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**Abstract**

The purpose of this study is to determine the physical strain occupational and physical therapists place on their body by analyzing the ground reaction forces elicited while engaging in manually lifting a subject through the use of a pivot transfer, while comparing the differences between experienced and non-experienced therapists. Participants included 9 adult male and female occupational therapists and physical therapists ranging in age from 40 to 55 years and 14 occupational and physical therapy students ranging in age from 22 to 32 years. Each participant was required to perform 12 pivot transfers ranging in assistance levels of Min, Mod, Max and Total assistance, the order of which was randomly assigned. A 2 X 4 repeated measures ANOVA was used to evaluate the differences between groups and a 1 X 4 repeated measures ANOVA was calculated for the patient's force plate in order to analyze the assistant levels throughout the four conditions of Min vs. Mod, Mod vs. Max, and Max vs. Total. This study demonstrates that there is a difference between experienced and non-experienced therapists when comparing ground reaction forces when using a pivot transfer during a patient handling task, especially when the individuals had to transfer at the higher assistance levels with the non-experienced individuals generating greater ground reaction forces. Overall, the study enhances the exploration of safe patient handling techniques and seeks to reveal the risks involved in a pivot transfer at the various assistance levels for experienced and non-experienced therapists. Future research should aim towards evaluating the forces at the lumbar while performing various patient handling tasks as well as additional research on the perception component for grading transfers.

**Introduction**

Patient handling has been and remains a concern for healthcare providers, including occupational therapists, leaving them at risk for musculoskeletal disorders (MSD) and career altering injuries. In 2010, The Bureau of Labor Statics calculated an 8.6 incidence rate for non-fatal injuries and illnesses for nursing care facilities incident rates of 249 per 10,000 workers. The healthcare and social assistance industry has one of the highest rates of work related injuries and illnesses with 152,000 more cases than manufacturing (Bereau of Labor Statistics, 2011). These injuries are partially due to working conditions that involve repeated motions associated with manually lifting patients as well as improper body mechanics throughout the work day. Main (1997) calculated that nurses lift an average of 1.8 tons in a typical eight hour shift. In addition Stubb, Buckle, Hudson, Rivers, and Worringham (1983), reported that nurses spend an average of 1.6 hours per shift in a stooped posture. Awkward posture (e.g., stooped posture) has been identified as being one of the risk factors recognized by OSHA for developing musculoskeletal injury (Sanders, 2004). Specifically, when a patient handler spends large amounts of time in a stooped and awkward posture he or she is at risk for low-back disorders (Waters, Collins, Galinsky, & Caruso, 2006). The population that represents the healthcare industry is at a high risk of injury due to the physical demand of manually lifting patients; therefore, there is a great need to investigate this area with the ultimate goal of eliminating these causes in health care workers

Evidence-based practice has allowed for exploration of the forces acting on the spine as health professionals are manually lifting patients. For example, in the lumbar spine forces that cause the two vertebrae to slide with respect to one another in the frontal plane are considered lateral shear forces. Then anterior and posterior shear forces are forces resulting in pushing the vertebrae to slide across each other in the sagittal plane. When the back muscles contract, they exert a longitudinal pressure or compression on the vertebral column which results in pressure on the intervertebral discs in the spine (see Figure 1). This pressure, or compression, can be a result from lifting and lowering patients during transfers (Bogduk, 2005). The risk factors associated with manually lifting patients including repetition, awkward postures, forces, and compression can, overtime, result in wear and tear on the ligaments, muscles, and joints that can cause musculoskeletal disorders (Sanders, 2004).

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The cost associated with MSDs in healthcare providers is high and will vary according to the specific job title and industry. According to a nationwide study of reported incidences conducted by the Bureau of Labor Statics, injuries and illness for nurses cost 900 million dollars and 40 million dollars for license practical nurses in 1993 (Waehrer, Leigh, & Miller, 2005). In 2011 , the hospital industry was ranked as being the third most expensive of 313 U.S. industries, with injuries representing 90 percent and illnesses representing 10 percent of the total cost (BLS, 2011). The injuries specifically associated with handling patients is expensive and costs the United States over $7 billion each year in workers compensation costs, medical bills, and staff replacements (American Nurses Association, 2012). While incidence of MSDs in the health industry continue to rise, so will the cost related to the compensation for those injuries.

In several research studies, the risk for the type of musculoskeletal disorders can be ascertained through self-report surveys. For instance, Trinkoff, Bradey and Nielson (2003) surveyed 1163 randomly selected currently working nurses with a 74 % return rate. Respondents were asked to report on their prevalence of neck, shoulder, and/or back pain symptoms. These researchers found that there were significantly fewer neck or back MSDs if mechanical lifting devices were available compared to when no mechanical lifting devices were available (Trinkoff, Brady, & Nielsen, 2003). In a similar study, Rice, Dusseau and Kopp Miller (2011) electronically delivered a questionnaire to 1,113 occupational therapists and assistants in the state of Ohio. With a 26% return rate, 64% indicated they were required to manually lift patients, and 8% indicated receiving an injury. Furthermore, 11% reported missing days from work with sustained injury, and 12% considered leaving the profession due to the demands of patient handling.

Another important topic to consider is the link between patient handling and the quality of care provided by health professionals. The American Nursing Association (ANA, 2001) conducted a survey of 4,800 nurses with 76% reporting that their ability to provide quality of care was influenced by unsafe working conditions (Nelson, Collins, Siddharthan, Matz, & Waters, 2008). On the other hand, patients are also at risk for injuries during patient handling by healthcare providers. Using equipment during patient handling activities often leaves the patient feeling more secure, less subjected to awkward or forceful handling, with decreased anxiety and increased autonomy, as well as preserved patient dignity (De Castro, 2006).

Marras, Davis, Kirking, and Bertsche (1999) evaluated one person transfers verses two person transfers from multiple surfaces, while using a variety of techniques, which measured the lateral shear force, anterior-posterior shear force, and compression forces acting on the spine during transfers. These researchers evaluated the risk of lower back disorders associated with the transfers. The researchers indicated that none of the lifting techniques are considered safe to use regardless if one or two patient handlers contributed to the transfer. They found that the spinal loads during the transfers exceeded their tolerance measured by the low- back disorder risk model. According to past evidence, recommendations for manually lifting patients is set at a maximum limit of 35 lbs (Waters, 2007). Knapik and Marras (2009) evaluated other strategies such as pushing and pulling instead of manually lifting the patient. By using an electromyography-assisted biomechanical model assessing spine loading during pushing and pulling this study revealed that 20% of the lifters own body weight was the limit of acceptable exertion, while pulling at low and medium heights (Knapik & Marras, 2009).

Every health care provider dealing with daily patient care has presumably been taught manual lifting techniques as part of his or her curriculum or job training. Unfortunately, some methods (e.g., manual lifting) are considered unsafe, yet are still being used by health care providers. One reason practicing healthcare providers are currently using these methods is because they are still being instructed to use them (Slusser, Rice & Kopp Miller, 2012). Moreover, Owen (1999) evaluated the primary reason the hook and toss technique is still being used in the U.S. is because 83% of the educators are teaching this method. Not only are the out dated manual lifting techniques like the hook and toss technique, which Owen (1999) discussed in his research, putting the lifter at risk for injury, so can the patient's unpredictable behaviors. The unanticipated movements and complications associated with manually lifting a patient can create loads within the lifter's spine that can be greater than them lifting a stable object (Waters, 2007). For this reason, there has been a call for a new curriculum in educational programs across the U.S. to stop teaching outdated approaches and implement safe patient handling techniques focusing on evidence-based methods and technologies to reduce injury among patient handlers (Nelson & Baptiste, 2006). Recommendations from Nelson and Baptiste (2006) are to implement patient care ergonomic protocols and patient lift teams. They also proposed that a no lift policy be implemented except in life threatening situations. Another suggestion enlightened traditional training in proper body mechanics and lifting techniques, as well as training on the use of mechanical lifting devices.

Mechanical lifting devices have been recommended as an alternative to manually lifting patients. There are a variety of mechanical lifting devices that can be substituted for lifting patients in multiple environments and transfers. When comparing floor-based mechanical lifting devices to overhead lifting devices, a study found that over-head devices required less force to push, pull and rotate patients' when compared to a floor-based device (Rice, Woolley, & Waters, 2009). This study concluded that the use of overhead-mounted devices could possibly reduce the probability of injury while lifting and transferring patients. However, floor-based lifts can be useful for certain transfers. Although mechanical floor-based devices may be more time consuming, evidence-based research has deemed them to be safer for the patient and care giver than manually lifting the patient (Collins, Wolf, Bell, & Evanoff, 2004; Fragala & Nelson, 2003; Zhuang, Stobbe, Collins, Hongwei, & Hobbs, 2000).

Collins et al. (2004), embarked on a six-year study that involved six different nursing homes and 1,728 nursing staff members focusing on a program for preventing musculoskeletal injuries, called "best practices." All participants and facilities were required to use mechanical lifts, repositioning aids, a zero lift policy, and implemented employee training on lift usage. The "best practice" program significantly reduced injuries and lowered workers' compensation costs, as well as lost work days due to injuries after the intervention. In less than three years the initial investment of $158,556 for lifting equipment and workers' training was regained through reduced workers 'compensation costs and resulted in post-intervention savings of $55, 000.

(Collins et al., 2004). In another sense, Zhuang, Stobbe, Collins, Hongwei, & Hobbs (2000) evaluated the psychophysical stress involved with transferring residents from a bed to a chair in nursing homes while using the following: a nine battery-powered lifts, a sliding board, a walking belt, and a baseline manual method. According to the psychophysical assessment, the nursing assistants reported significantly lower stress when using assisted devices during the transfer than with the manual methods (Zhuang et al., 2000). Over the past 10 years, evidence-based practice has supported newer interventions by utilizing technology and best practices to prevent injuries for caregivers and patients (Nelson & Baptiste, 2006). Evidence-based practice in mechanical lifting devices and assistive equipment has been shown to be safer than manually lifting patients and is being advocated for through the safe patient handling movement to reduce musculoskeletal disorders in healthcare providers.

Equally important is the healthcare professionals view point on their ability to provide quality care for their patients. One complaint among health-care providers that affects the quality of care they provide is low staffing. According to the 2,554 responders on the Nursing Standard survey, nurses ranked themselves a seven out of ten for their ability to provide quality of care to their patients. The researchers found that the number one factor that would enhance their quality of care ratings would be to improve staffing levels (Duffin & Waters, 2012). If facilities improved staffing levels, implemented new standards as recommended by OSHA for safe patient handling, and invested in adequate numbers of new equipment for handling patients; the risk of injury would decrease as well as the costs associated with those injuries (Collins et al., 2004; Nelson & Baptiste, 2006).

Nursing and nursing assistants remain to be a focus for research on reported injuries related to manually lifting patients and the long-term effects of their injuries on their quality of care. In the meantime, occupational therapists and physical therapists are also facing career and life altering musculoskeletal disorders due to the physical demands of manually lifting patients. Darragh, Huddleston, and King (2009), surveyed 3,297 randomly selected Wisconsin-based physical and occupational therapists, in order to receive the incidences of work-related injuries in these health-care populations. Of the 36 percent of therapists that reported, the study found annual incidence rates of work-related injuries that reflected 12.4 per 100 full-time workers in 2004, 12.9 per 100 full-time workers in 2005, and 16.7 per 100 workers in 2006 (Darragh, Huddleston, & King, 2009). Furthermore, the highest rated injury among both professionals was lower back which represented 30 percent of occupational therapists and 33 percent of physical therapists. Despite the injuries and pain, it is not uncommon for occupational and physical therapists try to tolerate and work through their discomfort. For this reason, Darragh and Campo (2012) focused their research on the impact of work-related pain in occupational and physical therapists. The therapists explained they had to alter their work habits to stay productive and to fulfill their responsibilities to patients and coworkers. The therapists in this study also expressed concerns of career longevity and possibly changing career paths if their pain continued to affect their ability to provide optimal care. In addition, the therapists in the study reported their lives outside of work were greatly affected and endured personal consequences in their own daily occupations due to job-related pain.

As reported by Alnaser (2007), a systematic review showed that among occupational therapists, the most common job-related factor causing work-related injuries was patient handling. Of the 22 research articles from 1990-2005, one common risk factor qualitatively speaking was the level of experience and age; specifically, the therapists with less experience and those who were younger incurred a greater number of injuries (Alnaser, 2007). Furthermore, the average age nurses and physical therapists commonly experienced injuries was before the age of 30 (Alnaser, 2007). In addition, Molumphy, Unger, Jensen and Lopopolo (1985), sought to investigate the incidence of work-related low back pain (LBP) in physical therapists as well as identify common characteristics of therapists who reported work-related LBP. Of the 500 surveys mailed to physical therapists, 344 were returned at a 69% return response. From the surveys, 29% of therapist had experiences LBP and the initial onset of their symptoms occurred between the ages of 21 and 30 and occurred within the first four years of practice (Molumphy et al. 1985). However, limited research explains the personal factors associated with the level of experience as they relate to occupational and physical therapists at risk for job related injuries involving manual transfers comparing the difference between experienced and non-experienced therapists. If experience is a risk factor then research should evaluate the factors that put younger and less experienced therapist at higher risk for injuries.

Manually lifting patients is one of the expected job duties of occupational and physical therapists. The ability to determine levels of assistance a patient requires for transfers is another responsibility of therapists. The traditional protocol used for grading the patient for a transfer is the Functional Independence Model (FIM). There are four levels of required assistance on the part of the patient (Uniform Data System for Medical Rehabilitation, 2012). These include: minimal assistance (min), moderate assistance (mod), maximal assistance (max), and total maximal assistance (Tot). As defined by the FIM, the patient will complete 75% of the transfer to be considered min assist, 50%-74% to be considered mod assist, 25%-49% to be considered max assist, and less than 25% to be considered total assist. According to Medicare guidelines, the FIM and the Minimum Data Set (MDS) provide guidelines to evaluate the functional status in a variety of healthcare settings for reimbursement (Clauser & Bierman, 2003). In order for a therapist to determine a transfer grade for a patient he or she would have to engage in a transfer that requires the therapist to assess how much of the transfer the patient is completing. Initially evaluating transfers grading can be risky for the therapist because they may have to engage in a transfer unaware of the amount of assistance the patient may require. Therefore, the therapist could be lifting more than the maximum weight recommendations of 35 pounds (Waters, 2007) or the 20% guideline set forth by Knapik and Marras (2009) and therefore may put themselves at risk for injury. For this reason, research relating experience and perceived assistance in manually lifting patients in occupational and physical therapists is essential for eliminating the causes of work-related injuries in these health professionals. The purpose of this study is to analyze the ground reaction forces elicited to determine the physical strain occupational and physical therapists place on their body while engaging in manually lifting a subject through the use of a pivot transfer, while comparing the difference between experienced and non-experienced therapists. This study hypothesizes there will be a difference between the experienced and non-experienced group in the amount of ground reaction forces that are elicited.

## Methods

### Participants

Participants included 22 adult male and female occupational therapists and physical therapists as well as students ranging in age from 22 to 55 years. Originally, a sample size of 40 was planned for based on a study with a similar independent variable by Rudolph (2012). In particular, it was anticipated that with a standard deviation of 2.5, $\alpha = .05$, and $\beta = .8$, the proposed sample size would provide adequate statistical strength to reach significance. The difference between the planned and the actual number recruited occurred due to the lack of participant availability. All participates recruited for the study were deemed competent by taking part in a screening assessment for pivot transfers. Participants varied in experience and were divided into either an experienced group or a non-experienced group. Inclusion criteria for the experienced group required that they be licensed to practice Occupational Therapy or Physical Therapy and that their most recent year of employment required them to perform manual transfers as a regular part of their job duties. Inclusion criteria for the non-experienced group was that participants not be licensed to practice Occupational Therapy or Physical Therapy, but were students pursuing an education to be licensed in either field. Another inclusion criterion for the non-experienced group includes, no prior experience in performing manual patient transfers before the study except in their educational programs.  Exclusion criteria excluded any participants with a history of back injury, musculoskeletal disorder involving pain or injury that would inhibit their ability to safely perform a pivot transfer. The participants were recruited by advertisement posters posted at community centers, through newsletter and email advertisements. All participants were required to transfer the same person. See Table 1 for participant demographic information.

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## Apparatus

An eight camera 3-dimensional motion capture system using Cortex software (Motion Analysis Corporation, 3636 North Laughlin Road, Suite 110, Santa Rosa, CA) collected kinematic data for analysis.  In addition, two force plates (Amti model # OR6-5-1, 176 Waltham

Street Watertown, MA 02472 and Bertec model # 4060A, 6171 Huntley Road Suite J Columbus, OH 43229 captured ground reaction forces for both the participant and patient, respectively.

**Procedure**

This study involved two experiments. During both experiments, two people were involved, a consistent volunteer performing the role as the ‘patient’ and either an occupational or physical therapist or student performing the role of a ‘caregiver’ who was transferring the patient. During Experiment 1, participants were required to perform multiple pivot transfers representing four conditions of the Functional Independence Measure (FIM) which included: minimum assistance (Min), moderate assistance (Mod), maximum assistance (Max), and total assistance (Tot). For example, Min assistance involved the patient weight bearing between 76% and 99% of his mass, Mod assistance involved patient weight bearing between 51% and 74% of his mass, Max assistance involved patient weight bearing between 26% and 49% of his mass, and Total max assistance involved patient weight bearing between 1% and 24% of his mass. The patient imitated the multiple weight bearing conditions in the randomized order of the sequence computed for that caregiver (participant). Then the caregiver and patient received a practice trial for one transfer so that the participant could become accustomed to the process for the transfers. The participant was required to perform three transfers in each condition, so data were collected on a total of twelve transfers by each participant. The participant manually transferred the patient using a pivot transfer method (Pierce, 2008) with the ‘patient’ grading his own weight bearing status. The ‘patient’ graded his own weight bearing status based on feedback from ground reaction forces generated through a force plate which was displayed on a monitor beyond the ‘caregivers’ view. The study focused on evaluating the generating ground reaction forces when performing a series of pivot transfers. The caregiver donned 37 reflective markers at the following locations of the body: left head, right head, T1, left scapula spine, left shoulder, left upper arm, left elbow, left lower arm, left wrist, left 5$^{th}$ metacarpal, left 2$^{nd}$ metacarpal, left Posterior Superior Iliac Spine, left Anterior Superior Iliac Spine, left trochanter, left upper leg, left knee, left lower leg, left ankle, left 5$^{th}$ metatarsal, left 2$^{nd}$ metatarsal and the above was mirrored on the right side except for the left scapula spine. The caregiver and patient were positioned with his or her feet located on his or her respective force plates during the series of transfers. Prior to the practice trial, a marker identification and force plate zeroing/calibration trial occur for each participant. This required the participants to stand in an anatomical position for 1 second duration both off the force platform and once on the platform (respectively for force platform zeroing and marker identification). Throughout the series of transfers the patient and caregiver remained on their own respective force plates. After each transfer, the caregiver reported on his or her perception of the level of assistance they provided for the patient. Data were collected on participants transferring experience, height, mass, age, gender, ethnicity, profession, years of transfer experience, and limb dominance in a computer software program.

**Dependent Variables and Statistical Analyses**

Ground reaction force data was analyzed using the Visual 3D software version 4.87.0 (C-Motion Inc, 20030 Century Blvd Suite 104A, Germantown, MD 20874). In addition, the between subjects factors of percentage of caregivers' weight (e.g. >20%) to the patient's weight was analyzed which included the level of experience upon each dependent variable.

## Results

There were 14 non-experienced therapy students and 9 experienced therapists, with a total of 22 subjects who participated in the study. Data from one experienced therapist were not included in the analysis due to a protocol breech (i.e., stepping off of the force plate). A 2 X 4 repeated measures ANOVA was used to evaluate the differences between groups, experienced and non-experienced, as well as repeated measures difference contrasts for the assistance levels (i.e. Min vs. Mod, Mod vs. Max, and Max vs. Total). In addition, a 1 X 4 repeated measures ANOVA was calculated for the patient's force plate in order to analyze the assistant levels throughout the four conditions of Min vs. Mod, Mod vs. Max, and Max vs. Total. By evaluating the patient's force plate, the researchers can find the maximum weight exerted through the force plate during each trial. The exerted weight was then calculated into a percentage (the current weight divided by the person's measured weight) which will be referred to as normalized weight distribution throughout the four conditions.

There was a statically significant difference for the patient's force plate data with $F(3, 63) = 98.22$, $p < .0001$. Follow-up contrasts revealed significant differences between all three comparisons of assistance levels (e.g., Min vs. Mod, Mod vs. Max, and Max vs. Total), *ps* <.0001. Therefore, the patient was able to distribute his weight significantly different for each condition (Table 2 and Figure 2).

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Insert Table 2 and Figure 2 about here

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There was a difference between assistance levels when comparing experienced therapists and non-experienced therapy students, see Table 3. Post-hoc contrasts revealed a significant difference between Max and Moderate conditions, and between Total and Maximum conditions (Table 4). Furthermore, the post-hoc contrasts of the interaction between Assistance Level and Experience Level revealed no statistically significant interaction between Min and Moderate conditions, nor between Moderate and Maximum conditions, but did reveal a statistically significant difference between the Max vs. Total conditions, see Table 4. The significant difference shows that the two groups behaved differently when the individuals had to transfer at the higher assistance levels (Figure 3). For example, the experienced group plateaued after the Max assistance level and only allowed their bodies to tolerate a certain amount of weight. However, as the amount of assistance increased, so did the percentage of normalized weight distribution on the non-experienced group's force plate (see Table 5). This increase shows that the non-experienced group did not have a ceiling or cut off point for their transfer and instead of controlling the amount of weight the patient bore through his force plate like the experienced group did, they allowed more weight to be born on themselves.

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Insert Tables 3, 4 and 5 and Figure 3 about here

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## Discussion

The hypothesis for this study was supported when comparing the experienced and non-experienced therapist to their normalized weight distribution percentage throughout the trials. The results inferred that the two groups behaved differently during the trials, particularly when performing transfers at higher assistance levels. There are several implication for practice and safety concerns for therapists with less years of experience or just beginning in the field were patient handling is an expected job duty. First, when reviewing the experienced therapist's performance throughout the trails, in general the group's normalized weight distribution was consistently less than the non-experienced group's weight distribution. Although there was no significance for the lower assistant levels, the trend was that the non-experienced group still bore more weight than the experienced group at the lower assistance levels. Second, as the experienced therapists plateaued between the Max and Total assistance levels, the non-experienced group proportionally increased the amount of weight they would bear on themselves. Therefore, we can deduce that at higher assistance levels, non-experienced therapists could be at greater risk for injury and possibly long term consequences as a result of patient handling.

In this study, the experienced participants showed better control during the transfers by requiring the patient to bear more weight through his feet instead of through his or her own body. Despite the fact that the experienced therapists performed the transfers using less force, it is still common for occupational and physical therapists to acquire work related injuries due to patient handling. Darragh and Campo (2012) focused their research on the impact of work-related pain in occupational and physical therapists to find out therapists are still acquiring injuries due to patient handling and these injuries are leading to concerns of career longevity and effecting the therapist's daily occupations. Due to the recent evidence supporting safer patient handling techniques (Collins et al., 2004; Fragala & Nelson, 2003; Knapik & Marras, 2009; Rice et al., 2007; Waters, 2007; Zhuang et al., 2000), the experienced therapists may have had more exposer to enforcing these recommendations in practice. For example, a common technique taught for performing a pivot transfers involves using a knee blocking technique. The knee blocking technique was used frequently throughout the study with subjects from both groups. Even though the non-experienced group used similar techniques of knee blocking, there was still a difference between the groups at the higher assistance levels. Similarly, Marras et al (1999) researched one person patient handling techniques, but computed compression forces as opposed to our current study analyzing ground reactions forces. Marras et al (1999), found that during the lifting and lower phases of the one person transfers the participants compression forces were over the minimum compression tolerance limits. However, Marras et al (1999) did not distinguish the level of assistance the patient being transferred demonstrated during the transfers nor did the caregivers have to decipher the difference in assistance levels to justify the transferring technique being used. While the current study only focuses on one type of transfer, it did include the continuum of assistance levels requiring the caregiver to distinguish the difference between the levels. In addition, the ground reaction forces were calculated for each group based on the transfers the participants performed in each category of the FIM assistance levels.

The differences found in this study may have been due to the experienced therapists being able to control the pivot transfer by using better body mechanics and by forcing the patient to bear more of his own weight through his feet and force plate. In addition, the experienced therapists may have leaned the patient forward more, which most likely would have shifted his center of gravity forward, thus forcing the patient to bear more of his own weight. With this in mind, the experienced group also plateaued at the higher assistance levels, meaning they would only bear a certain amount of weight which could be explained by the previous statement. However, the non-experienced participants continued to increase their normalized weight distribution percentage through their own force plate as the assistance levels increased, causing them to put more strain on their own bodies. If the non-experienced group used very similar techniques as the experienced group then we can infer that the groups behaved differently during other points during the transfer. For example, the non-experienced participants may not have leaned the patient forward as much as the experienced participants or focused on allowing the patient to do more work than themselves. Consequently, while the non-experienced group used the recommended knee blocking technique, their use of body mechanics was not as efficient resulting in a potentially increased probability for injury.

Beyond the above mentioned biomechanical difference, perhaps the experienced therapists developed a natural threshold their bodies acquired overtime for handling people. Although the assistance level increased for the experienced group, the group maintained a threshold for a maximum amount of weight they would accommodate for the patient. This sense of a threshold may be due to the therapists' experience and exposure in the field which allowed them to acquire these skills over time of self- preservation. As an individual is exposed to a repetitive training regime in a technique involving performing pivot transfers in various situations, it is plausible that a sense of energy conservation naturally embeds itself in the therapist's work day in order to allow that therapist to be more productive with frequency of transfers. The resulting strategy may involve the experienced therapist conserving energy, knowing that he or she will have multiple transfers to perform, requiring the patient to bear more weight through his feet instead of upon themselves. This may also be explained through the concept of the participant's strength, which can build up one's endurance for the task. The experienced therapists are routinely transferring patients on a daily bases as opposed to the non-experienced therapists who are not performing transfers regularly. Therefore, the non-experienced group may have a lower strength and endurance tolerance for performing the task and may be compensating for their lower endurance by loading too much of the patients weight during the transfers. As opposed to the experienced group, who has built up a higher strength and endurance for this type of task through their experiences and daily job duties. Just because the two groups used the proper body mechanics for a pivot transfer doesn't necessarily mean the lifting task was not stressful on their bodies or that they are free from injuries. Many times, the job task may not appropriately fit the worker performing the task. In this case, the job tasks presented may have been more appropriate for a higher level or experienced therapist simply due to the environmental restraints and repetition the research set-up had on the participants.

There are several implications for practice to discuss from the results of this current study. For instance, training in patient handling in therapy programs should allow the students to experience the various assistance levels. Having a clearer understanding of the differences between the levels will allow the students to make appropriate adjustments for the higher assistance levels, for example, by leaning the patient over more and focusing on good body mechanics during the transfer. Another example is, to provide more training on the understanding of assistance levels to the students so they may be more prepared for future situations for acquiring a threshold for loads put on themselves during transfers and may assist with clearer documentation. In addition, along with the knee blocking technique being utilized in therapy programs as a transferring technique other parts of the transfer should be a focus as well. For instance, therapy programs should emphasize the importance of leaning the patient forward to allow him or her to bear more weight through his or her own feet, rather than take on the load themselves. Equally important, students should become familiar with the amount of force a transfer is putting on their bodies and realize that just because the assistance level increases for a patient doesn’t mean that they have to accommodate drastically more for that patient. Specifically, they could accommodate by using the other techniques previously discussed like leaning the patient forward and getting a feel for how to move the patient’s center of gravity to minimize the load the therapist must bear. Furthermore, non-experienced therapists should take caution when performing pivot transfers at higher assistance levels and focus on forcing the patient to bear weight through their feet as opposed to on themselves. Lastly, mechanical lifts have proven to be a great alternative for manually lifting patients, and can decrease the risk to injury if properly utilized. Knowing when to use a mechanical lift is a part of the problem-solving process for preventing injuries related to manually lifting patients. The VA has developed a safe patient handling algorithm for a reference guide in order to assist with the proper processing for when to use a mechanical lift (Nelson, Matz, Chen, Siddharthan, Lloyd, & Fragala, 2006). Algorithm One is relevant for this study and suggests that if the patient can partially bear his or her own weight and is cooperative, then the caregiver can use a stand pivot transfer using a gait belt to manually lift the patient from one chair to the other with one caregiver or a power standing assist lift could be used. Other suggestions from the algorithm were to use a slide transfer board and a full body sling lift if the patient could not bear his or her own weight (see Appendix) (Nelson et al., 2006).

There were some limitations in the present study that should be discussed. First, the sample size for the study was small for both groups. In addition, the participants were all recruited from the same geographical area. These therapists could have performed differently than therapist from another geographical area due to the difference in training. Therefore, caution should be taking when generalizing the results of the study to the general population. In addition, the environment for the study was artificial in nature, which could have influenced the results of the study. For example, the subjects were asked to keep their feet on a separate force plate from the patient. This limitation resulted in the subjects having to use a slightly atypical version of a pivot transfer, which still allowed them to use a knee blocking technique. The separate force plates may have caused the participants to act differently or use posturing that they would not have normally used during the trials than if they were in a more natural situation. Along with the artificial setting of the lab, the patient used in the study was a very compliant and may not reflect the unpredictable nature of actual patients. Furthermore, 36 reflective markers were placed on various joints for identification purposes, which could have posed an artificial response from the participants causing them to act differently throughout the trials.

## Conclusion

Overall, the study did show statistical significance when comparing the non-experienced therapy students and experienced therapists. The difference was particularly seen when the participants had to transfer at the higher assistance levels. Statistical significance was shown between groups when comparing the Mod vs. Max and between the Max vs. Total assistance level trials. The experienced group plateaued after the Max assistance level and would only allowed their bodies to tolerate a certain amount of weight thus having the patient bore more of his own weight through his force plate. On the other hand, the non-experienced students continued to increase their normalized weight distribution on their force plate as the amount of assistance increased, therefore; increasing their risk for injury during the transfers. Although the two groups used very similar techniques of knee blocking, leaning the patient forward and proper body mechanics for a safe transfer the normalized weight distribution increased significantly for the Mod and Total transfers when comparing the two groups. This increase shows that the non-experienced participants did not have a cut off point for their tolerance of weight they would transfer and instead they allowed more weight to be born on themselves. Therefore, non-experienced therapists could be at a higher risk for developing MSD or injured early on in their careers. However, we should not negate the fact that manually transferring patients is still a risky job task for occupational and physical therapists regardless of the therapist's experience level. In addition, we should continue to utilize recommendations set forth through evidence-based practice and use the guidelines for safe patient handling in order to decrease the incidence of

MSD and injuries. Lastly, proper body mechanics and technique may not be enough for teaching safe transfers in occupational and physical therapy programs, but understanding the balance of weight distribution how to control a patient’s center of gravity maybe particularly beneficial as well as when to use mechanically lifts. Future research should aim towards evaluating the forces at the lumbar spine while performing various patient handling tasks. In addition, research on the perception component for grading various transfer tasks would be beneficial as well.

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Participant Demographics

Table 1. *Participant Demographics.*

| Group | n | Gender | Mean Age, Range | Dom | Mean Weight, Range (lbs) | Years of Experience, Range |
|---|---|---|---|---|---|---|
| Experienced | 8 | M=3<br>F=5 | 49.9, 40-55 | R=4<br>L=4 | 195, 162-238 | 25.5, 15-32 |
| Non-Experienced | 14 | M=3<br>F=11 | 24.4, 22-32 | R=13<br>L=1 | 148 ,103-199 | 0 |

Patient's mean normalized peak weight as a percentage

Table 2. *Patient's mean normalized peak weight as a percentage across four conditions.*

| Assistance Level | Mean Normalized Peak Weight (%) | St Dev |
|---|---|---|
| Min | 120.36 | 9.07 |
| Mod | 104.51 | 11.96 |
| Max | 90.98 | 9.84 |
| Total | 87.01 | 14.60 |

ANOVA table for assistance and experience level

Table 3. *ANOVA table for Assistance Level and Experience Level.*

| Source | Type III SS | Df | Mean Square | *F* | *p* |
|---|---|---|---|---|---|
| Within Subjects | | | | | |
| Assistance | 4509.15 | 3 | 1503.05 | 26.06 | <.001 |
| Assistance X Experience | 443.98 | 3 | 148.00 | 2.57 | .063 |
| Error | 3460.80 | 60 | 57.68 | | |
| Between Subjects | | | | | |
| Experience | 310.56 | 1 | 310.56 | 1.144 | .298 |
| Error | 5429.64 | 20 | 271.48 | | |

Within subjects contrasts and interactions table

Table 4. *Within subjects contrasts for assistance level and for assistance X experience level interactions.*

| Source<br>Condition | Type III SS | *df* | Mean Square | *F* | *p* |
|---|---|---|---|---|---|
| Assistance | | | | | |
| Mod vs Min | 235.21 | 1 | 235.21 | 21.30 | .160 |
| Max vs Mod | 2498.42 | 1 | 2498.42 | 50.89 | <.001 |
| Total vs Max | 3634.59 | 1 | 3634.59 | 32.04 | <.001 |
| Assistance X Experience | | | | | |
| Mod vs Min | 81.21 | 1 | 81.21 | .74 | .401 |
| Max vs Mod | 5.45 | 1 | 5.45 | .11 | .742 |
| Total vs Max | 532.99 | 1 | 532.99 | 4.70 | .042 |
| Error | | | | | |
| Mod vs Min | 2208.92 | 20 | 110.15 | | |
| Max vs Mod | 982.30 | 20 | 49.12 | | |
| Total vs Max | 2268.63 | 20 | 113.43 | | |

Mean and standard deviation normalized weight as a percentage across assistance levels

Table 5. *Mean and standard deviation of normalized weight as a percentage across the four assistance levels for the Experienced and Non-Experienced groups.*

| **Groups** | **Assistance Level** | **Mean** | **Standard Deviation** | **N** |
|---|---|---|---|---|
| Non-Experience | Min | 119.524 | 17.223 | 8 |
| Experience | Min | 115.924 | 11.438 | 14 |
| | | | | |
| Non-Experience | Mod | 124.92 | 16.679 | 8 |
| Experience | Mod | 117.325 | 14.913 | 14 |
| | | | | |
| Non-Experience | Max | 132.781 | 20.699 | 8 |
| Experience | Max | 128.219 | 9.435 | 14 |
| | | | | |
| Non-Experience | Total | 144.217 | 25.376 | 8 |
| Experience | Total | 128.733 | 9.782 | 14 |

Loading Forces on the Spine

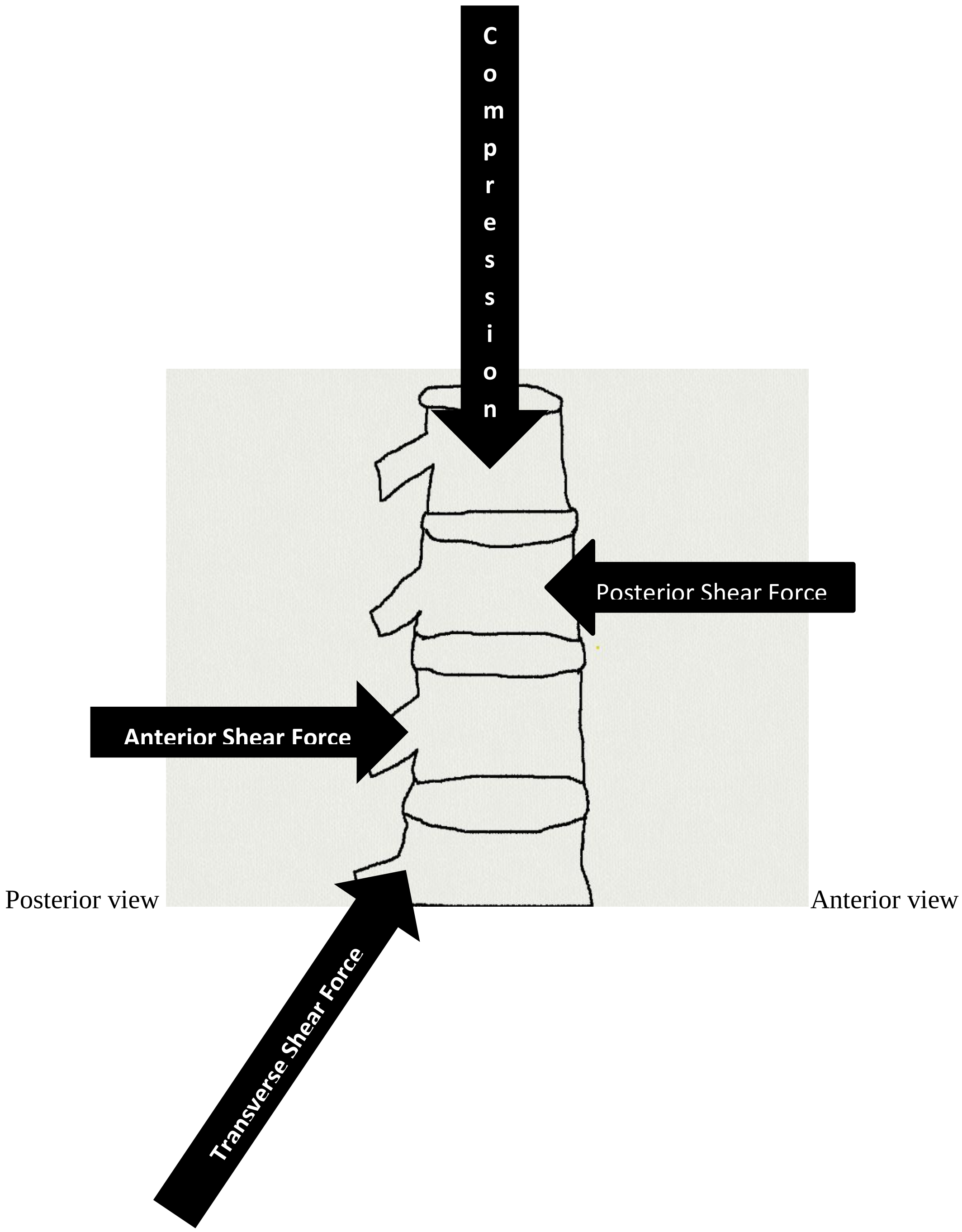


*Figure 1.* Loading Forces on the Spine during Manual Lifting

Patient's normalized weight as a percentage across assistance levels

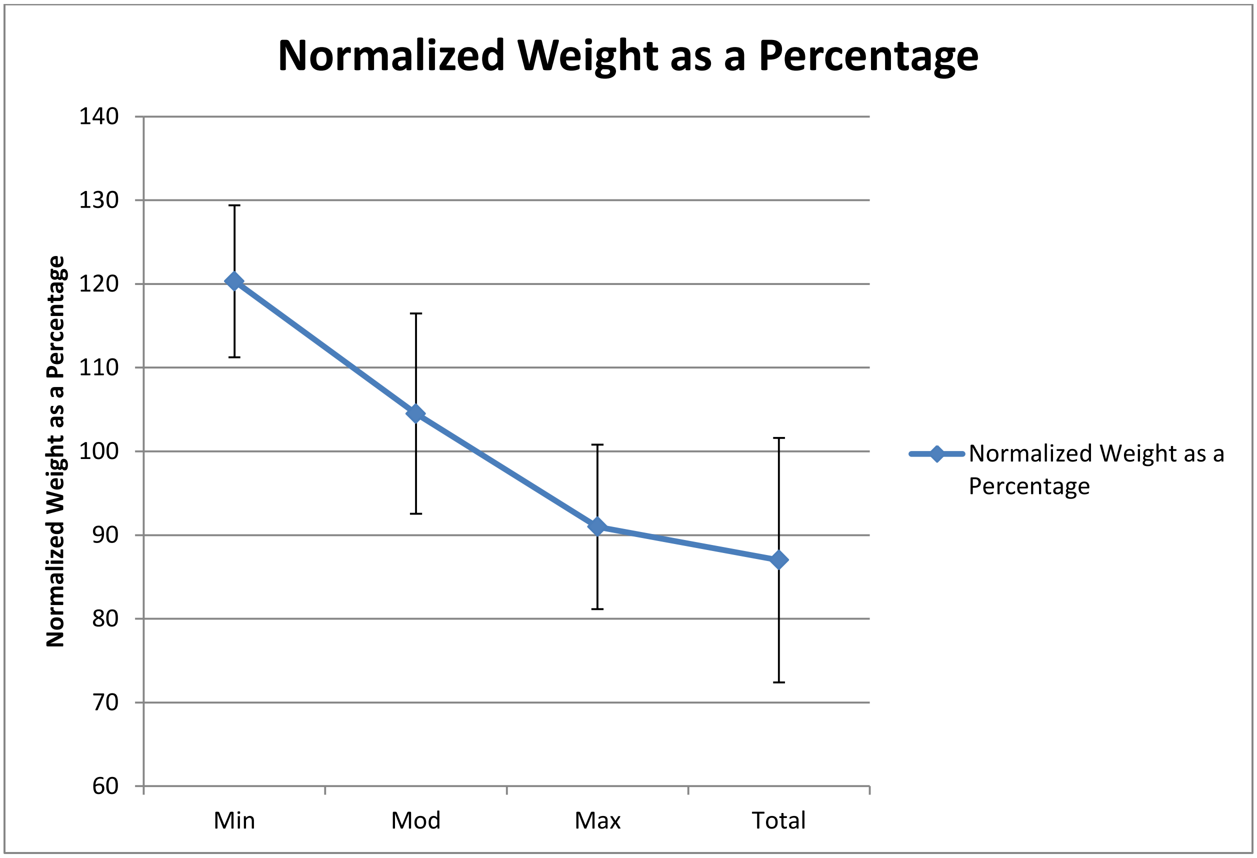


*Figure 2.* Patient's normalized weight as a percentage across the four assistance levels

Comparing Groups Normalized weight distribution across assistance levels

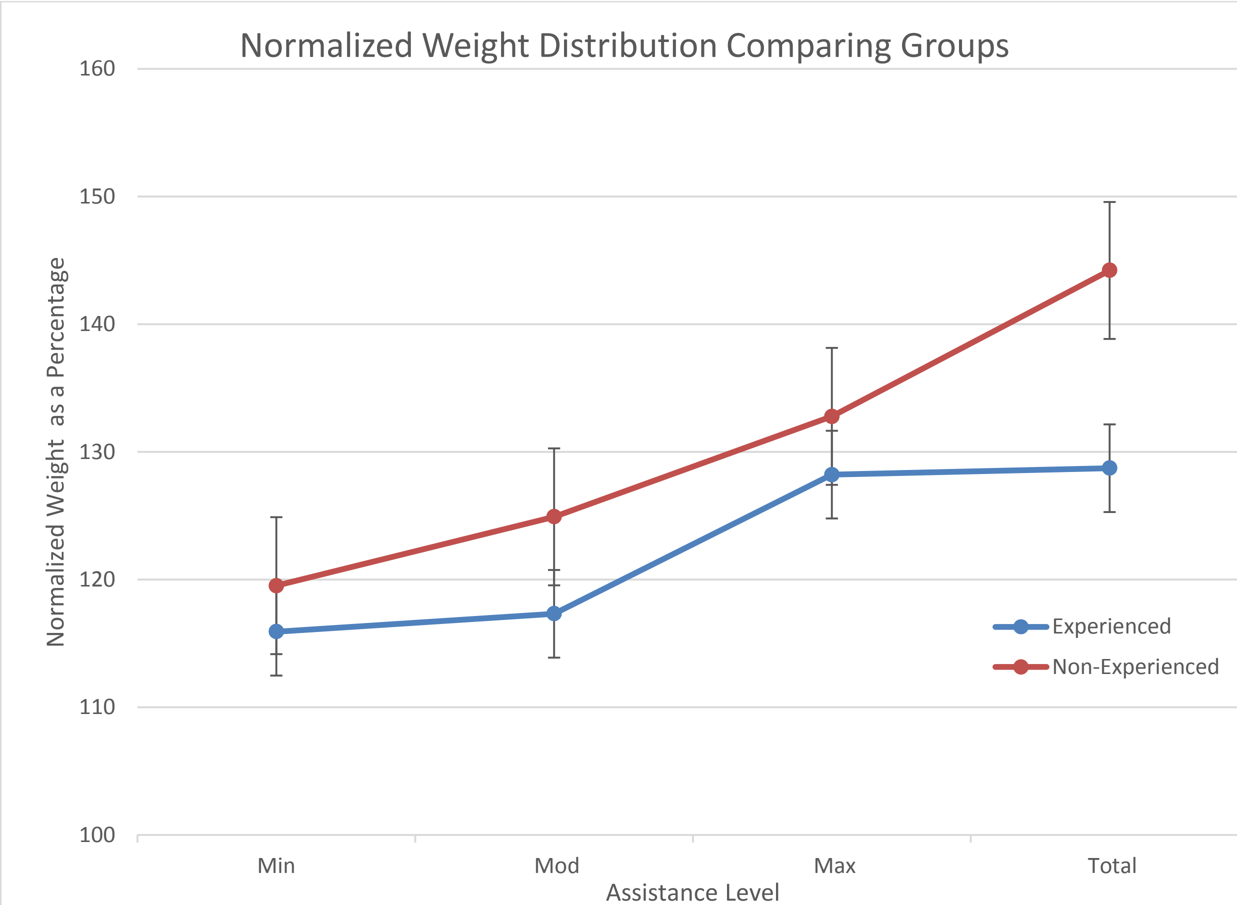


*Figure 3.* Mean and standard deviation of the normalized weight as a percentage across the four assistance levels.

# Appendix

**Algorithm 1: Transfer to and From: Bed to Chair, Chair to Toilet, Chair to Chair, or Car to Chair**

Last rev. 10/012008