

| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 339 |
| Components | |
| Erector Spinae | 299 |
| Rectus Abdominus | 0 |
| Abdominal | 11 |
| Hand Loads | 3 |
| Upper Body Weight | 48 |

W11· Flexed Trunk, Lifting <10 lbs (Severe Flexion)



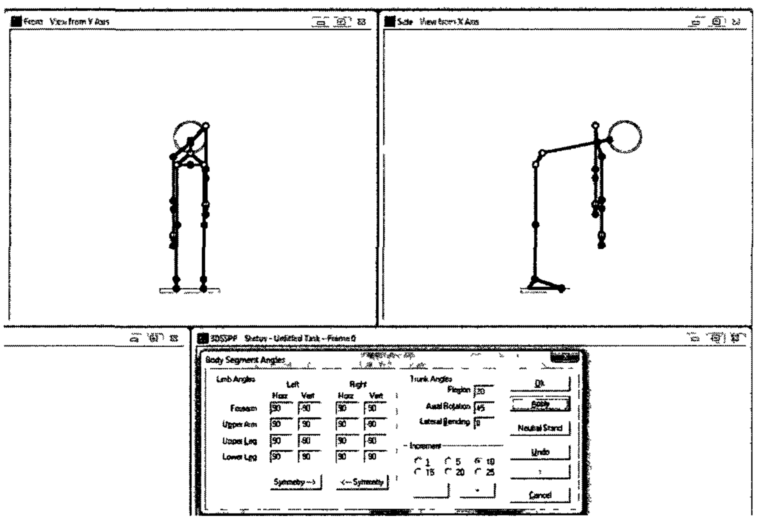
| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 509 |
| Components | |
| Erector Spinae | 513 |
| Rectus Abdominus | 0 |
| Abdominal | 16 |
| Hand Loads | 2 |
| Upper Body Weight | 11 |

Wil: Flexed Trunk, Lifting <10 lbs (Laterally Bent Flexed)



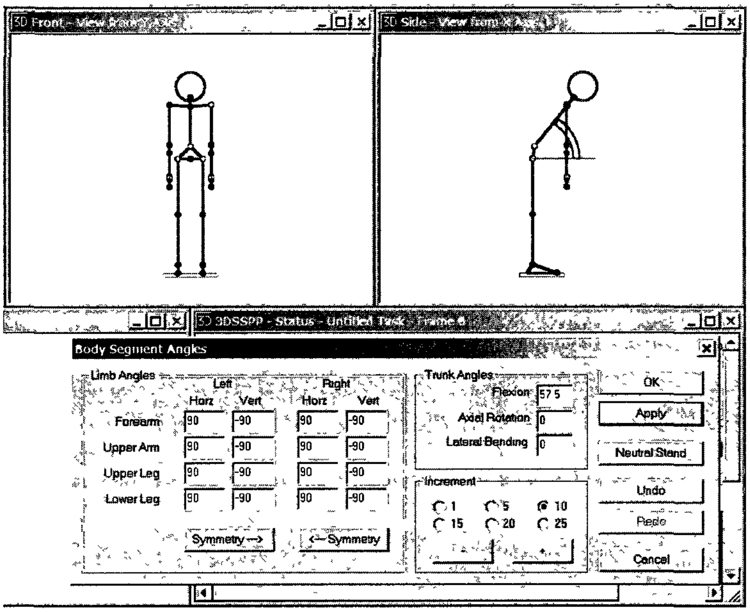
| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 503 |
| Components | |
| Erector Spinae | 494 |
| Rectus Abdominus | 0 |
| Abdominal | 19 |
| Hand Loads | 3 |
| Upper Body Weight | 24 |

Wil: Flexed Trunk, Lifting <10 lbs (Laterally Twisted Flexed)



| Compression Force at L5/S1 | |
|---|---|
| Total Compression (lb) | 505 |
| Components | |
| Erector Spinae | 497 |
| Rectus Abdominus | 0 |
| Abdominal | 19 |
| Hand Loads | 3 |
| Upper Body Weight | 24 |

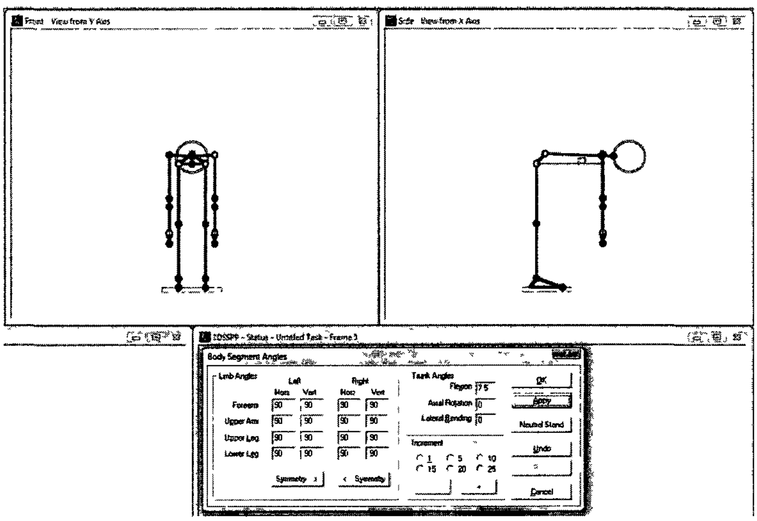
## Wi2: Flexed Trunk, Lifting 10-50 lbs (Moderate Flexion)



Compression Force at L5/S1

| | |
|---|---|
| Total Compression (lb) | 449 |
| Components | |
| Erector Spinae | 400 |
| Rectus Abdominus | 0 |
| Abdominal | -19 |
| Hand Loads | 20 |
| Upper Body Weight | 48 |

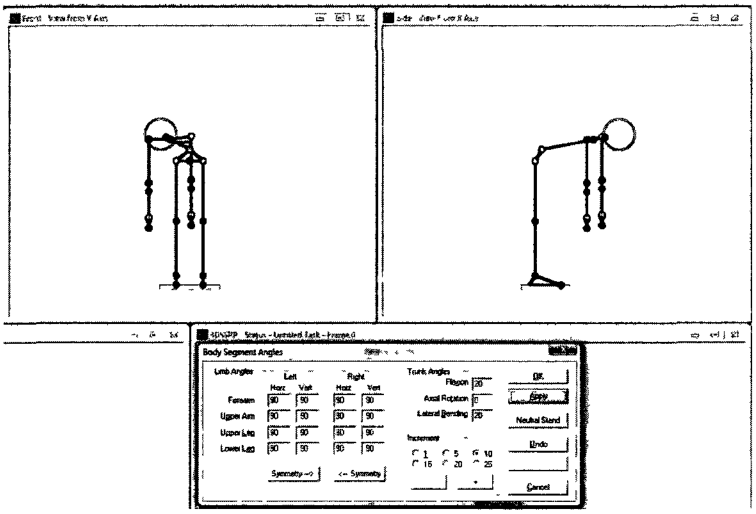
## Wi2: Flexed Trunk, Lifting 10-50 lbs (Severe Flexion)



Compression Force at L5/S1

| | |
|---|---|
| Total Compression (lb) | 637 |
| Components | |
| Erector Spinae | 645 |
| Rectus Abdominus | 0 |
| Abdominal | -24 |
| Hand Loads | 5 |
| Upper Body Weight | 11 |

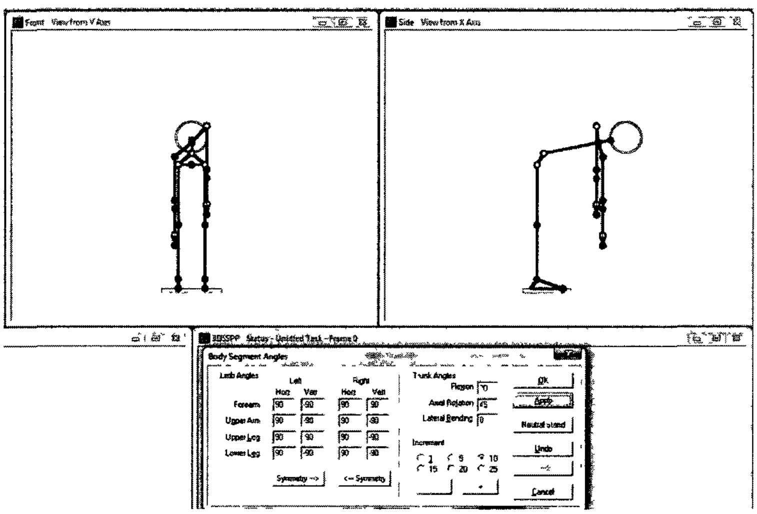
## Wi2: Flexed Trunk, Lifting 10-50 lbs (Laterally Bent Flexion)



Compression Force at L5/S1

| | |
|---|---|
| Total Compression (lb) | 626 |
| Components | |
| Erector Spinae | 620 |
| Rectus Abdominus | 0 |
| Abdominal | -28 |
| Hand Loads | 10 |
| Upper Body Weight | 24 |

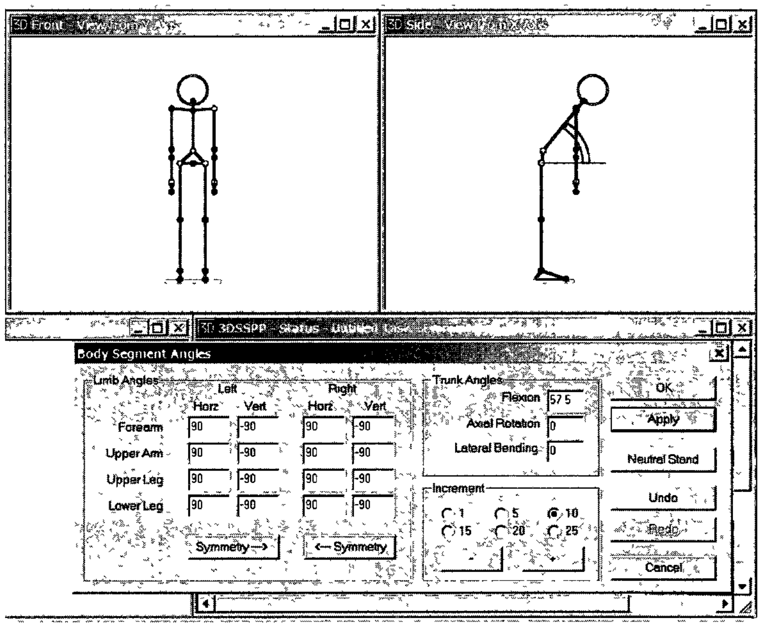
## Wi2: Flexed Trunk, Lifting 10-50 lbs (Laterally Twisted Flexion)

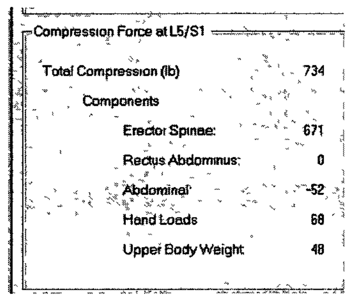


Compression Force at L5/S1

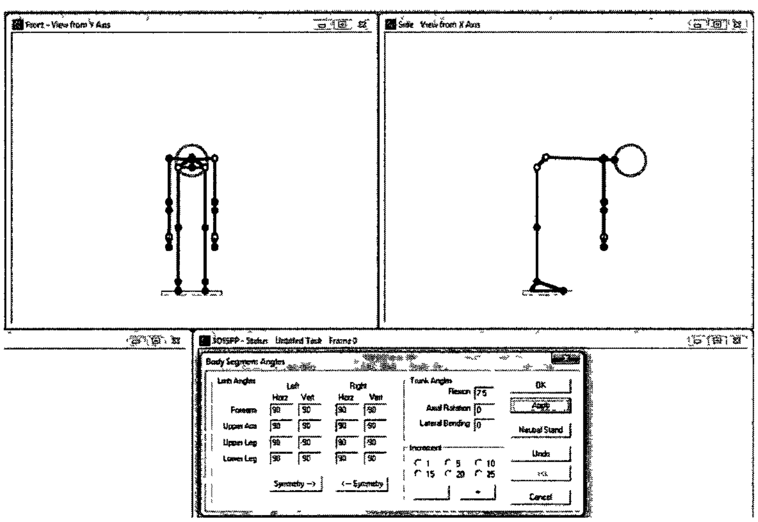
| | |
|---|---|
| Total Compression (lb) | 629 |
| Components | |
| Erector Spinae | 623 |
| Rectus Abdominus | 0 |
| Abdominal | 29 |
| Hand Loads | 10 |
| Upper Body Weight | 24 |

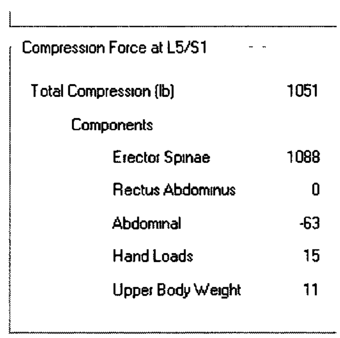
Wi3: Flexed Trunk, Lifting >50 lbs (Moderate Flexion)



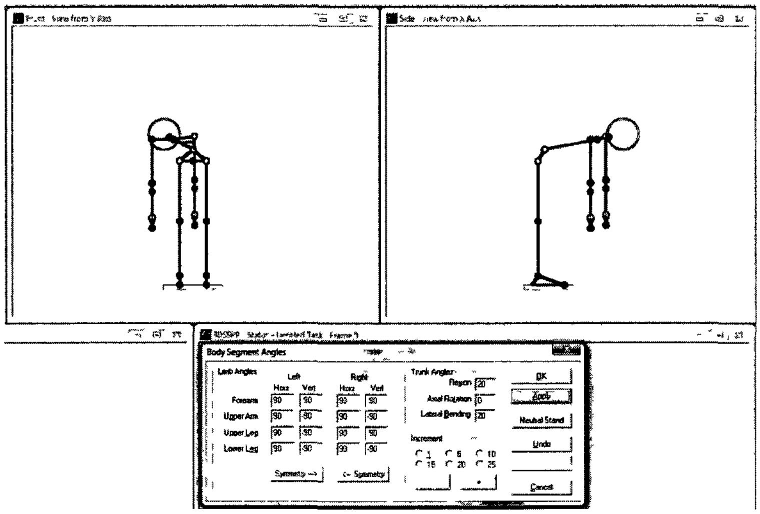




Wi3: Flexed Trunk, Lifting >50 lbs (Severe Flexion)





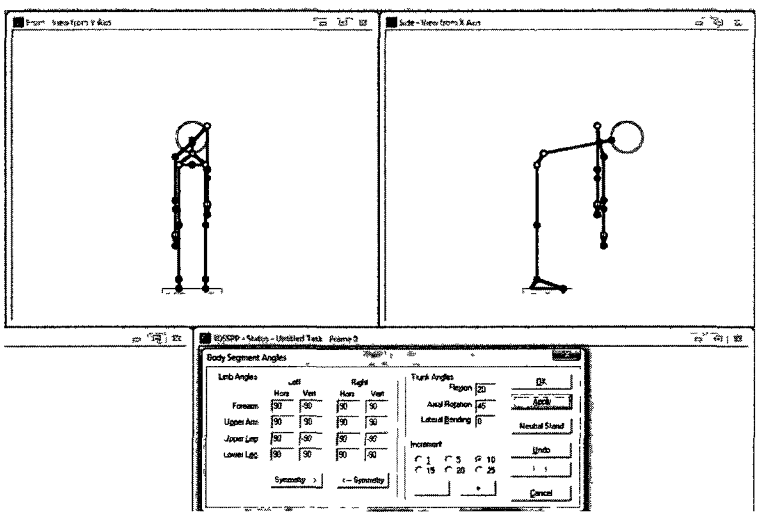
Wi3: Flexed Trunk, Lifting >50 lbs (Laterally Bent Flexion)



Compression Force at L5/S1

| | |
|---|---|
| Total Compression (lb) | 1018 |
| Components | |
| Erector Spinae | 1036 |
| Rectus Abdominus | 0 |
| Abdominal | 76 |
| Hand Loads | 34 |
| Upper Body Weight | 24 |

Wi3: Flexed Trunk, Lifting >50 lbs (Laterally Twisted Flexion)



Compression Force at L5/S1

| | |
|---|---|
| Total Compression (lb) | 1022 |
| Components | |
| Erector Spinae | 1041 |
| Rectus Abdominus | 0 |
| Abdominal | -78 |
| Hand Loads | 34 |
| Upper Body Weight | 24 |

## BIOGRAPHICAL SKETCH OF AUTHOR

The author, Alicia Kurowski, is originally from Weymouth, Massachusetts and attended Northeastern University where she received a Bachelor of Science degree in Industrial Engineering in 2004. She received her Master of Science degree in Occupational Ergonomics from the University of Massachusetts Lowell in 2007. Her M.S. Capstone project examined changes in manual handling activities of nursing assistants after the introduction of a safe resident handling program.

While pursuing her doctoral studies, Alicia worked as a research assistant for the Center for the Promotion of Health in the New England Workplace (CPH-NEW). For CPH-NEW she worked on the Pro-Care project, promoting health to caregivers through transdisciplinary interventions. Her work specifically involved the ergonomic evaluation of a safe resident handling intervention in a series of nursing homes. Her research interests include healthcare ergonomics, workplace intervention studies, and musculoskeletal disorder epidemiology, and her future goals include research on the sustainability of safe resident handling interventions. In her free time she likes to travel, cook, quilt, paint, and read.