Caregiver Forces Required for Sliding a Patient Up in Bed Using an Array of Slide Sheets

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May 2012

Abstract

OBJECTIVE: This study investigated the forces required while performing the common patient handling task of moving a patient up in bed when using regular and friction-reducing slide sheets.

METHOD: Twenty-nine healthy adult participants aged 18 to 36 years of age were recruited to participate as "patients." Hand forces and lumbar compression and shear forces were calculated on the 'caregiver' when performing the repositioning task.

RESULTS: There was a statistically significant difference between the three sheets, in terms of lumbar compression forces and lumbar sagittal shear forces at L4-L5 and at L5-S1 of the caregiver when repositioning the patient up in bed. The McAuley disposable sheet elicited the least force, followed by the Arjo Maxislide ™, both of which elicited less force than the traditional cotton sheet. No statistically significant differences were found in terms of lumbar lateral shear forces at L4-L5 and at L5-S1. No significant difference was found between the slide sheets, in terms of the peak sum hand force, however the traditional cotton sheet created the greatest force at the hands and every sheet exceeded the summative hand force over the recommended 35 lbs lifting recommendation.

CONCLUSION: The use of friction-reducing slide sheets within the healthcare setting is supported in this study. Both devices decreased internal spinal loads when compared to using a traditional cotton sheet. Future research should examine the hand and internal spinal forces when completing a variety of common patient handling repositioning and transfer tasks.

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Introduction

Every day, healthcare professionals are required to perform physically demanding patient handling tasks, which put them at a higher risk of developing work-related musculoskeletal disorders (MSDs) (Waters & Rockefeller, 2010). In addition, healthcare professionals are exposed to the awkward nature of lifting, unpredictability of the patient, and forces exerted by weight of the patient during handling of the patient. Among these healthcare professions, nurses rank within the top ten in incidence of work-related MSDs (Waters & Rockefeller, 2010). Occupational therapists (OTs) and physical therapists (PTs) are also involved in many patient handling tasks, although they may move patients differently than nursing personnel due to their education in ergonomics and academic training (Darragh, Huddleson, & King, 2009). These researchers also report that OTs and PTs use safe patient handling and transferring techniques to promote independence and restore function to the patients; also exposing them to the high risk of work-related injuries and developing work-related musculoskeletal disorders (WMSDs) (Darragh et al., 2009) According to Rice, Dusseau, and Kopp Miller (2011), “occupational therapy is recognized as a profession that has expertise in safe patient handling knowledge and practice.” (p. 12) This statement leads to further investigation by occupational therapists and occupational therapy students to study the most effective safe patient handling techniques and tools available today to reduce injuries to healthcare workers and to protect the well-being of our patients

In 2009 there was a 5% increase in incidence rates of MSDs of registered nurses compared to 2008 reports. Of the five occupations that had MSD case counts over 10,000, nursing aides, orderlies, and attendants had the highest rate of 266 MSD cases per 10,000 full-time workers (Bureau of Labor Statistics 2009) In addition, “overexertion” was the cause of 48% of reported cases by nursing aides, orderlies, and attendants (Bureau of Labor Statistics 2009). Retsas and Pinikahana (2000) reported approximately 68% of manual handling injuries were associated with direct patient care tasks, and 34.4% were related to lifting patients, among occupational injuries. Darragh et. al. (2009) surveyed occupational and physical therapists regarding injury incidence rates among full-time workers. The survey reported, “An annual incidence rate of 16.5 injuries per 100 full-time workers among OTs and 16.9 injuries per 100 full-time workers among PTs.”

Researchers have identified activities completed by healthcare personnel relating to patient handling that increase MSDs. They include transfers to and from: bed and chair, chair and toilet, chair and chair, chair and stretcher, chair and examination table, or car and chair (Nelson, Owen, Lloyd, Fragala, Matz, Amato, Bowers, Moss-Cureton, Ramsey, & Lentz, 2003). Also, lateral transfers including moving a patient to and from bed, stretcher or bath seat, as well as activities associated with repositioning in bed, wheelchair, or geriatric chair (Nelson et al., 2003). Many times repositioning requires moving the patient sideways or pulling the patient up on his or her supporting surface. Specific patient lifting tasks have also been identified by Waters, Nelson, & Proctor (2007) as high risk within critical care. They include pushing occupied beds or stretchers, lateral patient transfers, moving patients to the head of the bed, repositioning patients in bed, making occupied beds, applying antiembolism stockings, and lifting or moving heavy equipment (Waters, et al., 2007). The focus for this paper will be on the high volume task of repositioning patients vertically to the head of the bed.

There is a growing body of evidence to support new interventions in the prevention of musculoskeletal injuries associated with patient handling. Yet, the knowledge and the use of these interventions are not well used on any consistent basis within the United States. Nelson and Baptiste (2004) claim that intervention strategies used to reduce or prevent musculoskeletal injuries associated with patient handling are based upon tradition and personal experience rather than evidence based practices. General guidelines are available for completing safe patient handling (Baptiste et al., 2006) but specific approaches are not yet available for assistive transfer methods.

Factors to consider during patient handling can be assessed upon patient admission using a standard patient assessment guide. This assessment includes evaluating the level of assistance needed by the patient, whether or not they are able to bear weight, either partially, fully, or not at all, also the patient's upper extremity strength, patient's level of cooperation and comprehension, patient's size, and conditions that are likely to affect the transfer or repositioning process (Nelson et al. 2003).

The evidence-based practices that create the most promise and have the strongest level of evidence include, (a) use of patient handling equipment/devices, (b) patient care ergonomic assessment protocols, (c) no lift policies and, (d) patient lift teams (Nelson & Baptiste, 2004). Nelson, Matz, Chen, Siddharthan, Lloyd, Fragala (2006) completed a study of a multifaceted ergonomics program in at 23 high risk facilities. The aim was to promote a safer working environment for nursing staff that provide direct care using the previously discussed evidence-based practices. The evidence-based interventions used over a period of nine months resulted in a "statistically significant decrease in the rate of musculoskeletal injuries as well as the number of modified duty days taken per injury" (Nelson et al. 2006, p. 717). Nursing self-reports concluded that the use of equipment was rated most effective (96%), followed by No Lift Policy at (68%) (Nelson et. al., 2006). All other evidence-based practices such as use of friction-reducing devices were rated above 40% in self-reports of interventions deemed “extremely effective.”

One study completed by Marras, Davis, Kirking, and Bertsche (1999), estimated the internal spinal loads exerted on caregivers when completing routinely performed tasks within patient handling. A Lumbar Motion Monitor (LMM) was used to measure trunk motion variables and electromyographic (EMG) activity was collected through placing electrodes on major trunk muscle sites within this study. This study compared a one-person transfer versus a two-person transfer and various techniques to transfers between chair, bed, and wheelchair, as well as patient repositioning while in bed. The EMG-assisted spine loading model confirmed that all transferring techniques had loads that were near or surpassed the spine tolerances at which caregivers begin to have injuries, especially with one person completing the transfer (Marras et al, 1999). The majority of the one-person transfers exceeded the maximum recommended limit and approximately 20% of the two-person transfers resulted in compression forces above 6400N tolerance limit (Marras et al, 1999).

In another study, evaluating peak and cumulative spinal loads during simulated patient handling tasks using assistive devices, Daynard, Yassi, Cooper, Tate, Norman, and Wells (2001) found an increase in spinal loading when joined with variations in methods. High risk wards were randomly assigned to one three groups (arm A, arm B, or arm C). Arm A represented the control group, where participants received no formal back-care education. Arm B wards were under a “safe lifting policy,” receiving extensive education in back care using transfer belts, sliding devices such as the Easy Slides™, and total body mechanical lifts. The arm C group adopted a “no strenuous-lifting” program where they received the same training as in arm B, but were supplied new assistive devices and equipment such as sliding devices (MaxiTube™, MaxiTransfer™) sit-stand lifts (Sara 2000™), and a total body mechanical lift (MaxiMove™ 2000) (Daynard et. al. 2001). This study used a quasi-dynamic biomechanical computer model of the lumbar spine to evaluate the peak and cumulative compressive and shear loads at L4-L5 while completing a number of patient-handling tasks. Results revealed the use of assistive transfer equipment such as friction-reducing slide sheets and mechanical lifts decreased peak spinal loads by, "reducing lifting, pushing or pulling forces," although, "its use required workers to spend greater amount of time in forward flexed postures while readying the patient or the equipment" (Daynard et.al. 2001, p. 211). The results continued to claim that the use of assistive equipment may increase the exposure to prolonged forward-flexed trunk posture due to the multiple actions necessary to complete the transfers. This study recommended that patient handling tasks be assessed separately to establish which assistive devices decrease spinal peak and cumulative loads for a particular task to determining the most appropriate methods of transfers (Daynard et al., 2001).

A laboratory study completed by Fragala (2011), investigated the use of a gravity assist feature in a bed system designed for post-acute health care. The study simulated the common, high risk repositioning task of pulling a 200-pound patient to the head of the bed. Results revealed that using the gravity assist and a slide sheet work demands decreased by 35% at a bed angle of 0º, by 46% at a bed angle of 4º, and work load was also decreased by 64% when bed angle reached 6º (Fragala, 2011). The researchers noted that the work demands continued to decrease as the bed angle increased to 8º and 12º as well. Clinical implications can be made from this particular study especially when repositioning larger patients. Fragala (2011) illustrated, "when caregivers are required to move larger residents toward the head of the bed, these greater bed angles might be used in conjunction with slide sheets" (p. 66).

Waters (2007) developed and evaluated the National Institute for Occupational Safety and Health (NIOSH) Revised Lifting Equation and claimed that this equation should not be used for assessing the handling of patients. The reason is due to the unpredictably of the patient such as combativeness and patients who experience muscle spasms or resist, as well as conditions of slips, falls, and unexpected heavy loads (Waters, 2007., Waters, Putz-Anderson, Gar, & Fine, 1993). Waters (2007) recommends a maximum of 35 lbs for most patient lifting tasks, only under the most ideal conditions. The lifting load is even less when the less ideal circumstances occur such as lifting with extended arms, lifting with one hand especially in a restricted space, lifting with trunk twisted or the load to the side of the body, lifting when sitting or near the floor, or lifting during a shift lasting longer than eight hours (Waters, 2007). When the lifting load exceeds 35 lb, assistive devices should be used and or more caregivers assisting with the lift.

Waters et al. (2007) suggested that, "additional research is needed to design technologic solutions for the high-risk, high-volume patient handling task of repositioning patients to the head of a bed" (p. 137). The assistive devices that will be under evaluation include commercial "friction-reducing" devices designed to ease the load of repositioning or transferring patients in a bed or chair. This low-friction material makes sliding easier and can reduce force necessary to move the patient significantly (Nelson et al., 2003). The key to these devices is matching the size of the device to patient dimensions, the material type, the weight limit, ease of use, the time needed for operation, ease of portability, safety features, existing handles, and specific method of operation (Baptiste, Boda, Nelson, Lloyd, & Lee, 2006). The devices used in this current study include the Arjo Maxislide ™, McAuley Medical disposable slide sheet, and a traditional cotton draw sheet.

The purpose of this study was to investigate the forces required while performing the patient handling task of moving a patient up in bed when using a variety of friction-reducing slide sheets. It is hypothesized that there will be a significant difference in the forces (hand and lower back) required by the ‘caregiver’ when sliding a ‘patient’ up in bed when using a variety of different slide sheets (traditional and reduced friction slide sheets).

Method

Participants

In this study, 29 healthy adult participants (male and female) aged 18 to 65 years of age were recruited to participate. Participants ranged in age from 18 to 36 years (M = 24.1 years, SD= 4.6 years). Participant body mass ranged from 100 to 226.2 pounds (M = 145.8 years, SD= 25.72 pounds). Recruitment for participants was completed through “word of mouth”, through flyers posted in common areas of a public university and through university email. The consistent ‘caregiver’ was a 25 year old female weighing approximately 130 lbs throughout data collection.

Apparatus

A 3-dimensional motion capture system using four ProReflex cameras along with Qualisys Tract Manager Software Version 2.3 was used and synchronized with a force plate and Imada DPS-220 force gauges. The Imada DPS-200 digital force measurement gauges were used to calculate the compression and tension forces at the hands while the participant was repositioned “up in bed.” The hospital bed was manufactured by Linak (model# CB9140AE-3+A011F, No. 106). The ‘slide sheets’ used in this study included the McAuley Medical disposable fabric slide sheet, Arjo’s Maxislide ™ slide sheet produced in several countries including the United States in Roselle, IL, and the traditional cotton draw sheet. Figure 1 is a photograph of the research set up.

[Insert Figure 1 about here]

Dependent Variables

Hand forces and compression and shear forces of the lumbar region was calculated on only one of the 'caregivers' when performing each of the repositioning tasks for continuity during this study. In calculating the force exerted at the right and left hands of the caregiver, data reduction was completed by finding the maximum force for each trial for each slide sheet condition and taking the average of those trials.

The spinal loads were calculated using 3D Static Strength Prediction Program (version 4.3, University of Michigan, 3003 S. State St. #2071, Ann Arbor, MI 48109-1280). Specifically, the angles of the body and extremities where the point at which the sum peak force from both hands occurred during the transfer were entered into the 3D Static Strength Prediction Program which, in turn, calculated the spinal loads. The angles of the body were derived from Visual 3D software, (version 4.87.0, C-Motion, 20030 Century Blvd Suite 104A Germantown, MD 20874). That is, the 3cd files from Qualysis track manager were entered into Visual 3D which interpolated data with less than 10 samples gaps, smoothed data using a 6 Hz dual pass Butterworth filter, calculated joint angles of the body and calculated the hang forces throughout the trial. The ground reaction forces were not calculated due to equipment error.

Procedure

This study was approved by Biomedical IRB from The University of Toledo. Informed consent was obtained from each participant prior to data collection and data were collected from July through October of 2011. Upon the recruitment of each participant a consent form was signed, the participant weighed, and a series of 12 patient transfers for each of the three transfer devices was completed. After receiving informed consent and being weighed the participant was instructed to lay supine in the hospital bed upon one of three patient handling sheets. The order of presentation for the sheets was randomized into one of three possible combinations (Sheet1, Sheet2, and Sheet 3). The transfer technique employed is referred to as "pulling patient up in bed" (Fragala, 2011), commonly called "boosting" a patient up in bed. The participants in this study acted as the 'patients' and the investigators (*n*=2) or investigator assistants (*n*=3) acted as the 'caregivers.'

The bed was horizontal with an angle of 0 ° and two 'caregivers' stood on either side of the bed while involved in the repositioning the 'patient.' The height of the bed was adjusted so that it stood at 46% of the height of the shorter of the two people completing the transfer (Lindbeck & Engkivist, 1993). The 'patient' was initially asked to assume a position with his or her heals approximately 4-inches from foot of the mattress with hands across their chest. Participants were then instructed to not help the repositioning task by pressing his or her feet on the foot of the bed. A marker was placed on the on the bed 12-inches above where the 'patient's' head was to mark the distance of the repositioning. Reflective markers were placed on the head, shoulders, elbows, wrists, back, legs, ankles and feet of one consistent 'caregiver'. Once the 'patient' and 'caregivers' were in their initial places, the 'caregiver' with the reflective markers initiated the repositioning by communicating with the other 'caregiver' by saying, "on the count of three, one, two, three" at which time the two 'caregivers' slid the participant up in bed 12-

inches. The same ‘caregiver’ with reflective markers, stood upon the Bertec force plate then moved to the Amti force plate during the transfer of the ‘patient’ to the head of the bed to calculate the change in ground reaction forces.

Statistical Analysis

This study used a repeated measures design using an analysis of variance (ANOVA) with three factors. The repeated factors were the three slide sheets, the McAuley Medical disposable fabric slide sheet, Arjo’s Maxislide ™ slide sheet, and a traditional cotton sheet. Multivariate descriptive statistics was performed to determine the mean and standard deviations for each of the independent variables of interest. Repeated measures ANOVA were used to analyze the dependent variables on the three sheets with follow up focused contrasts to determine specific differences between each of the slide sheets.

Results

Data from 20 participants were included in the peak sum of hand force analysis while data from 17 participants were included in the low back compression and shear force analyses. Some of the data for the hand force dependent variable were discarded due to equipment malfunction. Some of the data from the low back compression and shear force dependent variables were discarded due to marker gaps being larger than 10 samples. There were no order effects for any of the dependent variables (*ps* >.05).

The means of the peak sum of the right and left hand forces for each condition are tabulated in Table 1. During the repositioning task of lifting a patient “up in bed,” there was no significant difference found between the Maxislide™, McAuley’s disposable, or cotton sheets, in terms of the peak sum hand force of the right and lefts hands. See Table 2.

[Insert Tables 1 and 2 about here]

The traditional cotton sheet created the highest mean peak sum hand force value for the left and right hands, followed by the Arjo's Maxi-slide™ sheet. The McAuley's Medical Disposable sheet ranked the lowest mean peak force of the three sheets. See Table 1. Each created a summative peak hand force well over the recommended 35 lbs lifting recommendation (Waters, 2008) (Figure 2).

[Insert Figure 2 about here]

Means and standard deviations for Peak Sum of Hand Forces, L5-S1 and L4-L5 Compression and Shear Forces at L5-L4, L-5-S1 can be found in Table 1. During a two person repositioning task of pulling a patient to the head of the bed, there was a statistically significant difference between the three slide sheets, in terms of low back compression forces of the caregiver at L4-L5 and at L5-S1, see Table 2.

The repeated measures ANOVA with follow up contrasts compared Arjo's Maxi-slide™ to the traditional cotton sheet and the McAuley Medical's disposable slide sheet to the traditional cotton sheet. Significant differences were found when calculating within-subject effects of both L4-L5 compression forces and L5-S1 compression forces with each slide sheet comparison (see Table 2). The contrasts revealed that the McAuley sheet required significantly less compressive forces than the Maxi-slide™ and the traditional sheet at both L5-S1 and L4-L5. The Maxi-slide™ required significantly less compressive forces than the traditional sheet at L4-L5, but not at L5-S1. See Table 2.

There was no significant difference among the sheets on the factor of L5-S1 sagittal (A-P) shear forces but there was a significant difference on the factor of L4-L5 sagittal (A-P) shear forces. The contrasts revealed that the McAuley sheet elicited significantly less sagittal (A-P) shear force than both the Maxi-slide™ and traditional sheets while the Maxislide™ required significantly less shear force than the traditional sheet (Table 2).

Discussion

As suggested by previous researchers, further evidence- based research is needed to propose new solutions to the risky and recurring patient handling task of repositioning patients to the head of a bed (Waters et. al, 2007). The purpose of this study was to investigate the forces required of a caregiver while performing the patient handling task of moving a patient up in bed when using a variety of friction-reducing slide sheets. Statistically significant differences were found in the lumbar compression forces at L4-L5 and L5-S1, and at L5-S1 in terms of sagittal (A-P) shear forces of the 'caregiver' when sliding a 'patient' up in bed using a variety of different slide sheets (traditional and reduced friction slide sheets). This particular repositioning task has been identified as being a high risk patient handling task within critical care and is thought to be a contributor to the injuries sustained within the healthcare field (Waters et. al., 2007). Researchers in this study concluded that the use of friction-reducing slide sheets required less compression forces and sagittal shear forces at the lower back; therefore have the potential to reduce injuries of the lower back due to common patient handling tasks, such as repositioning at patient in bed.

During the repositioning task of lifting a patient "up in bed," there was no significant difference found among the Maxislide™, McAuley disposable, or cotton sheets, in terms of the peak sum hand force of the right and lefts hands. However, the mean peak hand forces were the lowest with the McAuley disposable slide sheet and Arjo's Maxi-slide™ sheet compared to the traditional cotton sheet. While not statistically significantly different, the trend of the traditional cotton sheet requiring greater force than the two reduced friction sheets is in line with the other results in terms of back compressive forces. Regardless, the peak force of pulling a patient up in bed was relatively high when considering Water's 35 pound limit for safe patient handling. Assistive devices are recommended if the patient lifting exceeds 35 lbs., and in this case each of the sheets under study exceeded the 35 pound limit.

During a two person repositioning task of pulling a patient to the head of the bed, there was a statistically significant difference between the three slide sheets, in terms of lumbar compression forces of the caregiver at L4-L5 and at L5-S1. There were also statistically significant differences, in terms of lumbar sagittal (A-P) shear forces at L5-S1, but not at L4-L5 between the three slide sheets. Lateral shear forces may have not occurred during this repositioning task due to the minimal lateral trunk deviations completed by the designated 'caregiver' under investigation. As the 'caregivers' repositioned the 'patient' up in bed, the 'caregiver' under study moved laterally stepping their right foot one-step, bending at the knees, and gathering the left foot one-step laterally, within minimal lateral flexion at the trunk. Additionally, the caregivers tended to orient their bodies perpendicular to the line of pull. The minimal lateral trunk flexion and body mechanics among the 'caregivers' may have lead to this conclusion. These results are similar to Marras et. al (1999) study where researchers compared one and two-person transferring and repositioning tasks. They found that single-person transfers resulted in greater lateral shear forces than the two-person transfers, explaining that, "patient handlers tend to move their feet more during the two-person lifts, thus, reducing the motions that influence lateral shear forces" (Marras, 1999, p. 197).

As mentioned above, Marras et al. (1999) performed a repositioning (slide a person up in bed) task in addition to transfers. Marras tested four methods for repositioning a person in bed including one involving a draw sheet. The forces Marras et al. reported are somewhat greater than what the researchers in this current study found (for lateral shear, A-P shear, and compression forces). It is possible that the positions and techniques used in these two studies differed. Marras et al. provided a photograph of their method and it appears that the investigators were standing facing each other while holding onto the draw sheet. It appears that the investigators are flexing at their hips with their upper bodies somewhat flexed over the ‘patient’. Flexing the spine, even so slightly, will dramatically increase the compressive and shear forces (i.e., A-P) compared to if the spine were in a more extended pattern as in the current study. It also appears that the technique they used involved lifting the ‘patient’ vertically then they would step sideways while providing vertical lift (i.e., a ‘dead lift’) for the patient. This is a different technique than what was used in the current study where the ‘caregivers’ used a pull and slide technique. Additionally in the current study the bed was raised to 46% of the height of the ‘caregiver’ under investigation, or as Lindbeck & Engkvist (1992) claim as a “high bed.”

The sliding method was used in accordance with the Workers’ Compensation Board Guide for the use of transfer devices. The guide suggested that it is important to use proper body mechanics to avoid a lift when using a slide sheet. With the bed raised to a height to reduce trunk flexion, each ‘caregiver’ stood with feet shoulder distance apart and proceeded one step laterally, pulled sheet, and slid the ‘patient’ 12 inches to head of bed, bringing the other foot to follow the first, ending shoulder width apart. Furthermore, another potential reason for the differences in lower back forces is that the Marras group used a Lumbar Motion Monitor device whereas this current study used the University of Michigan’s 3D Static Strength Prediction program. As these two methods are significantly dissimilar from each other, these differences may have contributed to the variation.

The NIOSH guidelines (1981) consider safe spinal compression to be less than 3400 N for individuals involved in patient lifting. Both friction-reducing slide sheets involved in this study were under 3400 N at each condition (L5-S1, L4-L5), whereas the traditional slide sheet just exceeded this limit at L5-S1 compression forces as shown in Table 1. According to NIOSH, the action limits (AL), is between 3400-6400 N and is potentially dangerous thereby requiring 'action.' Therefore, researchers in this study can recommend that the use of the traditional sheet should reduce the potential for musculoskeletal injury. NIOSH considers the maximum permissible limit to be 6400 N and if patient handling tasks are over this number, it should be totally avoided to reduce their risk of back injury (NIOSH, 1981). The limit established for anterior-posterior shear (McGill, 1994, Yingling, 1999) and for lateral shear (Miller, 1986) is 1000N. No device used in this study approached this limit in any of the conditions; however the McAuley disposable slide sheet produced significantly lower L4-L5 sagittal (A-P) shear forces than the Arjo's Maxi-slide™ and traditional cotton sheets. Significant differences were also found when completing within subject effects for L4-L5 sagittal (A-P) shear forces between Arjo's Maxi-slide™ and traditional cotton sheet.

Fragala (2011) found that using gravity and a slide sheet to assist in repositioning a 200 lb. patient to the head of the bed decreased work demands by 35% at a bed angle of 0º, which is similar to the current study's set up. The work demands decreased as the bed angle increased, suggesting that the use of a friction-reducing slide sheet in combination with an increased bed angle will provide the caregivers with a decrease in work demands when moving heavier patients. The evidence in the current study is based upon repositioning a patient up in bed at a bed angle of 0º, therefore it can be inferred that with the use of a larger bed angle compression forces at L4-L5 and at L5-S1 may be reduced, especially with heavier patients.

When completing within-subject contrasts, there was a significant difference between the Maxi-slide sheet and the traditional cotton sheet, with the Maxi-slide requiring less low back compression forces (L4-L5 and L5-S1) of the caregiver during the repositioning task. There was also a significant difference between McAuley Medical's disposable slide sheet and the traditional cotton sheet, with the disposable slide sheet requiring even less compression forces of the caregiver. These results indicate that the friction-reducing slide sheets produced less internal spinal loads when compared to the traditional cotton sheet often used in the hospital setting among healthcare workers. Recommendations for the use either slide sheet depends upon the facility's culture, staff preferences, and the unit's physical characteristics (Nelson et. al., 2006). The Maxi Slide™ has specific physical attributes such as a flat sheet design made of nylon, provides the caregiver with ergonomic handles to use while repositioning the patient, is washable, and costs around $144.00. McAuley Medical disposable slide sheet is made of non-woven fabric with a low friction coating on the underside. This slide sheet is for single patient use and is packaged in dispenser packs of 50, costing around $119.00. Baptiste et. al (2006) also suggested that the key to using friction-reducing devices is matching the size of the device to patient dimensions, as well as considering the material type, the weight limit, ease of use, the time needed for operation, ease of portability, their safety features, existing handles, and specific methods of operation.

Implications

By using evidence-based practices discussed in the literature review, healthcare personnel have the potential to reduce their own MSDs. The use of these intervention strategies used to reduce or prevent musculoskeletal injuries associated with patient handling should be supported and facilitated by knowledgeable practitioners in the workplace. Occupational therapy is known as a profession that “has expertise in safe patient handling knowledge and practice” (Rice et. al., in press). Occupational therapy practitioners can be involved in the process of educating and training any health care professional (e.g., nursing personnel, health clinic workers, and other health related professional) due to their knowledge and academic training in ergonomics. According to the practice framework, “Occupational therapy practitioners analyze activities to understand what is required of the client and determine the relationship of the activity’s requirements to engagement in occupation” (AOTA, 2008). Moreover, requirements of successful completion may include the need for assistive technology (e.g. friction-reducing slide sheet) when a healthcare practitioner is performing patient handling tasks. Occupational therapists can play a large role in implementing safe patient handling programs within their facility and use the evidence-based practices that promote the best and most safe practices, including the use of the devices examined in this study.

Limitations and Future Research

Several limitations in the current study should be addressed. Also the weights of the patients, although varied, did not exceed 226.2 lbs. In Marras et al. (1999) study examining the internal spinal loads when transferring and repositioning patients using a variety of techniques; a “standard” patient was 110 lb. consistently. Realistically, patients will come in all different shapes and sizes. “Patients” in this study also were asked to remain still and refrain from assisting in the repositioning task to control for trial variation. In the hospital setting, patients are frequently asked to give assistance to the transfer or repositioning task such as pressing their feet against the bed and assisting in the push or pull, in accordance with their rehabilitation goals of needing decreased assistance by discharge. In some settings healthcare staff can be ‘pressed for time’ and may end up giving total assistance to these patients instead of asking for his or her participation. However the situation handled, “patients” in this study gave zero assistance and required a total lift, or repositioning in this case, as many patients may require in the hospital setting.

Secondly, the current study was completed under contrived laboratory conditions. While using force gauges in a laboratory setting is necessary to finding the forces exerted by the caregiver, it is not a naturalistic occurrence. Most likely the healthcare practitioner will use his or her own hands to grip the sheet and may not complete the repositioning task over a length of 12 inches; however this was considering a best case scenario where the caregiver’s environment was ideal. Also the “patients” recruited for the study were healthy cooperative adults, not patients with co-morbid conditions that may affect the safe repositioning task. Additionally, in the hospital setting, many patients have various intravenous lines, catheter lines, or other obstacles that could potentially require the health care provider to assume an awkward posture in order to ‘safely’ reposition the patient. The rest of the equipment used in the study such as the bed and bed sheets are common to the hospital setting, although the study was not completed in the natural setting. Future research could take place in the hospital setting; however patient consent and privacy concerns would occur as well as a change of apparatus’ to capture the motion of the caregivers.

When interpreting the results of this study, it must be understood that the forces calculated at the hands were the maximum summative force of both left and right hands, not individual left or right hand forces. Also the body was exposed to tension and compression forces throughout the transfer beyond just the moment when the peak force occurred; resulting in more risk than what was calculative. Authors speculate that healthcare practitioners are at risk for cumulative trauma injuries because of the repetition even beyond just maximum 35 lb peak forces when completing multiple transfers, lifting, and repositioning tasks. This study showed that even when using a friction-reducing slide sheet the recommended 35 lb. lift limit was exceeded when repositioning a patient to the head of the bed (Waters, 2007).

Lastly, the study was limited to one repositioning task and technique, although used consistently, throughout the study with one “caregiver.” The force at the hands and lower back may be dramatically different with a different caregiver and the assistance of other caregivers when completing two person transfers. Future studies may calculate the force at the hands and lower back with each caregiver simultaneously during the same repositioning transfer and possibly test different body mechanics and techniques to assist in establishing body mechanic guidelines for a variety of patient transfers.

Conclusion

It is important to determine the efficacy of new technologies designed to assist in safe manual handling practices among healthcare workers, such as friction-reducing slide sheets supported in this study. Specifically, this study found that friction-reducing slide sheets produced less internal spinal loads when compared to using a traditional cotton sheet. The current study contributes to the body of evidence-based research in the area of safe patient handling practice.

The future health of our healthcare practitioners in the U.S. may be affected by the changes in the size of patients. Data from the National Health and Nutrition examination survey reported that as of 2004, close to 66 percent of the adult Americans were overweight or obese and it predicted an increase to 75% by 2015 (Wang & Beydoun, 2007). With the population of patients growing in size, healthcare practitioners will increasingly be exposed risks associated with lifting, transferring, and repositioning these patients. Prevention is key and can play a vital role in maintaining the health our healthcare practitioners.

Researchers in this study concluded that in each of the conditions the McAuley's disposable slide sheet faired the best among the friction-reducing slide sheets, reducing the both compression and shear forces, with significant results in compression at L4-L5, L5-S1 and sagittal L4-L5 next to Arjo's Maxi-slide™. The Maxi-slide™ resulted as the second best option, also producing statistically significant lower L4-L5 compression and sagittal shear forces when compared to the traditional cotton sheet. The traditional cotton sheet was third among the slide sheets, in terms of compression and shear forces, however just exceeded the compression action limit set by NIOSH at L4-L5. Researchers within this study safely assume that the use of the traditional cotton sheet is ubiquitous, as it is available among patients in bed in the hospital setting. Although limited friction sheets are much less common, they are proving to be a contender in current evidence-based practice solutions to reduce the risk of injury among healthcare workers (Baptiste et. al, 2006; Nelson & Baptiste, 2004).

Future research directions should focus on the efficacy of the use of a variety of assistive devices when completing an array of different transfer, lifting, and repositioning techniques. More evidence is needed to prove healthcare practitioners are exceeding their body's physical capabilities and placing them at a high risk for work-related musculoskeletal disorders. With an increase in related studies, evidence-based practices will soon become a necessary component to the rehabilitation model and will serve as a standard practice, keeping our patients and ourselves safer from injury.

Acknowledgements

It is a pleasure to thank those who have made this research study possible this past year. I would like to thank my research advisor Dr. Martin Rice for the guidance, encouragement, and support which enabled me to develop an understanding of the topic and the current evidence-based practices within safe patient handling. Thank you for all the time you spent setting up laboratory equipment, trouble shooting problems during data collection, fixing equipment, completing statistical analyses, and teaching me how to use a drill. Thank you for inspiring in me a new interest and enthusiasm for research. I owe deep gratitude to my fellow research team under Dr. Rice including Michael Iott, Emily Fahrer, and Kareisha Sackaloo. Without their help and support, it would have been very difficult to complete the project, thank you. Michael my lower back thanks you too. I would also like to offer my thanks to the work study students who helped make this research project possible. Thanks to Reggie Kehoe, Laura Kristofferson, Sarah Bialecki, Grace Lunsford, and Heather Deaton. Finally, I would like to thank the class of 2013 for their continued support throughout this program.

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Table 1

Means and standard deviations for Peak Sum of Hand Forces, L5-S1 and L4-L5 Compression and Shear Forces at L5-L4, L-5-S1.

Conditions	***M***	***SD***	***N***
Peak Sum of Hand Force-R+L (Pounds)			
Arjo Maxislide	45.86	12.39	20
McAuley Medical Disposable	44.43	14.57	20
Traditional Cotton Sheet	49.81	18.51	20
L5-S1 Compression Forces (Newtons)			
Arjo Maxislide	948.27	230.24	17
McAuley Medical Disposable	850.86	248.88	17
Traditional Cotton Sheet	1,057.39	241.00	17
L4-L5 Compression Forces (Newtons)			
Arjo Maxislide	2,646.96	549.13	17
McAuley Medical Disposable	2,089.11	485.12	17
Traditional Cotton Sheet	3,428.07	805.71	17
L5-S1 Sagittal (A-P) Shear Forces (Newtons)			
Arjo Maxislide	346.96	40.88	17
McAuley Medical Disposable	339.84	49.69	17
Traditional Cotton Sheet	373.96	75.22	17
L4-L5 Sagittal (A-P) Shear Forces (Newtons)			

Arjo Maxislide	279.70	41.86	17
McAuley Medical Disposable	257.91	57.38	17
Traditional Cotton Sheet	319.56	50.84	17
L5-S1 Frontal (Lateral) Shear Forces (Newtons)	0.00	0.00	
Arjo Maxislide	-107.91	32.21	17
McAuley Medical Disposable	-101.86	35.54	17
Traditional Cotton Sheet	-122.90	69.88	17
L4-L5 Frontal (Lateral) Shear Forces (Newtons)			
Arjo Maxislide	-198.97	54.76	17
McAuley Medical Disposable	-170.06	53.20	17
Traditional Cotton Sheet	-202.31	107.69	17

Table 2

Repeated measures analyses of variance within subject effects with follow up contrasts comparing within-subject effects for Maxi-slide, McAuley Disposable, and Traditional sheets.

Condition	*dF*	SS	MS	*F*	*p*
Peak Hand Sum Force					
Within subjects effects	2	310.91	155.20	1.51	.236
Error	38	3928.93	103.39		
L5-S1 Compression Forces					
Within subjects effects	2	18344.77	9172.38	4.11	.026
Error	32	71343.12	2229.47		
Within subject contrasts					
Maxi-slide vs. Traditional	1	10236.94	10236.94	1.92	.185
McAuley Disposable vs. Traditional	1	36649.83	36649.83	5.357	.034
McAuley Disposable vs. Maxi-slide	1	8147.53	8147.53	6.77	.019
L4-L5 Compression Forces					
Within subject effects	2	777294.88	388647.44	27.65	<.001
Error		449745.12	14050.54		
Within subject contrasts					
Maxi-slide vs. Traditional	1	524189.41	524189.41	12.91	.002
McAuley Disposable vs. Traditional	1	1540317.34	1540317.34	50.02	<.001
McAuley Disposable vs. Maxi-slide	1	267377.88	267377.88	12.91	.002
L5-S1 Sagittal (A-P) Shear Forces					

Within subject effects	2	556.24	278.12	2.82	.074
Error	32	3155.26	98.60		
L4-L5 Sagittal (A-P) Shear Forces					
Within subject effects	2	1680.17	840.09	11.87	<.001
Error	32	2265.07	70.78		
Within subject contrasts					
Maxi-slide vs. Traditional	1	1365.03	1365.03	12.47	.003
McAuley Disposable vs. Traditional	1	3266.99	3266.99	14.52	.002
McAuley Disposable vs. Maxi-slide	1	408.50	408.50	4.53	.049
L5-S1 Frontal (Lateral) Shear Forces					
Within subject effects	2	201.14	100.57	1.46	.247
Error	32	2202.58	68.83		
L4-L5 Frontal (Lateral) Shear Forces					
Within subject effects	2	542.43	271.22	1.61	.216
Error	32	5395.81	168.62		

Note: Alpha set at .05

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Figure 1. Research set up.

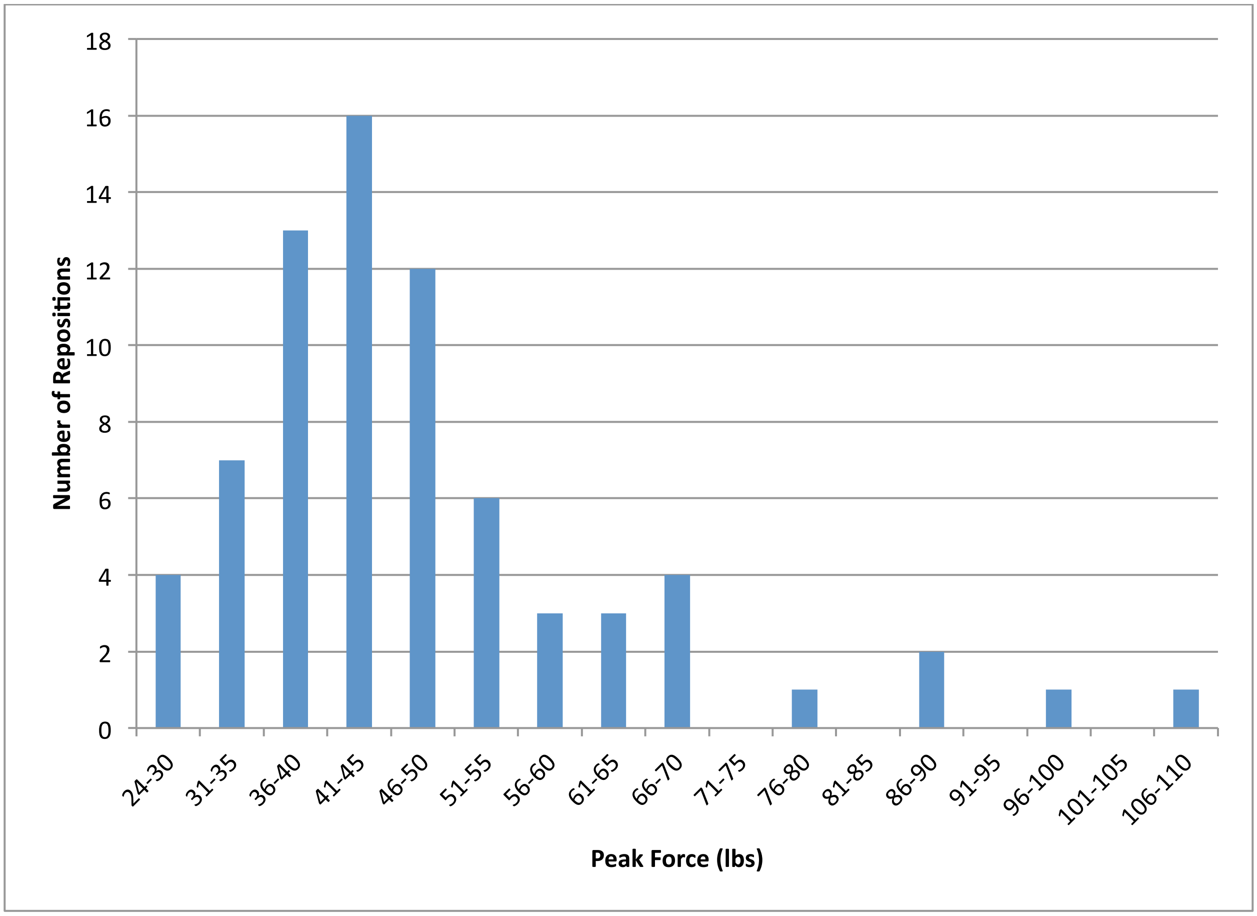

Figure 2. Histogram for number of repositions and sum peak force for left and right hands.