Safe patient handling research : forces involved when completing a lateral bed to bed transfer

Robert E. Larson

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Robert E. Larson and

Faculty Mentor: Martin S. Rice Ph.D., OTR/L, FAOTA

Site Mentor: Martin S. Rice Ph.D., OTR/L, FAOTA

Department of Rehabilitation Sciences

Occupational Therapy Doctorate Program

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This document describes a capstone dissemination project reflecting an individually planned experience conducted under faculty and site mentorship. The goal of the capstone experience is to provide the occupational therapy doctoral student with a unique experience whereby he/she can demonstrate leadership and autonomous decision making in preparation for enhanced future practice as an occupational therapist.

Abstract

OBJECTIVE: This study investigated the effects of 3 different types of transfer devices upon hand forces while sliding a patient up in bed. The devices used were the SallyTube Single Patient Use Slide Tubes, the Smooth Mover lateral transfer board, and a standard cotton sheet. METHOD: There were 35 participants in the course of this study, aged 18-51, both male and female, ranging in weight from 110-262 pounds. Hand forces were taken from the subjects for data analysis as they participated in the task of completing a lateral bed to plinth transfer. RESULTS: A repeated measures analysis of variance (ANOVA) with 3 levels to the repeated factor (device type) was used, along with post-hoc repeated measures contrasts to compare differences between each condition. The results showed a significant reduction in required force when using the friction reducing devices as compared to the cotton sheets when used according to manufacturer recommendations. However, even with the reduction in force when using friction reducing sheets, it is important to note that all forces were above the 35 pound recommended lifting limit. CONCLUSION: This study shows the importance of using friction reducing slide sheets while engaging in manual patient handling. The reductions of the forces exerted on the body are important in keeping healthcare workers safe. Other research that should be completed includes looking at the forces involved with other friction reducing materials and methods as well as the possibility of combining said materials and methods.

Keywords: Bedding and Linens, Cotton, Friction, Nursing Staff, Hospital, Moving and Lifting Patients, Aged, Posture, Body Mechanics, Sheets

Forces Involved when Completing a Lateral Bed to Bed Transfer

Introduction

Healthcare is an important field as many people experience illness and injury every day and must be treated by appropriate professionals. In the United States, 136.3 million people visited the emergency room in 2011 alone (CDC, 2015). While treating those injured and ill, healthcare professionals put themselves in potentially hazardous situations. There are many situations in which there is potential for harm to the worker, and one of the foremost of those is when they manually handle patients (OSHA, 2011). This danger affects mainly nurses and nursing assistants, as they are the ones most involved with patient repositioning. However, it also affects occupational and physical therapists among other healthcare workers as they are involved in many similar and related healthcare tasks and thus are at risk for contracting comparable work related musculoskeletal disorders.

Occupational and physical therapists receive training in their education and on the job regarding how to ergonomically transfer and handle patients during therapeutic interactions (Darragh, Campo, & Olson, 2009). In addition, there are also specific safe patient handling techniques and knowledge of materials bestowed upon students in this field, but there is variation on what and how it is taught (Slusser, Rice, & Miller, 2012). Notwithstanding, these professionals are still at risk for having a musculoskeletal disorder at some point in their careers (Bork et al., 1996). As such, there is a focus on how to reduce the number of injuries that healthcare workers incur (Li, Wolf, & Evanoff, 2004; Owen, Keene, & Olson, 2002; Waters, Collins, Galinsky, & Caruso 2006). This is particularly important as the demographics of the nation are changing to include older and larger individuals, which can pose an even more substantial risk to healthcare workers (CDC, 2013).

Although the overall numbers of work related injuries of employees in all fields of employment in the United States for 2013 were reduced from the previous year, the number of days away from work to recover from the injuries remained unchanged. Among those who incurred musculoskeletal injuries, registered nurses nursing assistants continue to account for two of the top five careers which had musculoskeletal disorder claims in 2013 (BLS, 2014). The other three of the top five at risk professions include construction workers, truck drivers, and janitors. In these lines of work there is a very strong physical component that must be incorporated in the line of duty. Nursing also includes a physical component. It has also been reported that on an 8-hour shift, a member of the nursing staff typically lifts up to 1.8 tons cumulatively during patient handling responsibilities, which plays into their having among the highest rates of musculoskeletal injury (Tuohy-Main, 1997).

After having contracted a work related musculoskeletal injury, the median recovery time for registered nurses was 8 days and for nursing assistants was 75 days. There were 11,430 registered nurses and 22,000 nursing assistants who experienced a work related musculoskeletal disorder in 2013 (BLS, 2014). The math on these numbers comes to a total of 245,440 days of missed work. In addition to these two professions, statistics for personal care aides and home health aides could also be included in those numbers as they are related professions and should be considered. The numbers for these professions come to a total of 4,920 cases with a median of 8 days recovery time and 3,880 cases with a median of 9 days recovery time respectively. The summation of these numbers comes to 74,280 days of missed work. Interestingly, altogether that is just under 878 years of work for one person if they work every day of the week for as long as it would take to make up the deficit. This loss obviously costs our nation a significant amount of money both because of work that is lost as well as the cost for recovery of the individual. It is enlightening to look more in depth at injuries experienced by occupational therapists who often do the same or parallel tasks in similar workplace settings as the nursing staff throughout the course of their careers.

There have been lifting limits derived from extensive research and sound equations for the lifting weight, lower back compressive force, anterior shear force, and lateral or sagittal shear force. This particular study did not observe the lower back forces as will be discussed later with regard to Bartnik and Rice (2013) and Larson (2015).

In 1993, Waters, Putz-Anderson, Garg, and Fine submitted that a healthcare provider should not lift more than 35 pounds during the manual handling of patients, which recommendation was reiterated later by Waters (2007). This guideline is known colloquially as the NIOSH equation and is based upon three criteria: biomechanical, physiological, and psychophysical aspects. The biomechanical area was defined by disc compression force and concentrates on the lumbosacral stresses placed on the body. The physiological area was defined by energy expenditure and outlines metabolic stress. The psychophysical area was defined by acceptable weight, which is the workers' perceived lifting capacity. These categories were chosen by a panel of experts in each of these areas. All of these areas were analyzed separately in order to discover the limits of each, and then they were united and combined with injury data to create a more conservative recommendation for maximum lifting tasks. The equation requires three categories, standard lifting location, the load constant, and a combination of the three factors mentioned above. The conclusion reached was that 35 pounds should not be exceeded in any sort of lifting task relating to the manual handling of patients. This guideline, if adhered to as Waters et al. suggest, has the potential to reduce work related musculoskeletal disorders.

Within the field of occupational therapy, a study by Rice, Dusseau, and Miller (2011) found that of respondents, 5% of occupational therapists and occupational therapy assistants in Ohio experienced a musculoskeletal injury secondary to patient handling activities within the past year. When the study focused in on those therapists and assistants who were required to handle patients on a regular basis the injury rate jumped to 8.3%. Overall, 21% of respondents had experienced regular pain within the last 5 years due to patient handling. There were also a substantial amount of occupational therapists and occupational therapy assistants, specifically 11%, who had missed work due to a patient handling related musculoskeletal injury, and 12% of respondents had considered leaving the profession due to concerns about work related musculoskeletal disorders. Of the 1,113 emails that were sent out across the state, 285 of them were completed coming to a total response rate of 25.6%.

Another study, done by Darragh, Huddleston, and King (2009), reduced the propensity of therapists to underreport their injuries. They did this by having the therapists that were surveyed mark their pain level on a visual analog scale and then describe the frequency of the pain. If the response was greater than a four out of ten on the 0-10 point visual analog scale for either more than a week or at least once a month for current practitioners, then it was counted as a work related musculoskeletal injury. With this methodology the authors found that in Wisconsin 21.8% of occupational therapists experienced injuries. That is over one fifth of the therapist population. If all of them experienced a musculoskeletal disorder at the same time then the healthcare system of Wisconsin would be severely taxed and therapy departments would suffer across the state. Of the 3,297 physical and occupational therapists in Wisconsin who were mailed a survey, 1,158 were included in the final data analysis for a 35.1% return rate. Of those returned, 477 were from occupational therapists and 681 were from physical therapists.

Some facilities are attempting to address the issue of the high number of musculoskeletal disorders in healthcare professionals in a responsible and efficient manner. For instance, a unique patient handling program was implemented and tracked in skilled nursing facilities between the years 1995 and 2000. There were six different skilled nursing facilities that ranged from 60 to 120 beds for a total of 552 beds. This program implemented mechanical lifts, repositioning aids, a zero lift policy, and employee training for all of the equipment and policy implementation that was necessary for this to be successful. The initial cost to the facilities totaled $158,556. However, with the benefits that these facilities saw they were able to recover the cost within three years and proceeded to save the facilities $55,000 in worker's compensation costs annually (Collins, Wolf, Bell, & Evanoff, 2004). This shows the importance of reducing the risk of musculoskeletal disorders in order to prevent their occurrence, as well as showing how much money can be saved by using various safe patient handling methods and supplies.

A study by Yassi et al. (2001) outlines a randomized controlled trial in which facilities were assigned to one of three possibilities: a "no-strenuous lift" program, a "safe lifting" program, or "usual practice." The "no-strenuous lift" program involved the use of mechanical devices to do the majority of the actual lifting in place of the staff, thus reducing the workload required of the healthcare workers. The "safe lifting" program involved use of assistive devices such as transfer belts and slide devices whose purpose was to decrease biomechanical loading. "Usual practice" was, of course, leaving the facility to do what they typically do without the aid of any sort of device. Three service areas were included in each condition: the medical, surgical, and rehabilitation wards. Thus there were 9 wards total involved in the study. All of the wards were similar in patient type, patient population, staffing, and number of caregiver injuries in the preceding 3 years. Over the course of a year, 346 nurses and unit assistants were interviewed 3 times, once at baseline, once at 6 months, and once at the year mark (Yassi et al., 2001). The interviews were used in order to gain information on how many patient lifts and transfers the nurses and unit assistants perform during a typical shift, what sort of work fatigue and discomfort they were experiencing, and their current state of general health, safety, pain, and disability.

Interestingly, the total number of injuries was not statistically reduced overall for any of the arms of the study, but the type and location of the injuries changed (Yassi et al., 2001). It is important to note that this study only had a 40-60% power to detect changes in injury rates, which could be why there was no significant reduction in injuries found, as well as a small sample size and a large number of variables. Those who used more mechanical means of moving patients were found to have reduced numbers of back and trunk injuries. There was a very specific decline in injuries found in the medical ward of the no-strenuous lift program, but since it was only one part of one arm of the experiment it was not conclusively significant. However, it was the only detectable decline in injury rate and the authors feel that this shows that mechanical lifting devices are important in certain settings but not as much in others. Aside from injury data, the authors found that there was a significant decrease in levels of fatigue in both of the intervention arms compared with the usual care arm, which could indicate a better working environment and could influence job satisfaction. There was also an increase in comfort in patient handling tasks as well as an increase in the perception of safety among the intervention groups, which could also influence the aforementioned areas of workplace wellness.

Marras, Davis, Kirking, and Bertsche (1999) discuss the spinal forces involved in various transfer tasks. Certain transfer tasks were deemed “high risk.” These were where the participant was required to employ maximal sagittal flexion, a high lift rate, maximum external momentum, maximum lateral velocity, and high twisting velocity. During the high risk transfer tasks, it was found that there was a 10% increase in risk for lower back disorder and the forces involved were

300 to 400 N greater for lateral shear force and 1300 to 1700 N greater for compression forces than lower risk transfer techniques. The anterior-posterior shear force was relatively similar in most of the trials, whether high risk or not.

Even with two caregivers involved in the transfer task, 10-15% of the tasks surpassed the 6400 N top limit for force at the lumbosacral joint, which is well above the 3400 N action limit prescribed as safe (Marras et al., 1999). The shear forces involved also approached or exceeded the prescribed limits, thus showing that all of the transfer tasks observed in this study can be considered unsafe. Also interesting is that the results showed the caregivers experiencing more shear force during the lowering phase which may indicate an increased risk of lower back disorder with that motion. One of the tasks in this study was a repositioning task which included four different techniques: a manual one-person hook, manual two person hook, manual two-person using a draw sheet, and a manual two-person lifting under the thigh and shoulders. Of these, it was shown that the least amount of force was generated using the draw sheets, which shows that the draw sheet method is potentially the method with the least amount of risk involved for the caregivers. The authors also found that the single-person hook method generated the highest amount of force for a repositioning task with a probability of high risk of lower back disorder above 90%. The draw sheet method had a risk of being considered high risk for lower back disorder at 70%, which is substantially lower than the hook method, but is still considered high risk.

It was further described by Skotte and Fallentin (2008) that in repositioning tasks with patients who have some type of plegia there is a higher risk of musculoskeletal disorder. This is due to an increased amount of force being put on the healthcare worker’s body. Skotte and Fallentin had 9 healthcare workers perform 6 different repositioning tasks with a patient in bed, and of the 418 trials used in the data analysis, 25% exceeded the compression force recommendation of 3400 N in the lower back. Skotte and Fallentin also observed the effect of different patient weights on the forces caregivers exerted and found that heavier patients pose a greater risk than lighter patients.

The commonly accepted method of completing a lateral bed to plinth transfer begins with at least two healthcare workers, both on the same side of the patient (Smith, 2011). If three or four healthcare workers are indicated, such as when a particularly large or combative patient is being moved, then the third and fourth healthcare workers stand at the opposite side of the bed to push the patient from the other side. At times it is even indicated to have five healthcare workers. When this is the case, the final healthcare worker stands at the patient’s head. When the transfer takes place, one of the workers counts to three and the healthcare workers pull the sheet from one side, push the patient from the other, and maintain the position of the head from the top. If the situation only requires two healthcare workers, then they both pull the transfer sheet from the same side. The recommended bed height is 46% of the shorter healthcare worker's height (Lindbeck & Engkvist, 1993). According to the OSHA and the material manufacturers, the official transfer method when using a lateral transfer board or other friction reducing device is to put the device in place and then place a cotton sheet or a friction reducing sheet over the top of it, then pull on the top sheet in order to complete the transfer (OSHA, 2009; Tollos, n.d.).

With the 35 pound guideline in mind, there are many different methods that work at reducing the amount of force that a healthcare provider applies in a transfer task. Some of these include mechanical lifting equipment which includes sit-to-stand devices and floor lifts (Nelson, 2005). There is other equipment as well which is designed to ease the burden of the therapist including hover mats, repositioning sheets, gait belts, sliding transfer boards, and pivot discs

(Nelson, 2005). One technique studied by Fragala (2011) may help to keep healthcare workers within the advised limit of force expenditure. He noted that it is possible to allow gravity to help with repositioning patients in bed fairly simply by inclining the bed so that the patient's head is lower than his or her feet, then sliding the patients up in bed, and then readjusting the bed back to normal. He found that this technique offers up to a 67% decrease in work with a 12 degree incline resulting in 58.59 pounds of force being exerted by the worker. This shows that even though it is closer to being within the recommended lift limit of 35 pounds, that the limit is still being exceeded. Another important indication for patient handling purposes is that there should always be more than one healthcare provider involved in the repositioning task in order to further reduce the strain on an individual healthcare worker (Nelson, 2005).

Researchers have also shown that low friction bed sheets effectively reduce the time that healthcare practitioner's muscles are contracting as well as reducing the percentage of muscle involved in the transfer task (Theou et al., 2011). These sheets also have been shown to reduce the amount of friction by 65% when a slide sheet was used in conjunction with another slide sheet underneath. McGill and Kavcic (2005) found that when using three different friction reducing devices at different times, they were able to reduce the amount of friction by about 50% when compared to a standard cotton sheet. They looked at a rollboard, bubbleboard, and a slider all versus a standard cotton sheet as a control. The 3 participants all moved a 72.7 kg manikin in three different trials with the various devices, a push transfer, a pull transfer, and a twist transfer. While it was shown that the friction was reduced significantly, there were tremendous variations on the spinal loads recorded.

In another study that also investigated friction reducing devices for positioning patients, Bartnik and Rice (2013), using uniaxial handheld force gauges, investigated the forces acting on the hands and lower back during the repositioning task of pulling a patient up in bed. They found that although effective at reducing friction and the time it takes to reposition a patient, friction reducing sheets, specifically the McAuley disposable sheet and the Arjo Maxislide, still required more force than the 35 pound lifting limit in order to complete the task. In fact, the sum of the peak forces at the hand in this study came out to be 45.86 pounds for the Arjo Maxislide, 44.43 pounds for the McAuley disposable, and 49.81 pounds for the standard cotton sheet. This shows that there is a decrease in required force when using a friction reducing device, but the levels are still too high for healthcare workers to be exerting while being considered safe.

Further analyzing the gathered data and using the University of Michigan's 3D Static Strength Prediction Program which relies on joint position data and force data in order to calculate spinal forces, Bartnik and Rice (2013) also investigated compression and shear forces in the lumbar region. They found that the compressive forces at the spinal levels of L5-S1 and L4-L5 varied depending on which type of sheet was used. The McAuley disposable sheet resulted in the least amount of compressive force at both joints, whereas the Arjo Maxislide resulted in less compressive force than traditional cotton sheets at the L4-L5 joint, but not at the L5-S1 joint. As far as shear forces are concerned, there was a significant difference between the various sheets. Specifically, the McAuley disposable sheet elicited the least amount of L4-L5 sagittal shear force followed by the Arjo Maxislide and finally the traditional cotton sheet. With this in mind, it is important to note that the shear forces did not approach the recommended action limit and only the traditional sheet barely surpassed the recommendation for compressive action limit force.

According to these results the impact of lifting and repositioning tasks on the muscles of the lower back is of chief concern, while the shear and compressive forces acting on the spine should not be ignored as they still may have a cumulative effect over time. There was the concern that since the Bartnick and Rice (2013) force gauges were uni-dimensional there may have been a significant amount of data lost during collection as they only collected force in the z plane and force was elicited in the x, y, and z planes. Another important note is that the University of Michigan's 3D Static Strength Prediction Program is, as its title states, static, whereas the task at hand is dynamic.

In a follow up study, Larson (2015) found that by using tri-axial hand gauges the shear and compressive forces involved with the same types of sheets were not above the recommended action limits of 500 Newtons and 3400 Newtons respectively. This could be because the participants were able to keep a very upright position when completing this task. They did find, however, that there were higher numbers involved with the hand forces than in Bartnik and Rice's study. Although the forces were reduced using the friction reducing materials, the hand forces were all over the 35 pound recommended limit for patient handling tasks (Bartnik and Rice, 2013; Larson, 2015). These studies were completed using two types of friction reducing devices. Other devices need to be explored.

Lloyd and Baptiste (2006) investigated eleven different lateral transfer devices and recorded the peak force elicited by the individual performing the transfers. These devices ranged from typical draw sheets to air filled devices to plastic bags. In this study, they were attempting to analyze the force data supplied with the University of Michigan 3DSSPP computer program in order to calculate a percentage of healthcare workers that could safely perform the transfer using the different devices. This was based on normative stature and strength data in conjunction with 3DSSPP to derive the numbers. They used one 50th percentile male individual to perform all of the transfers, and one mannequin weighing 196 pounds was placed on the transfer devices. The highest peak force found in this study was with the draw sheet and it was 145 pounds, which is far beyond the upper recommended limit. The lowest force was with the Arjo Maxislide, which was also over the recommended limit at 40 pounds of force. Once important note with this study is that there was only one person performing all of the transfers. It is possible that with two individuals or more, as is recommended, the force required could drop below the recommended limits.

From here, Lloyd and Baptiste (2006) used the 3DSSPP program to evaluate the percentage of healthcare workers who would be capable of completing these tasks based on strength at the elbow, shoulder, and torso. The highest rate for projected success was 70%, and that was with the most effective friction reducing materials. The lowest rate was 0% with the draw sheet and plastic bags. This shows that using a draw sheet is not safe for any healthcare worker while using widely known devices is unsafe for 30% of healthcare workers. Two of the three devices used in the current study were not analyzed by Lloyd and Baptiste.

Baptiste, Boda, Lloyd, and Lee (2006) did a clinical investigation of different transfer devices when performing a lateral transfer. Over the course of ten months, five in 2002 and five in 2003, eight different clinical settings were each given one type of transfer device to utilize for a two week period. The devices were randomized to the facilities. They would use the devices for two weeks, and every time one was used, a survey containing five questions each with a 0-10 Likert scale response was completed. The elements of the survey included comfort, ease of use, effectiveness of reducing injury, efficiency, and patient safety. One hundred and seventy-nine transfers were completed during the course of this study. The authors found that air devices were consistently rated at the top of the list in every category while the typical draw sheet and the Maxi Tran were consistently rated at the bottom. There was quite a bit of variation, and it is important to note that clinician perception does not always reflect the conditions as they are in reality with regard to patient and caregiver safety.

A question that naturally follows the push for safe patient handling techniques is: what of the patients? How does all of this affect patient outcomes and safety? Elnitsky, Lind, Rugs, and Powell-Cope (2014) attempt to answer this question. They take the perspective of potential negative outcomes or events that may happen in a hospital setting due to the use of safe patient handling equipment. The authors begin with a discussion about how safe patient handling practices have lowered the risk of musculoskeletal injury for nursing staff and how important that is. They then discuss some risks to patients associated with utilizing safe patient handling. Chiefly, there is a certain likelihood for skin abrasions and lacerations, complications of pressure ulcers, and also a certain amount of risk of broken bones, concussion, and death. Although a potential for these complications is present, the risk factors for them includes an insufficient knowledge of the equipment by healthcare workers, faulty equipment, or a worker misjudging the situation and using the incorrect equipment. The authors stress the need for education on the equipment, using the proper equipment as indicated, and ensuring the integrity of the equipment is up to par. The information was garnered through a survey to all VA hospitals in the United States and had a response rate of 36%.

Another study, by Darragh, Mariya, Margulis, and Campo (2014) asks more specifically about therapeutic outcomes related to safe patient handling. This was a retrospective study observing outcomes of patients in an acute care setting before and after a safe patient handling and mobility program was established at a specific facility. There has been some discussion regarding the outcomes of patients and if they are potentially held back by the healthcare workers using safe patient handling techniques and materials. In this study, there were almost

1,300 patient outcomes assessed. The information was retrieved and then modified in ways the authors deemed appropriate, then they were handled in order to make the two groups more comparable such that the outcomes would be more representative of the total population. After doing this, it was noted that there were older people involved in the non-safe patient handling cohort, but there were more complex and multiple diagnoses contained in the safe patient handling cohort. The authors used FIM scores in order to determine outcomes. The scores across the board were statistically the same, showing that safe patient handling practices neither hinder nor promote positive recuperative outcomes. Importantly, it shows that there is no detriment to using these methods in order to protect the healthcare workers.

The purpose of the current study was to investigate the forces acting on the hand while completing a lateral bed to plinth transfer. There was a variety of slide sheets used, both standard cotton sheets as well as two types of friction reducing materials, the Smooth Mover lateral transfer board, and the SallyTube Single Patient Use Slide Tubes. The researchers hypothesized that there would be significantly less force required when using the friction reducing devices compared to traditional cotton sheets.

Methods

Participants

The participants of this study included 35 healthy adults, with 6 males and 29 females, between 18 and 51 years of age. The weight of the participants ranged from 110 pounds to 262 pounds, with a mean of 165.54 pounds. Based on data from Bartnik and Rice (2013), it was estimated that a sample size of 29 would be large enough to generate adequate statistical power to yield significant results. Participant recruitment was completed solely through “word of mouth.” The “caregivers” throughout the data collection process were consistent and the participants rotated in and out as the “patients.”

Apparatus

DATAQ (version DI-710 Screw Terminal Access) was the analog to digital system in which the data were collected. The Futek MTA 400 tri-axial load cells, modified with handles and couplers (Tri Axial Load Cell Model, 10 Thomas, Irvine CA 92618) were used for data collection in this study. The compression and tension forces at the hand were measured using the Futek MTA 400 tri-axial load cells while completing a lateral bed to plinth transfer. Data were collected at 200 Hz. The hospital bed in this study was manufactured by Linak (Model# CB9140AE-3+A011F, No. 106). A plinth (manufactured by Bailey, 118 Lee St., Lodi, OH, 44254) that was set so that when a “patient” was on the bed, the plinth and the bed were level. The three types of devices used were a traditional cotton draw sheet, the Smooth Mover lateral transfer board, and the SallyTube Single Patient Use Slide Tubes.

Dependent Variables

This study analyzed the forces at the hands required during a lateral bed to plinth transfer. The data from the Futek load cell force gauges was used and analyzed to determine the hand forces involved in a lateral bed to plinth transfer generated using the three different types of transfer devices. Results were then converted into pounds for each device.

Procedure

Approval from the Biomedical IRB from The University of Toledo occurred before study implementation. The researchers obtained informed consent from every participant prior to data collection, which occurred in February, 2015. The participants in this study acted as the “patients,” and the investigator assistants acted as the “caregivers.” Upon recruitment, each participant read and signed the consent form, then the participant’s height and weight were recorded, and a series of 9 patient transfers (3 for each of the 3 conditions) were performed. The "caregiver" participants also signed the informed consent. The order of the presentation of the transfer device types were randomized into one of 3 possible combinations (SallyTube, Smooth Mover, or cotton). This particular transfer technique has been termed "lateral bed to plinth transfer" (Smith, 2011).

The hospital bed was horizontal next to the plinth. The two were secured in order to reduce the likelihood of either surface moving. The two "caregivers" stood on the same side of the bed throughout the transfers. The height of the bed was put at the same height as that of the plinth in order to provide for a level transfer workspace. The "patient" began in a position with his or her arms across his or her chest and his or her legs straight. This position was maintained throughout the transfer. The "patient" started in the center of the hospital bed. The "caregivers" stood next to the plinth, grasped the handles and prepared to slide the "patient" from the hospital bed onto the plinth. The "caregivers" then communicated to each other by to counting up to three, at which point the "caregivers" slid the "patient" from the hospital bed to the plinth.

Statistical Analysis

This study used a repeated measures design with a focus on device type (SallyTube, Smooth Mover, and Cotton). A repeated measures analysis of variance (ANOVA) with three levels to the repeated factor (device type) was used, along with a post-hoc repeated measures contrasts analysis for the data at the hands.

Results

Data were collected and analyzed from 6 males and 29 females and were recorded in volts by the DATAQ computer system in February 2015. The data were then converted into pounds of force in accordance with the baseline pound per volt level as reported by the Futek company calibration sheets. The data were then smoothed using a dual pass Butterworth low pass filter using a 10Hz cutoff frequency.

There was no order effect during the research process as reported by a test of between-subjects effects returning a *p*-value of greater than 0.05. Overall, there was a significant difference among the three hand force conditions. $F(2,68)=342.18$, $p<.001$. The repeated measures contrasts analysis revealed a significant difference between all conditions. The cotton sheet elicited the highest hand force for the transfer task, the Smooth Mover lateral transfer board required less force than the cotton, and the SallyTube required less force than the other two categories. The average peak force utilized when performing the bed to plinth lateral transfer with the cotton sheet was 70.52 pounds, with the Smooth Mover lateral transfer board was 55.61 pounds, and with the SallyTube was 41.24 pounds, see Figure 1. The effect sizes can be found in table 2.

Insert Tables 1 and 2 and Figure 1 about here

Discussion

With so many healthcare workers putting themselves at risk on a daily basis, it is vital that the most effective methods of patient handling be used as a matter of best practice, while the least effective methods need to be abandoned. This study was an attempt to determine the efficacy of certain patient handling methods over others. The specific purpose of this study was to investigate the forces acting on the hands while performing a lateral bed to plinth transfer using various devices. The researchers hypothesized that there would be significantly less force required when completing the transfer when using the friction reducing devices compared to traditional cotton sheets.

There was a significant difference between using a standard cotton sheet versus the Smooth Mover lateral transfer board as well as between the cotton sheet and the SallyTube friction reducing lateral transfer device. Interestingly, there was also a difference between the two friction reducing devices in that the SallyTube elicited less hand force than the Smooth Mover (See Table 1 and Figure 1).

More importantly, the SallyTube had an average peak force of just over 41 pounds, which is very near the recommended upper limit of 35 pounds for patient handling tasks (Waters et al., 1993). This is important because as the demand on healthcare workers is reduced by simply using a different material for the same tasks that they would have to be completing anyways, their careers can be lengthened and quality of life both in and out of the clinic could potentially be improved. That being said, the reduction in required force for this particular transfer with these particular materials is significant, but it is not enough. The forces are still above the recommended limits, and that is with a population that is relatively small and very cooperative.

The Smooth Mover lateral transfer board condition only reduced the overall hand force required by the caregivers by 21% compared to the cotton sheet. The SallyTube reduced the force required by the caregivers by 42% compared to the cotton sheet condition, thus still requiring a minimum average of 41.24 pounds of force per transfer. This is a very important reduction in force as it very nearly brings the required force under the recommended limit (Waters et al., 1993). This shows that with advances in technology and if healthcare workers are compliant with safe patient handling protocol, their backs can be protected beyond what they have been thus far and their careers can potentially be extended and quality of life improved both on the job and off.

An important note is that the average participant in this study was fairly small compared to hospital patients. The average weight was 165.54 pounds. So even with this lower mean weight population, the limits were being exceeded. If the heaviest individual is analyzed, whose weight was 262 pounds, the required force for the transfer using the most effective friction reducing material, the SallyTube, was 58 pounds. This is better than the 101 pounds that was required using the cotton sheet, but it is nowhere near where it needs to be (Waters et al., 1993).

As far as the recommended limits go, as Waters et al. (1993) suggest, healthcare workers should not be consistently lifting over 35 pounds when handling patients. As found in this study, as well as in other studies mentioned in this paper, many of the safe patient handling materials are successful at making conditions and situations more safe, but are less successful at bringing the required forces into an acceptable range (Bartnik & Rice, 2014; Larson, 2015; Yassi et al., 2001). This suggests that until even better supplies and materials are available at a reasonable cost to facilities, said facilities should consider adopting zero lift policies in order to keep their employees safe and reduce the costs to their facilities over time (Collins, Wolf, Bell, & Evanoff, 2004).

In light of the commonly accepted method of conducting a lateral transfer by using either a cotton sheet alone or by using a cotton sheet in conjunction with another device designed to reduce friction, it is important to note that many devices are indeed successful at reducing friction and thus reducing the required forces while completing the transfer (Tollos, n.d.; OSHA, 2009).

Especially important to occupational therapists are the functional outcomes of the patients in a healthcare setting. There has been some concern about the impact of safe patient handling methods on patient outcomes in these settings (Darragh, Mariya, Margulis, & Campo, 2014). These concerns have been shown to be unfounded as facilities who have adopted safe patient handling procedures have shown no difference in functional outcomes amongst clientele. There have even been trends toward those patients who enter after the safe patient handling practices have been established having better outcomes than those in typical care. This is important because it shows that not only are safe patient handling methods beneficial to the healthcare workers in preserving their bodies, but it also has the potential to create a better rehabilitative environment for the patients under their care.

Although the friction reducing devices do indeed reduce friction when used in accordance with the manufacturer's guidelines, there is still a significant amount of force being placed on the bodies of caregivers and healthcare workers (Tollos, n.d.; OSHA, 2009). The greatest reduction in the rate of required force outlined above was 42%. A 42% reduction in required force could be beneficial to the longevity of the healthcare worker’s career. For example, since according to Tuohy-Main the average member of nursing staff lifts 1.8 tons in an 8 hour shift, then a 42% decrease from 1.8 tons is a reduction of 1,512 pounds (1997). This illustrates the point that if the devices were used as intended, healthcare workers might only be lifting 1.04 tons per shift rather than 1.8 tons, thereby saving wear and tear on the body. This reduction of over 1500 pounds per shift would reduce the risk exposure for developing a work related musculoskeletal injury.

Using these friction reducing sheets and other available materials for safe patient handling can help to reduce the number of days workers are out of the workforce. With regard to the previous numbers reported by Tuohy-Main (1997), a 42% reduction in the required force is a very real difference in the amount of stress being placed on a healthcare worker’s body, and thus nurses and nursing aides as well as other healthcare personnel such as occupational and physical therapists will have to be out of work secondary to work related musculoskeletal injury less often than they currently are. The costs associated with work related musculoskeletal injuries should also be considered. In the study by Collins et al. (2004), the facilities were able to reduce the amount of workers compensation they were required to pay out due to work related musculoskeletal injuries by $55,000 every single year. If every facility in the United States adopted similar policies that were used in the facilities related to the study and were able to see comparable success, there would be millions if not billions of dollars saved in this country every year that could be put to better use elsewhere, such as research into how to improve safe patient handling methods.

Along with reducing the amount of weight being moved per shift, in accordance with Yassi et al. (2001) and Baptiste, Boda, Nelson, Lloyd, and Lee (2006) it can be seen that the self perceived fatigue levels of healthcare workers can be reduced in the various healthcare settings. This can positively impact the morale of the workers in the various types of healthcare facilities. If the workers are less fatigued when they go home at night, they will be motivated to provide better care throughout the day when they are at work. These benefits can extend into all areas of healthcare, but they can only be realized if the healthcare workers are using all of the available resources to maintain positive physical and mental health at work.

One aspect that needs to be readdressed at this point is that of education. As mentioned previously, there seem to be different methods of general patient handling that are taught in the various schools that instruct future healthcare professionals, and even different methods of safe patient handling throughout (Darragh et al., 2009; Slusser et al., 2012). With standardized instruction and comprehensive understanding across the board, some methods could be combined in order to increase the effectiveness of each individual technique. This could further protect healthcare workers in their jobs and help them to stay in their chosen career paths longer.

This is in keeping with the need to discover the most effective forms of patient handling, and once these more effective methods are found, they need to be taught to current and future practitioners rather than the less effective and more dangerous methods that are currently and have previously been used in the healthcare facilities.

If not significantly reduced so that they meet the recommended limits for patient handling, the stresses put on the healthcare worker's body from manually handling patients has a high risk of leading to injury. Then, as Rice, Dusseau, and Miller (2011) found, there will be a greater propensity of healthcare workers to leave their chosen professions in favor of less physically demanding work. That would be a shame after all of the time and money that the individuals put into gaining an education as well as expertise gained on the job. This possibility is especially true with the changing demographics of United States citizens. The people are becoming larger and older and will thus cause even greater amounts of force to be placed on healthcare worker’s bodies as the patients increase in mass and decline in physical and cognitive ability (CDC, 2013).

There are available strategies that guard against the high rates of injury among healthcare workers such as using friction reducing devices, using mechanical lifts, and having more than one healthcare worker involved in the task, but these methods need to be more widely taught, utilized, and researched. The "patients" in this study were relatively lightweight and were very cooperative. Many patients are going to weigh more than an average of 165.54 pounds, and some may not be particularly cooperative, which factors both lead to greater exertion by the healthcare worker and an increase in the risk of injury. By using the current most effective devices and methods of patient handling, these risks can likely be reduced.

As shown in this study, it is imperative for healthcare workers to do as much as they can to protect themselves. One way in which they can protect themselves in a relatively easy manner is by incorporating the use of assistive transfer devices. Doing this in the manner that the various manufacturers recommend can reduce the amount of force applied to the bodies of healthcare workers. This can result in reduced strain placed on the healthcare worker. This will potentially reduce the amount of wear and tear on those workers, which will potentially reduce the amount of work related musculoskeletal disorders acquired by healthcare workers through the manual handling of patients. Healthcare workers will then be able to remain as healthy as possible. It can be seen from the results of this study that using friction reducing transfer devices is more beneficial than using a cotton sheet in the manual patient handling task of a lateral bed to plinth transfer. If it is not possible to use these devices, then there needs to be at least four healthcare workers in order to reduce the load on the individual healthcare workers. Only when absolutely necessary, and never before, should cotton sheets be used for the handling of patients.

Limitations

This study was performed in a laboratory setting, so the results are not necessarily indicative of what would be found in the clinic. It was also completed by a population consisting largely of students and thus does not consist of healthcare professionals, so the results are not necessarily indicative of what healthcare workers would elicit in a similar situation.

The “patients” were an average of 165.54 pounds which is fairly small, especially considering that the trajectory of United States weight statistics show that the trend is to become heavier and heavier over time (CDC, 2013). The population of the United States of America is currently on the rise, and in addition to the extra weight, they come with many obesity related diseases and conditions. With this in mind, it is likely that many of the patients with whom healthcare workers will be dealing will weigh more than 166 pounds (CDC, 2013). This will lead to added stress on the bodies of healthcare workers and will lead to increases in the number of work-related musculoskeletal injuries.

Another limitation of this research is that with one larger “patient” in particular, when the transfer with the cotton sheet was commenced, the bed and the plinth slid approximately six inches. The sliding occurred in two out of the three transfers completed with the cotton sheet. This could have skewed the results lower than they should have been, but looking at the effect sizes it can still be reasonably assumed that the results are accurate. This serves to elucidate the problem with growing patients throughout the country. There will be more and more stress placed on healthcare workers’ bodies as this happens, and the limits of the current healthcare supplies will be tested, and potentially surpassed.

Future research should include different friction reducing devices, healthcare professionals performing the transfers, patients of different weights, real patients, and hospital settings. Another aspect that would be intriguing would be convening research related to discovering the forces involved for caregivers when using mechanical lifts and further research related to the impact of zero lift policies in various settings. It would also be illuminating to investigate one method of patient handling combined with another such as with the case of tilting the head of the bed down while using a friction reducing device. There is still much research that needs to be done in the area of safe patient handling, especially as new devices and methods are invented and discovered.

Conclusions

The SallyTube and Smooth Mover friction reducing devices were effective at reducing the hand force required to complete a lateral bed to plinth transfer compared to using a cotton sheet. While this reduction was statistically significant, the elicited hand forces were greater than the recommended limit of 35 pounds established by Waters et al. (1993). However, the SallyTube had a mean of 41.24 pounds with a standard deviation of 7.27 pounds, which shows that it is possible to get the force under the recommended limits with smaller patients. Even then, there is no guarantee, so healthcare workers need to be careful with patient handling tasks.

Healthcare workers need to be aware of the impact that the handling of patients has on their bodies. In light of these risks, they need to take precautions against injury. Currently, the most effective and efficient way to do this is to utilize the various equipment that is available. Manual lifts should be used, and when those are not available, it is important to incorporate the use of friction reducing devices.

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Table 1.

Total force in pounds at hands while performing lateral bed to plinth transfer using three different transfer devices.

Device	Mean	Standard Deviation
Cotton Sheet	70.52	12.10
Smooth Mover	55.61	9.71
SallyTube	41.24	7.47

Table 2.
Pairwise comparisons of the various conditions against each other.

Device 1	Device 2	Type III Sum of Squares	df	Mean Square	F	p-value	Effect Size
Cotton	Smooth Mover	7,780.12	1	7,780.12	229.44	<.001	1.36
	SallyTube	30,012.28	1	30,012.28	556.61	<.001	2.91
Error	Smooth Mover	1,152.90	34	33.91			
	SallyTube	1,833.29	34	53.92			
Smooth Mover	Cotton	7,780.12	1	7,780.12	229.44	<.001	1.36
	SallyTube	7,231.05	1	7,231.05	165.29	<.001	1.66
Error	Cotton	1,152.90	34	33.91			
	SallyTube	1,487.42	34	43.75			
SallyTube	Cotton	30,012.28	1	30,012.28	556.61	<.001	2.91
	Smooth Mover	7,231.05	1	7,231.05	165.29	<.001	1.66
Error	Cotton	1,833.29	34	53.92			
	Smooth Mover	1,487.42	34	43.75			

Figure 1.

Mean and standard deviation of total force at the hands while performing lateral bed to plinth transfer.

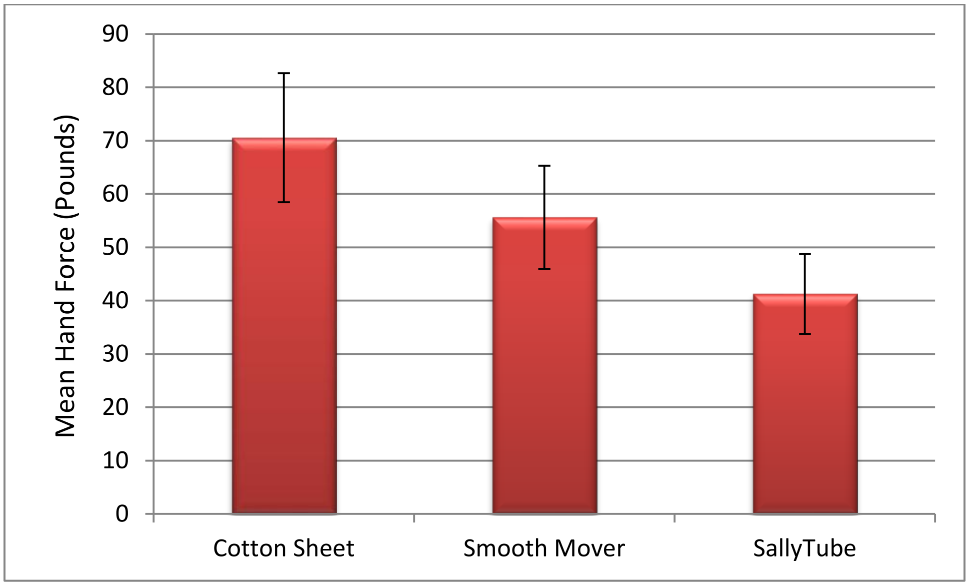

Figure 2.

Research setup.

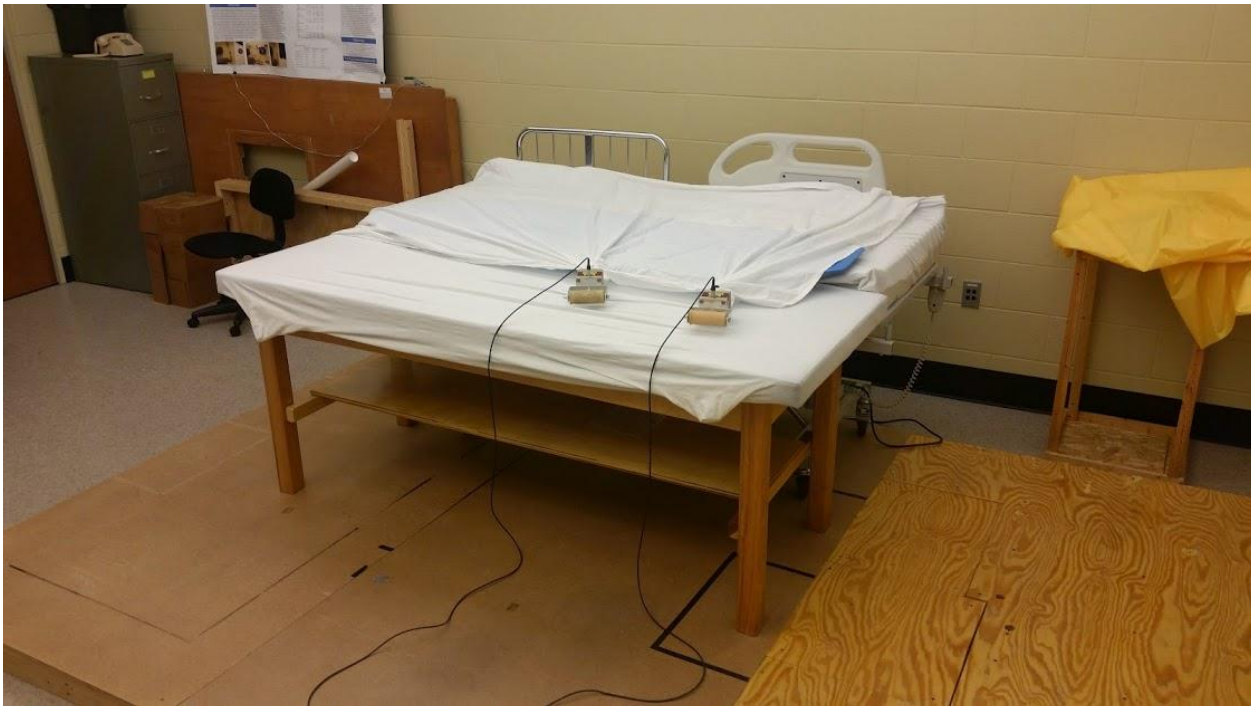

Figure 3.

Tri-dimensional hand gauge