CONTROL OF CUMULATIVE TRAUMA DISORDERS IN PERSONAL CARE FACILITIES

A Thesis in
Industrial Engineering
by
Cedric de Toffol

© 2010 Cedric de Toffol

Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Science

May 2010
The thesis of Cedric de Toffol was reviewed and approved* by the following:

Andris Freivalds  
Professor of Industrial and Manufacturing Engineering  
Thesis Adviser

Diane M. Spokus  
Instructor, Health Policy and Administration

Paul Griffin  
Professor of Industrial and Manufacturing Engineering  
Head of the Department of Industrial and Manufacturing Engineering

*Signatures are on file in the Graduate School.
ABSTRACT

High turnover has been a major problem in healthcare organizations. One of the fastest growing industries in the United States is nursing and personal care facilities. However, there are occupational injuries because of physical demands, job characteristics, social support and organizational characteristics that contribute to an older worker’s intent to leave the workplace. The main cause for many worksite injuries is in handling individuals who have mobility disabilities.

Different kinds of patient lifting devices were evaluated in a laboratory during a previous study made by Pan (1999). One of the devices was the Williamson Turn Stand, and it was shown that this device can substantially reduce stress on the lower back and shoulders of the users.

The goal of this new study was to validate the results of Pan (1999) in the real world. In order to do that, nursing aides were videotaped using current procedures, as well as the Williamson Turn Stand, while handling patients and were asked to express the pain felt using the Borg’s scale.

The results show that the Williamson Turn Stand significantly reduces the pain (p-value less than 0.05 for the shoulders, the low back and the overall job) and the force on L5/S1 (computed using the University of Michigan Model) was on average 257.8 pound-force in the best case and 418.4 pound-force in the worst case with the Turn Stand and 612.3 pound-force in the best case and 1028.4 pound-force in the worst case without it. Since the NIOSH Guidelines requires compression force to be less than 770
pound-force to consider a job to be safe, the final conclusions of this study are that the use of the Williamson Turn Stand will help significantly reducing the number of injuries among nurses.
# TABLE OF CONTENTS

LIST OF FIGURES ......................................................................................................... vi
LIST OF TABLES ........................................................................................................... vii
AKNOWLEDGEMENTS ................................................................................................ viii

Chapter 1: INTRODUCTION ........................................................................................ 1

Chapter 2: BACKGROUND .......................................................................................... 5

  2.1 Lifting Devices .......................................................................................... 5
  2.2 Borg’s Scale .............................................................................................. 7
  2.3 University of Michigan 3D Static Strength Prediction Program ..................... 8

Chapter 3: EXPERIMENTS ........................................................................................... 9

  3.1 Subjects .................................................................................................... 9
  3.2 Equipment Used ....................................................................................... 10
      3.2.1 The Williamson Turn Stand ........................................................ 10
      3.2.2 Bed/Wheelchair .......................................................................... 11
      3.2.3 Videos ......................................................................................... 11
      3.2.4 Perceived Exertion (Borg’s CR-10 scale) ..................................... 11
      3.2.5 Compressive Forces on the L5/S1 Disc ....................................... 12
  3.3 Procedure ................................................................................................. 14
  3.4 Experimental Design ................................................................................ 15

Chapter 4: RESULTS .................................................................................................... 16

  4.1 Borg’s CR-10 Scale .................................................................................... 16
      4.1.1 Shoulder ..................................................................................... 16
      4.1.2 Low Back ................................................................................... 18
      4.1.3 Overall ........................................................................................ 20
      4.1.4 Summary ..................................................................................... 22
  4.2 Compression Force on the L5/S1 Disc ..................................................... 22
      4.2.1 Best Case: Low Weight ............................................................... 23
      4.2.2 Worst Case: High Weight ........................................................... 25
      4.2.3 Summary ..................................................................................... 27

Chapter 5: CONCLUSIONS AND DISCUSSIONS ........................................................... 28

REFERENCES ............................................................................................................... 30

APPENDIX A: INVITATION LETTER FOR THE NURSES ................................................. 36
LIST OF FIGURES

Figure 3.1  The Williamson Turn Stand .................................................. 10
Figure 3.2  Borg’s CR-10 Scale ............................................................... 12
Figure 3.3  Handling the patient with the Turn Stand ................................ 13
Figure 3.4  Handling the patient without the Turn Stand .......................... 14
Figure 4.5  Normal Probability Plot of the Residuals – Shoulder .............. 17
Figure 4.6  Normal Probability Plot of the Residuals – Low Back .............. 19
Figure 4.7  Normal Probability Plot of the Residuals – Overall Pain .......... 21
Figure 4.8  Normal Probability Plot of the Residuals – Best Case: Low Weight 24
Figure 4.9  Normal Probability Plot of the Residuals – Worst Case: High Weight 26
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>Table 4.1</th>
<th>General Linear Model for the Shoulder (Minitab Output)</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 4.2</td>
<td>Two-Sample T-Test for the Shoulder (Minitab Output)</td>
<td>18</td>
</tr>
<tr>
<td>Table 4.3</td>
<td>General Linear Model for the Low Back (Minitab Output)</td>
<td>19</td>
</tr>
<tr>
<td>Table 4.4</td>
<td>Two-Sample T-Test for the Shoulder (Minitab Output)</td>
<td>20</td>
</tr>
<tr>
<td>Table 4.5</td>
<td>General Linear Model for the Overall Pain (Minitab Output)</td>
<td>21</td>
</tr>
<tr>
<td>Table 4.6</td>
<td>Two-Sample T-Test for the Overall Pain (Minitab Output)</td>
<td>22</td>
</tr>
<tr>
<td>Table 4.7</td>
<td>General Linear Model for the Best Case: Low Weight (Minitab Output)</td>
<td>23</td>
</tr>
<tr>
<td>Table 4.8</td>
<td>T-Test for the Low Weight</td>
<td>25</td>
</tr>
<tr>
<td>Table 4.9</td>
<td>General Linear Model for the Worst Case: High Weight (Minitab Output)</td>
<td>25</td>
</tr>
<tr>
<td>Table 4.10</td>
<td>T-Test for the High Weight</td>
<td>27</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENT

The author would like to express his sincere gratitude to Dr. Andris Freivalds, his thesis advisor, for his help to find the subject and for his guidance, time and patience. Sincere appreciation is extended to Dr. Diane Spokus for her expertise, help and comments on this study.

The author would also like to thank Mr. Andreas Thorsen and Mr. Sam Tajbakhsh for their advice, their support and their happiness.
Chapter 1

INTRODUCTION

In 2008, the average annual employment in the 18,000 private nursing and residential care facilities (National Nursing Home Survey, 2004) was 2,992,900 (Bureau of Labor Statistics, 2009). The incidence rate of nonfatal occupational injuries and illnesses was 8.4 per 100 full-time workers for this category, which is the third highest rate among all the different industries behind air transportation and couriers and messengers (both with a rate of 8.7). At the State level, Nursing and residential care facility employees represented 142,100 and the incidence rate of nonfatal occupational injuries and illnesses was 12.5, which is the highest rate.

If we look at the incidence rates of nonfatal occupational injuries and illnesses by major private industry sector, education and health services went from third place in 2006 with a rate of 5.4 to first place in 2008 with a rate of 5.0. Even if the rate decreased between 2006 and 2008, it decreased less than the construction and the manufacturing sectors which went respectively from 5.9 and 6.0 in 2006 to 4.7 and 5.0 in 2008 (Bureau of Labor Statistics, 2009).

In 2008 there were a total of 1,355,820 nonfatal occupational injuries (NOI) and illnesses involving days away from work. There were 54,050 NOI's among the nursing, psychiatric and home health aides in the private industry sector with a median of 6 days away from work. This is ranked fourth behind motor vehicle operators (102,860), material moving workers (101,800) and construction trade workers (99,010). This
number was 8,090 for the State government, second highest number behind the Law enforcement workers with 15,890.

Among the total injuries, 384,480 of them were caused by musculoskeletal disorders (MSDs) (Bureau of Labor Statistics, 2010). Lipscomb et al. (2004) gave a definition of a MSD: a MSD case occurs when “a moderate pain that lasted at least 1 week or occurred monthly during the past year” is reported.

Among the total injuries and illnesses previously cited, 449,910 concerned the trunk (shoulder and back) and 214,360 concerned the hands and the wrists (Bureau of Labor Statistics, 2010). These figures correspond to the observations of Daraiseh et al. (2010). According to them, nurses suffer pain from their lower back, shoulders and lower extremities. The results showed high prevalence rates of troubles. Moreover, it is possible that lower back problems lead to problems in other parts of the body.

These problems are not new. Buckle (1987) showed that nurses had some of the highest prevalence rates among all the different occupations and among 12 groups of a study by Jensen (1987), personal cares facilities employees had the highest incidence rates for disabling back disorders. Kumar (2004) confirmed these observations and found that nursing aides are the female workers who have the highest risk of having an MSD with a prevalence ratio of 2.0. These disorders are highly correlated with the fact that nurses have to lift and transfer patients (Lagerström et al., 1998, Vieira, 2007, Pompeii et al., 2009) with a maximum risk during the transfer from trolley to bed, bed to chair and chair to bed (Vieira and Kumar, 2009). They are also correlated with the number of nurses in the facility. Indeed, Trinkoff et al. (2005) showed that the more
nurses you have in a nursing home, the less injuries recorded. This could be explained by
the fact that nurses have more time for each patient and, therefore, they can be more
careful. Without helping devices, the repositioning of patients who cannot help a lot is
also pretty hazardous for the nurses (25% of the tasks represented a high risk) (Skotte
and Fallentin, 2008). Warming et al. (2009) also conducted a study to evaluate the level
of pain felt by nurses handling patients without a device. The results are that the pain
increased progressively during the 3 days (17% to 37%), and then decreased during the
day off. The percentage of nurses reporting MSD also increased during the 3 days (15%
to 30%). It has also been shown that the number of injuries may be higher than
expected, because facilities with a high proportion of registered nurses will report
injuries more often than facilities employing more nurse aides. Similarly, facilities
belonging to a chain are more likely to report injuries than for-profit facilities (Castle et
al., 2009).

Another factor which affects the number of injuries is the characteristics of the
population’s morphology. Two thirds of US adults are overweight (which is defined as a
Body Mass Index - BMI - between 25 and 30) and one fourth of the total population is
obese (having a BMI greater than 30) therefore the risk of injuries for both nurses and
patients increases. Solutions to this problem still need to be found (Humphreys, 2007,
Jang et al., 2007).

These problems also represent a loss of money: the total cost of low back pain in
2005 for workers ranged from $100 to $200 billion per year (Katz, 2006). Pain-related
lost productive time (work slowly or not at work) has an estimated annual cost of $61.2
billion and back pain costs $19.8 billion every year in loss of productive time (Stewart et al., 2003).

This is not a problem unique to the United States. MSDs cost A$169 million in Australia in 2000/01 as inpatient costs (Osborne et al., 2007) and C$25.4 billion in Canada in 1994 (Coyte et al., 1998). A manual was created in Europe (the “Manual Handling Directive”) in order to improve the handling of patients but it is difficult to implement because of the lack of research (and therefore recommendations), “guidance based on ergonomic standards, standards for educational programs, patient handling methods and equipment” (Hignett et al., 2007).

Studies have been conducted to reduce injuries and it has been shown that the risk of musculoskeletal injuries can be significantly reduced by decreasing the steps required during handling of patients, specifically during transfers (Vieira and Miller, 2008). Training also helps to reduce injuries while transferring patients (Resnick and Sanchez, 2009) but does not eliminate the problem because most of the tasks are too stressful (Garg et al., 1991a, 1991b). Therefore, lifting devices seem to be the best solution in reducing the number of injuries among nurses.
Chapter 2

BACKGROUND

The work done by Pan (1999) was done in a laboratory at The Pennsylvania State University and showed that lifting devices significantly decrease pain and relieve the stress on the low back. However, this study was not conducted with real nurses. Also, it could be useful to observe how nurses behave with the Williamson Turn Stand. The purpose of this study is to validate or to negate the conclusions made by Pan (1999). Some information regarding lifting devices can be found in the literature, but it is almost exclusively about ceiling devices and only few about floor devices. Since the Williamson Turn Stand is a floor based device, a study of it could give useful information. In order to better understand how the study was conducted, an explanation has to be provided about lifting devices, the Borg’s Scale and the University of Michigan 3D Static Strength Prediction Program.

2.1. Lifting Devices

In 1999, Pan did a literature review of lifting device research through 1999. However, there have been new studies conducted since that time. Evanoff et al. (2003) used stand-up lifts and full-body lifts and showed that musculoskeletal injuries can be reduced with a ratio of 0.82 between pre- and post-installation of the devices. Lost workday injuries and total lost days due to injury were also reduced with a ratio of 0.56 and 0.42 respectively. Collins et al. (2004) proved that lifting devices were efficient. The
study showed that the rate of claims per 100 full time equivalents (FTE) decreased from 13.7 (which is the average of workers’ compensation claims and Occupational Safety and Health Administration 200 logs) before the use of lifting devices to 6.6 after the use of these devices. The total number of lost workdays also decreased from 488 to 229 and its rate went from 5.8 to 2.0 per 100 nursing personnel. Li et al. (2004) found similar results: mechanical patient lifts helped reducing the number of injuries from 10.3 to 3.8 per 100 FTE and the number of lost day injuries from 2.9 to 1.9 per 100 FTE. However, correct training on how to use these devices is needed to assure the effectiveness (Nelson and Baptiste, 2004).

Among the different devices used nowadays, ceiling lifts decrease the risk of injuries and are preferred over floor-based devices by 75% of the workers even if they did not find any significant differences between the devices in term of risk of injuries (Miller et al., 2006, Santaguida et al., 2005).

When ceiling-based and floor-based devices can be used, ceiling-based devices should be preferred since they reduce the anterior/superior shear force. However if ceiling-based devices cannot be used, floor-based devices are still better than using no device since they reduce compression force. But the design of these devices should be improved in ways such as adding a motor to help rotation, or moving the handles laterally to reduce the shear force. Moreover, the design of the wheels should be well studied so that the device is easy to manipulate (Marras et al., 2009). Some people may think that ceiling devices are too expensive, but a study conducted at PeaceHealth's Sacred Heart Medical Center in Eugene, Oregon showed that an investment of $1.64
million to equip 309 rooms with ceiling lifts would be paid back in 2.5 years thanks to the 83% decrease in the annual cost of patient-handling injuries (Joseph and Fritz, 2006).

Therefore, we can see that there is strong evidence that lifting devices reduce the number of injuries and, consequently, the total cost due to injuries (Zadvinskis and Salsbury, 2010), but the devices have been understudied in regards to checking if current technology matches the needs (Rockefeller, 2008).

For the following study, the Williamson Turn Stand will be used. It is a floor based device which is “classified as a semi-manual device” (Pan, 1999). The patient has to stand up on a platform which can rotate when the nurse releases the breaks using a handle. Thanks to this device, the patient does not have to move his or her feet while rotating, thus reducing the likelihood to fall. Consequently, the nurse does not have to help the patient during the entire procedure.

2.2 Borg’s Scale

Borg created two different scales: the Borg CR10 scale and the Borg RPE scale. The RPE scale estimates the effort, fatigue and exertion during physical work. The CR10 scale estimates the pain felt during physical work. They are both based on the sensation felt by the worker (Borg, 1998).

The RPE scale was not used during the study, since the goal was to study the pain felt by people while handling a patient, which is the purpose of the CR10 scale. Borg (1998) recommends training the worker before they use the scale and to test their
rating behavior in order to get more accurate values. He also recommends normalizing the data to eliminate the variance between subjects.

2.3. University of Michigan 3D Static Strength Prediction Program

The University of Michigan 3D Static Strength Prediction Program (3D SSPP) is software which allows the computation of the force on the L5/S1 disks. It also allows finding the percentage of people who will be able to perform a certain task. The inputs are the angles of some body parts (e.g. upper and lower arms, legs, etc.), the load in each hand and the physiology of the worker (it is possible to use a 5th, 50th or 95th percentile male or female, or to input custom data for the weight and height).
Chapter 3

Experiments

3.1. Subjects

The goal of this experiment was to study the effectiveness of the Williamson Turn Stand in reducing the physical impact on nurses when moving a patient. Therefore, the main focus was the nurses and not the patients. The nurses participating in the experiments were workers from two nursing homes in State College, PA. Four of them came from Greenhills Village, and eight of them came from Foxdale Village. They were all in good health and none of them reported back problems. An invitation letter (Appendix A) was read to them and an informed consent form (Appendix B) had to be signed by them before the beginning of the experiments. In addition, two screening questions were asked of the workers which determined their eligibility to participate. They were at least 18 years of age.

Two patients were used, one at each facility. The patient from Greenhills Village was paralyzed on the left side (she was not able to move her arm) but was able to stand on her feet without any assistance. The patient from Foxdale Village did not have disabilities and was also able to stand on his feet. This fact was used as elective for the participation to the experiments since the Williamson Turn Stand requires the patient to stand up. The same invitation letter (Appendix C) was read and the two patients also had to sign an informed consent form (Appendix D) before the beginning of the
experiment. This form was read to them clearly and loudly to be sure they understood the purpose of the study.

3.2. Equipment used

3.2.1. The Williamson Turn Stand

As mentioned before, the objective of the study was to evaluate the effectiveness of the Williamson Turn Stand (Figure 3.1).

![Figure 3.1. The Williamson Turn Stand](image)

The Turn Stand has a width of 18 inches, a height of 39.5 inches and a length of 18 inches. Its weight is 32 pounds and, since it has two wheels, it is easily transportable. Its rotating platform and its handle allows the patient to stay upright and to rotate without twisting their feet. It also allows the nurse to transfer the patient with less effort and without twisting their trunk excessively.
Each facility received one Turn Stand prior to the beginning of the study, provided by The Pennsylvania State University.

3.2.2. Bed/Wheelchair

A standard wheelchair and the bed in the rooms of the patients were used during these experiments. For each experiment the patient was transferred from the bed to the wheelchair and then from the wheelchair to the bed or vice-versa.

3.2.3. Videos

A camcorder was used to videotape the transfers. This step was necessary to find the worst posture taken by the nurses so the 3D SSPP software could be used to compute the compression force on the L5/S1 disc. The model used is Sony DCR-TRV30 NTSC. No audio was recorded in order to guarantee the privacy of the patients. After each day of recording the videos were transferred to a PC at Penn State with limiting access. A login and a password were required to log on the computer, and only the researchers had access to it.

3.2.4. Perceived Exertion (Borg’s CR-10)

After each trial, the nurses were asked to answer their Perceived Exertion using the Borg’s CR10 scale (Figure 3.2) in regards to their shoulders, low back and whole body. A scheme was provided to clearly identify the areas targeted.
3.2.5. Compressive forces on the L5/S1 disc

After the transfer of the videos on the computer, they were studied to find the worst posture taken by the nurse. This posture was identified using guidelines (Chaffin and Andersson, 2006). Once the posture identified, a screenshot was made. Then Photofiltre (V 6.3.2, Antonio Da Cruz) was used with the plug-in Measurements (V 1.0, Pascal Flocard) to get the angles of the body parts.

Figure 3.2. Borg’s CR-10 scale

Once the angles were collected, the University of Michigan 3D Static Strength Prediction Program (3D SSPP) was used to compute the compressive force on the L5/S1 disc. The physical characteristics of a 50% percentile female were used (Chaffin and Andersson, 2006). However, it was not possible to measure the weight actually lifted by
the nurses. Therefore, using the observations made during the experiments, the following model has been created:

- If the Turn Stand is used (Figure 3.3), since the patients were able to stand up by themselves, it has been decided that in the best case the nurses were lifting a total weight of 0 pounds. In the worst case it has been decided that the nurses were lifting a total weight of 20 pounds.

- If the Turn Stand was not used (Figure 3.4), since the patient needed some help to stand up, it has been decided that in the best case the nurses were lifting a total weight of 20 pounds. In the worst case it has been decided that the nurses were lifting a total weight of 60 pounds.

Figure 3.3. Handling the patient with the Turn Stand
**3.3. Procedure**

For each facility, the nurses who agreed to participate in the study were brought together in a room in order to read them the Consent Form. Once the reading was done, each nurse received two consent forms: one for them and one for the records of the study.

Then a presentation of the Turn Stand was made to the nurses, and they were able to try it on one of the researchers. After that the Turn Stand was transported to the patient’s room and the consent form was read to the patient. Once everything was set, the nurses were randomly selected to do the experiment. Each nurse had to do the experiment twice: once with the Turn Stand and once without it. After each trial they were asked to fill the Borg’s CR-10 scale. A form was used to keep track of the different runs and to identify them on the videos.
3.4 Experimental Design

The influence of the Turn Stand was supposed to be the only one used. However, one of the patients was paralyzed on one side, and since the influence of the Turn Stand was the only factor targeted by the study, a design with blocks was used, with the patient confounded with the blocks. Furthermore, given the fact that it was not realistic to go from a facility to another, the runs were randomized under the level of the patient, making a block design absolutely necessary.

Since it was not possible to use the same patient in the two facilities, a 3-stages nested design was used. The first stage was the patient (or facility); the second was the nurses which was nested under the level of the patient; the last one was the Turn Stand. Since the Turn Stands used were strictly identical, it was not useful to nest them within the patients (Montgomery, 2009).

The data was then analyzed using Minitab 15.0. A General Linear Model was used to perform an analysis of the variance (ANOVA). The level of significance was set to 5%, and the normal plots for residuals were plotted to check the normality assumption of the data.
Chapter 4

RESULTS

The data collected during the different runs was analyzed using Minitab 15.0 in the Human Factors Laboratory of The Pennsylvania State University. Whereas only the Turn Stand was significant at the 5% level for the data from the Borg’s CR-10 Scale and for the Compression Force, it appeared that the patient also was significant for the Compression Force.

4.1. Borg’s CR-10 Scale

The data collected using the scale can be found in Appendix E.

4.1.1. Shoulder

A General Linear Model (GLM) was fitted with Patient, Nurse(Patient) and Turn Stand as factors (Table 4.1). Nurse(Patient) means that the factor Nurse was nested within the factor Patient. By doing that we eliminate the fact that the patients used were not the same and that the data was not collected the same day. With a p-value of 0.033, the Turn Stand is the only significant factor at the 5% level. With a p-value of 0.358 and 0.491 respectively, the Patient and the Nurse(patient) factors are clearly not significant. However, the residuals are not normally distributed, which may be due to an insufficient amount of data collected.
Table 4.1. General Linear Model for the Shoulder (Minitab Output)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Type</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>fixed</td>
<td>2</td>
<td>1, 2</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>fixed</td>
<td>12</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
<tr>
<td>Turnstand</td>
<td>fixed</td>
<td>2</td>
<td>0, 1</td>
</tr>
</tbody>
</table>

Analysis of Variance for Borg - Shoulder, using Adjusted SS for Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Seq SS</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>1</td>
<td>1.172</td>
<td>1.172</td>
<td>1.172</td>
<td>0.92</td>
<td>0.358</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>10</td>
<td>12.859</td>
<td>12.859</td>
<td>1.286</td>
<td>1.01</td>
<td>0.491</td>
</tr>
<tr>
<td>Turnstand</td>
<td>1</td>
<td>7.594</td>
<td>7.594</td>
<td>7.594</td>
<td>5.95</td>
<td>0.033</td>
</tr>
<tr>
<td>Error</td>
<td>11</td>
<td>14.031</td>
<td>14.031</td>
<td>1.276</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>35.656</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 1.12941 R-Sq = 60.65% R-Sq(adj) = 17.72%

Figure 4.5. Normal Probability Plot of the Residuals – Shoulder

A two-Sample T-Test was also computed in order to test if the two means of the Borg’s scores were equal (Table 4.2). With a p-value of 0.039, it can be concluded that at the 5% level, the 2 means are different with a value of 1.13 without the Turn Stand and 0.042 with the Turn Stand.
4.1.2. Low Back

The same GLM was fitted for the Low Back (Table 4.3). Again, with a p-value of 0.015 at the 5% level, the Turn Stand is the only factor which is significant. Indeed, with p-values of 0.531 and 0.460 respectively, the factors Patient and Nurse(Patient) are not significant. This time the plot of the residuals validates the normality assumption (Figure 4.4), but since the sample was too small, it is not possible to be conclusive.
Table 4.3. General Linear Model for the Low Back (Minitab Output)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Type</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>fixed</td>
<td>2</td>
<td>1, 2</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>fixed</td>
<td>12</td>
<td>1, 2, 3, 4, 1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
<tr>
<td>Turnstand</td>
<td>fixed</td>
<td>2</td>
<td>0, 1</td>
</tr>
</tbody>
</table>

Analysis of Variance for Borg - Low Back, using Adjusted SS for Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Seq SS</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>1</td>
<td>1.021</td>
<td>1.021</td>
<td>1.021</td>
<td>0.42</td>
<td>0.531</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>10</td>
<td>25.812</td>
<td>25.812</td>
<td>2.581</td>
<td>1.06</td>
<td>0.460</td>
</tr>
<tr>
<td>Turnstand</td>
<td>1</td>
<td>20.167</td>
<td>20.167</td>
<td>20.167</td>
<td>8.27</td>
<td>0.015</td>
</tr>
<tr>
<td>Error</td>
<td>11</td>
<td>26.833</td>
<td>26.833</td>
<td>2.439</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>73.833</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 1.56186   R-Sq = 63.66%   R-Sq(adj) = 24.01%

Figure 4.6. Normal Probability Plot of the Residuals – Low Back

The Two-Sample T-Test for the mean was computed (Table 4.4). A p-value of 0.020 was obtained, therefore the two means are different at the 5% level. The mean was 1.83 without the Turn Stand and 0.083 with it.
4.1.3. Overall

The last data collected with the Borg’s CR-10 Scale pertained to overall pain. The same GLM was fitted (Figure 4.5) and with a p-value of 0.021, the Turn Stand was again the only significant factor at the 5% level. Indeed, the factor Patient had a p-value of 0.305 and the factor Nurse(Patient) had a p-value of 0.277. The plot of the residuals does not help to reject the normality assumption since the sample was very small.
Table 4.5. General Linear Model for the Overall Pain (Minitab Output)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Type</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>fixed</td>
<td>2</td>
<td>1, 2</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>fixed</td>
<td>12</td>
<td>1, 2, 3, 4, 1, 2, 3, 4, 5, 6, 7, 8</td>
</tr>
<tr>
<td>Turnstand</td>
<td>fixed</td>
<td>2</td>
<td>0, 1</td>
</tr>
</tbody>
</table>

Analysis of Variance for Borg - Overall, using Adjusted SS for Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Seq SS</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>1</td>
<td>3.521</td>
<td>3.521</td>
<td>3.521</td>
<td>1.16</td>
<td>0.305</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>10</td>
<td>43.937</td>
<td>43.938</td>
<td>4.394</td>
<td>1.44</td>
<td>0.277</td>
</tr>
<tr>
<td>Turnstand</td>
<td>1</td>
<td>22.042</td>
<td>22.042</td>
<td>22.042</td>
<td>7.25</td>
<td>0.021</td>
</tr>
<tr>
<td>Error</td>
<td>11</td>
<td>33.458</td>
<td>33.458</td>
<td>3.042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>102.958</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 1.74404   R-Sq = 67.50%   R-Sq(adj) = 32.05%

Figure 4.7. Normal Probability Plot of the Residuals – Overall Pain

The Two-Sample T-Test was finally computed (Table 4.6) and with a p-value of 0.036, we can conclude that the means are different at the 5% level. The mean with the Turn Stand was 0.125 and 2 without it.
### Table 4.6. Two-Sample T-Test for the Overall Pain (Minitab Output)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnstand (Y=1/N=0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>12</td>
<td>2.00</td>
<td>2.70</td>
<td>0.78</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>0.125</td>
<td>0.311</td>
<td>0.090</td>
</tr>
</tbody>
</table>

Difference = μ(0) - μ(1)
Estimate for difference: 1.875
95% CI for difference: (0.150, 3.600)
T-Test of difference = 0 (vs not =): T-Value = 2.39  P-Value = 0.036  DF = 11

#### 4.1.4. Summary

With a p-value less than 0.05 in the 3 different cases, the Turn Stand has been proven to be significant in reducing the nurses’ pain. The factor Patient and Nurse(Patient) were never significant, thus we support the result that the Turn Stand is the factor which decreases the pain. The mean for the overall pain decreases from 2 (mild discomfort) without the Turn Stand to 0.125 (no discomfort) with it, which is a great improvement. However, since the Borg’s CR-10 Scale is based only on the nurses feeling, an analysis of the compression force may help accept or reject the hypothesis that the Turn Stand significantly reduces the risks of injury.

#### 4.2. Compression Force on the L5/S1 Disc

Using the data collected, 2 GLM were fitted: one for the best case with and without the Turn Stand and one for the worst case with and without the Turn Stand. The value for the compression forces found with 3D SSPP can be found in Appendix F.
4.2.1. Best Case: Low Weight

The same GLM than in section 4.1 was used to fit the data (Table 4.7). In opposition to the results from section 4.1, the Turn Stand is not the only significant factor anymore. Indeed, the Turn Stand has a p-value of 0.000 at the 5% level, but the Patient has a p-value of 0.001, which means that it also is significant. This difference can be explained simply. Indeed, the patient in one of the two facilities was paralyzed on one side. Therefore the handling was not as easy to perform, and even if the nurses were used to it, they had to take postures which were more dangerous for their low back. With a p-value of 0.899 the factor Nurse(patient) is again not significant.

Table 4.7. General Linear Model for the Best Case: Low Weight (Minitab Output)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Type</th>
<th>Levels</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>fixed</td>
<td>2</td>
<td>1, 2</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>fixed</td>
<td>12</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12</td>
</tr>
<tr>
<td>Turnstand</td>
<td>fixed</td>
<td>2</td>
<td>0, 1</td>
</tr>
</tbody>
</table>

Analysis of Variance for Force Low, using Adjusted SS for Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Seq SS</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>1</td>
<td>121203</td>
<td>121203</td>
<td>121203</td>
<td>18.54</td>
<td>0.001</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>10</td>
<td>28456</td>
<td>28456</td>
<td>2846</td>
<td>0.44</td>
<td>0.899</td>
</tr>
<tr>
<td>Turnstand</td>
<td>1</td>
<td>754022</td>
<td>754022</td>
<td>754022</td>
<td>115.37</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>11</td>
<td>71894</td>
<td>71894</td>
<td>6536</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>975574</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 80.8441  R-Sq = 92.63%  R-Sq(adj) = 84.59%

This time, even if the sample size was not big enough, the plot of the residuals validates the normality assumption (Figure 4.6). However a bigger sample size would be better to get more accurate conclusions.
The mean value for the Compression Force on the L5/S1 disc is 257.75 pound-force with the use of the Turn Stand and 612.25 pound-force without it. According to the NIOSH Guidelines (Chaffin and Andersson, 2006), the maximum acceptable value for this force is 770 pound-force. Here both cases are below this limit, but the value found without the Turn Stand is close to the dangerous zone. A T-Test was conducted to check if the means were statistically below 770 pound-force or above (Table 4.8). With p-values of 1.000, we can conclude that the 2 means are statistically below the limit. Therefore, it can be concluded that it is not hazardous to lift people without the Turn Stand, but the risk of injury is lower with the Turn Stand since the compression force is reduced by 450 pound-force.
Table 4.8. T-Test for the Low Weight

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>Bound</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low With</td>
<td>12</td>
<td>257.8</td>
<td>128.6</td>
<td>37.1</td>
<td>191.1</td>
<td>-13.80</td>
<td>1.000</td>
</tr>
<tr>
<td>Low Without</td>
<td>12</td>
<td>612.3</td>
<td>60.0</td>
<td>17.3</td>
<td>581.1</td>
<td>-9.11</td>
<td>1.000</td>
</tr>
</tbody>
</table>

4.2.2. Worst Case: High Weight

The General Linear Model used before was applied a last time to the worst case scenario (Table 4.9). The same phenomenon as in the best case appears again: the Turn Stand and the Patient are both significant factors with respective $p$-values of 0.000 and 0.003. With a $p$-value of 0.874, the factor Nurse(patient) is still not significant. The origin of these results comes again from the fact that one of the patients was paralyzed on the left side.

Table 4.9. General Linear Model for the Worst Case: High Weight (Minitab Output)

<table>
<thead>
<tr>
<th>General Linear Model: Force High versus Patient, Turnstand, Nurse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td>Patient</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
</tr>
<tr>
<td>Turnstand</td>
</tr>
</tbody>
</table>

Analysis of Variance for Force High, using Adjusted SS for Tests

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Seq SS</th>
<th>Adj SS</th>
<th>Adj MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient</td>
<td>1</td>
<td>252590</td>
<td>252590</td>
<td>252590</td>
<td>13.76</td>
<td>0.003</td>
</tr>
<tr>
<td>Nurse(Patient)</td>
<td>10</td>
<td>87362</td>
<td>87362</td>
<td>8736</td>
<td>0.48</td>
<td>0.874</td>
</tr>
<tr>
<td>Turnstand</td>
<td>1</td>
<td>2232600</td>
<td>2232600</td>
<td>2232600</td>
<td>121.60</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>11</td>
<td>201958</td>
<td>201958</td>
<td>18360</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>2774510</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$S = 135.498 \quad R-Sq = 92.72\% \quad R-Sq(adj) = 84.78\%$
The plot of the residuals confirms again the assumption of normality (Figure 4.6), but a bigger sample size would be required in order to be conclusive.

Figure 4.9. Normal Probability Plot of the Residuals –Worst Case: High Weight

The mean value for the Compression Force was 418.42 pound-force with the Turn Stand and 1,028.42 pound-force without it. A T-test was again conducted (Table 4.10) which shows that the mean force with the Turn Stand is statistically below the NIOSH limit with a p-value of 1.000, but the mean force without it is statistically above the limit with a p-value of 0.000. This time, it is safe to transfer people only with the Turn Stand. Clearly, handling people without the Turn Stand is dangerous for the nurses and can lead to severe low back injuries.
Table 4.10. T-Test for the High Weight

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
<th>Bound</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>High with</td>
<td>12</td>
<td>418.4</td>
<td>182.8</td>
<td>52.8</td>
<td>323.6</td>
<td>-6.66</td>
<td>1.000</td>
</tr>
<tr>
<td>High Without</td>
<td>12</td>
<td>1028.4</td>
<td>125.8</td>
<td>36.3</td>
<td>963.2</td>
<td>7.11</td>
<td>0.000</td>
</tr>
</tbody>
</table>

4.2.3. Summary

After computing the force on the L5/S1 disc using 3D SSPP, it is obvious that handling patients without the help of the Turn Stand will certainly lead to injuries. With an average force close to the limit of 770 pound-force from the NIOSH Guidelines in the best case and totally above the limit in the worst case, handling people bare handed should be avoided if nurses do not want to jeopardize their future in the profession. On the other hand, with an average force in the both cases below the limit, handling people with the help of the Turn Stand has been proven to be a safe job and should be recommended.
Chapter 5

CONCLUSIONS AND DISCUSSIONS

According to the results of this study, the Williamson Turn Stand is a tool which reducing the risk of injuries among nurses handling patients able to stand up. Therefore, these results confirm the one found by Pan (1999) in laboratory.

However, insufficient data was collected to fully corroborate the results. At the time of the writing of this work, new appointments are negotiated with Nursing Homes in the area of State College to get more data in order to publish more accurate results. This is not an easy task since a minimum number of nurses need to be available at the same time so the day-to-day effect is eliminated. Moreover, a time suitable for both the care team and the research team has to be found.

Interesting future work would be to conduct the same study but this time monitor the Compression Force using electromyography which would give more accurate values. Another work would be to find the panel of patients who can safely be handled with the Turn Stand. The last improvement would be to do the experiments at different times of the day. Indeed, all the runs for this study were conducted between 11AM and 1PM because it was the best time for both the patients and the nurses. Therefore, it did not reflect all the different factors like fatigue at the end of the day. Furthermore, since the data was collected the same day for each patient, it was not possible to check if there were differences between the beginning of the week and the end of the week. This would be a good improvement to this study.
After discussing with the nurses who participated in the study, the research team received very positive feedback about the Williamson Turn Stand. One of the facilities was already using the Turn Stand in two different rooms to help not only transfer the patients from the bed to the wheelchair, but also from the wheelchair to the commode. Indeed, the room commodes are equipped with rods to help patients when they can use them by themselves. However, when the patients need the assistance of a nurse, these rods obstruct the nurses and multiple cases of patients mixing their feet and falling were reported. But with the Turn Stand, the patients were easily transferred from the wheelchair to the commode and at this time no injuries have been reported.

To conclude, in every facility where ceiling devices cannot be installed, or where there is not enough money to pay for them, the Williamson Turn Stand should be installed since it is a low cost (its price is around $300) and easily transportable device.
REFERENCES


APPENDIX A: INVITATION LETTER FOR THE NURSES

INVITATION LETTER TO EMPLOYEES

January, 2010

Greetings from The Pennsylvania State University.

We are conducting research dealing with the unprecedented shift in the demographics in our Nation’s Workforce. We invite you to be a part of the survey and to also participate in the use of the Williamson Turnstand. One of the most powerful drivers at play is the aging of the workforce. Ten million workers age 55 and over will be added to the workforce in this decade compared to only 5 million in the 25 – 54 age range. Your organization will likely need to take a very serious look at how to retain the knowledge, skill, and productivity of their employees and by eliminating the risk of injury when transferring individuals from a bed to a wheelchair. You must be 18 years of age to participate.

Research volunteers are being recruited. This research study is being conducted by Dr. Diane Spokus, Ph.D., C.H.E.S., (814) 865-0716 and Dr. Andris Freivalds, Ph.D., (814-863-2361 from The Pennsylvania State University. The data from this study will be very important in formulating workplace policies related to retention strategies for healthcare workers. I invite you to complete a survey that asks you to indicate to what extent your organization is dealing with the aging of the workforce and to also use the Williamson Turnstand to transfer individuals from a bed to a wheelchair.

If you have any questions, please contact me directly at 814.865.0716 or via email dms201@psu.edu or Dr. Andris Freivalds at 814.863.2361 or via email axf@engr.psu.edu. Thank you in advance for your willingness to contribute to the project.

Best regards,

Diane Spokus, Ph.D., C.H.E.S.
Andris Freivalds, Ph.D.
APPENDIX B: CONSENT FORM FOR THE NURSES

Worker Informed Consent Form for Biomedical Research
The Pennsylvania State University

Title of Project: Job/worksite environmental factors that influence older health care worker
game of work life and physical well-being and the intent to continue to work.

Principal Investigator: Andy Freivalds, Ph.D.
The College of Engineering
The Pennsylvania State University
Industrial and Manufacturing Engineering
0310 Leonhard Building
University Park, PA 16802
Phone: 814-863-2361
Email: axf@psu.edu

Co-Investigator: Diane Spokus, Ph.D., C.H.E.S.
Health Policy and Administration
The Pennsylvania State University
501F Ford Building
University Park, PA 16802
Phone: 717-994-1798
Email: dms201@psu.edu

1. Purpose of the study:

The purpose of this research study will also examine whether or not the use of ergonomically
developed devices can reduce workmen’s compensation claims and attrition due to inability to
transfer individuals from a bed to a wheelchair either in a nursing home or for someone aging in
place.

2. Procedures to be followed:

You will be shown how to use the Williamson Turn Stand. You will then be asked to use the
Williamson Turn Stand to transfer an individual from a bed to a wheelchair and then back to the
bed. The Researcher/graduate assistant will video tape your proper use of the equipment and the
video will be viewed in the campus lab. There will be no audio recording taking place. The
audio will be turned off. You will be asked questions pertaining to pain or discomfort associated
with work.

3. Discomforts and risks:

You are free to decline to be in this study or to withdraw from it at any point. There are no risk
known.
4. Benefits:

The benefits include reduced injury due to improper transfer of individuals from beds to wheelchairs. The benefits to society include job/work site characteristics that influence older worker intent to continue to work. Few institutions have retention efforts in place for older workers and many current workers need and want to continue to work, stay active and relish the work lives they have established. Job/work site context has been inadequately studied as a predictor of turnover for older workers. Further, health care staffing shortages are creating stressful work environments.

5. Duration/time of the procedures and study:

It will take approximately 20 minutes to complete the survey and 15 minutes to transfer the individual using the Williamson Turn Stand. The observations will occur twice a week for at a time designated by the facilities.

7. Statement of confidentiality:

Your participation in this research is confidential. The video tapes will be kept in a locked file cabinet and will be viewed only by the researchers involved. The data will be stored and secured on the researcher’s computer in a locked/password protected file for one year until 2011.

Penn State’s Office for Research Protections, the Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project.

All records associated with your participation in the study will be subject to the usual confidentiality standards applicable to medical records (e.g., such as records maintained by physicians, hospitals, etc.). You can choose not to answer certain questions. In the event of any publication resulting from the research, no personally identifiable information will be disclosed.

If the research is regulated by the Food and Drug Administration (FDA), FDA representatives may access your research records.

8. Right to ask questions: Please contact Dr. Andris Freivalds, Principal Investigator, at his office phone: (814) 863-2361; email: axf@engr.psu.edu, with questions, complaints or concerns about the research. Dr. Freivalds’s office address is 310 Leonhard Building, University Park, PA 16802. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University’s Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

9. Voluntary participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusing to participate or withdrawing early from the study will involve no penalty or loss of benefits you would be entitled to otherwise.

12. Injury Clause: In the unlikely event you become injured as a result of your participation in this study, medical care is available. It is the policy of this institution to provide neither financial
compensation nor free medical treatment for research-related injury. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

_________________________________________________________________________  __________
Participant Signature                        Date
_________________________________________________________________________
Person Obtaining Consent                      Date
January, 2010

Greetings from The Pennsylvania State University.

We are conducting research dealing with the unprecedented shift in the demographics in our Nation’s Workforce. We invite you to be a part of the research study by participating in the use of the Williamson Turnstand. One of the most powerful drivers at play is the aging of the workforce. Ten million workers age 55 and over will be added to the workforce in this decade compared to only 5 million in the 25 – 54 age range. Organizations will likely need to take a very serious look at how to retain the knowledge, skill, and productivity of their employees and by eliminating the risk of injury when transferring individuals from a bed to a wheelchair. You must be 18 years of age to participate.

Research volunteers are being recruited. This research study is being conducted by Dr. Diane Spokus, Ph.D., C.H.E.S., and Dr. Andris Freivalds, Ph.D., from The Pennsylvania State University. The data from this study will be very important in formulating workplace policies related to retention strategies for healthcare workers. I invite you to participate in the use of the Williamson Turnstand which a worker will use to transfer individuals from a bed to a wheelchair.

If you have any questions, please contact me directly at 814.865.0716 or via email dms201@psu.edu or Dr. Andris Freivalds at 814.863.2361. Thank you in advance for your willingness to contribute to the project.

Best regards,

Diane Spokus, Ph.D., C.H.E.S.
Andris Freivalds, Ph.D.
Resident Informed Consent Form for Biomedical Research
The Pennsylvania State University

Title of Project: Job/worksite environmental factors that influence older health care worker quality of work life and physical well-being and the intent to continue to work.

Principal Investigator: Andy Freivalds, Ph.D.
The College of Engineering
The Pennsylvania State University
Industrial and Manufacturing Engineering
0310 Leonhard Building
University Park, PA 16802
Phone: 814-863-2361
Email: axf@psu.edu

Co-Investigator: Diane Spokus, Ph.D., C.H.E.S.
Health Policy and Administration
The Pennsylvania State University
501F Ford Building
University Park, PA 16802
Phone: 717-994-1798
Email: dms201@psu.edu

1. Purpose of the study:

The purpose of this research study will also examine whether or not the use of ergonomically developed devices can reduce workmen’s compensation claims and attrition due to inability to transfer individuals from a bed to a wheelchair either in a nursing home or for someone aging in place.

2. Procedures to be followed:

You will be asked by an employee to use the Williamson Turn Stand to transfer an individual from a bed to a wheelchair and then back to the bed. The Researcher/graduate assistant will video tape the employee’s proper use of the equipment and the video will be viewed in the campus lab. There will be no audio recording taking place. The audio will be turned off.

3. Discomforts and risks:

You are free to decline to be in this study or to withdraw from it at any point. There are no risk known.

4. Benefits:

The benefits include reduced injury to employees due to improper transfer of individuals from beds to wheelchairs. The benefits to society include Job/work site characteristics that influence
older worker intent to continue to work. Few institutions have retention efforts in place for older workers and many current workers need and want to continue to work, stay active and relish the work lives they have established. Job/work site context has been inadequately studied as a predictor of turnover for older workers. Further, health care staffing shortages are creating stressful work environments.

5. Duration/time of the procedures and study:
It will take approximately 15 minutes to transfer an individual using the Williamson Turn Stand. The observations will occur twice a week for at a time designated by the facilities.

7. Statement of confidentiality:
Your participation in this research is confidential. The video tapes will be made of the employee’s proper use of the equipment and the video tapes will be kept in a locked file cabinet and will be viewed only by the researchers involved. The data will be stored and secured on the researcher’s computer in a locked/password protected file for one year until 2011.

Penn State’s Office for Research Protections, the Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project.

All records associated with your participation in the study will be subject to the usual confidentiality standards applicable to medical records (e.g., such as records maintained by physicians, hospitals, etc.). You can choose not to answer certain questions. In the event of any publication resulting from the research, no personally identifiable information will be disclosed.

If the research is regulated by the Food and Drug Administration (FDA), FDA representatives may access your research records.

8. Right to ask questions: Please contact Dr. Andris Freivalds, Principal Investigator, at his office phone: (814) 863-2361; email: axf@engr.psu.edu, with questions, complaints or concerns about the research. Dr. Freivalds’s office address is 310 Leonhard Building, University Park, PA 16802. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University’s Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team.

9. Voluntary participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusing to participate or withdrawing early from the study will involve no penalty or loss of benefits you would be entitled to otherwise.

12. Injury Clause: In the unlikely event you become injured as a result of your participation in this study, medical care is available. It is the policy of this institution to provide neither financial compensation nor free medical treatment for research-related injury. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.
You must be 18 years of age or older to take part in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

_____________________________________________  ____ _________________  
Participant Signature       Date

_____________________________________________  ____ _________________  
Person Obtaining Consent    Date
### APPENDIX E: DATA COLLECTED USING THE BORG’S CR-10 SCALE

<table>
<thead>
<tr>
<th>Exp</th>
<th>Order</th>
<th>Patient</th>
<th>Nurse</th>
<th>With turnstand (Y/N)</th>
<th>Borg - Shoulder</th>
<th>Borg - Low Back</th>
<th>Borg - Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>N</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>N</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>N</td>
<td>0.5</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>N</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>N</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>2</td>
<td>5</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>N</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>2</td>
<td>6</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>2</td>
<td>6</td>
<td>N</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>13</td>
<td>2</td>
<td>7</td>
<td>N</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>2</td>
<td>8</td>
<td>N</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>9</td>
<td>2</td>
<td>9</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>N</td>
<td>3</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>19</td>
<td>16</td>
<td>2</td>
<td>10</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td>N</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>5</td>
<td>2</td>
<td>11</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>22</td>
<td>14</td>
<td>2</td>
<td>11</td>
<td>N</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>Y</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>15</td>
<td>2</td>
<td>12</td>
<td>N</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
APPENDIX F: COMPRRESSIVE FORCE ON L5/S1

<table>
<thead>
<tr>
<th>Nurse</th>
<th>Force: Low Weight With Turn Stand</th>
<th>Force: High Weight With Turn Stand</th>
<th>Force: Low Weight Without Turn Stand</th>
<th>Force: High Weight Without Turn Stand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>420</td>
<td>700</td>
<td>638</td>
<td>1081</td>
</tr>
<tr>
<td>2</td>
<td>497</td>
<td>705</td>
<td>697</td>
<td>1100</td>
</tr>
<tr>
<td>3</td>
<td>393</td>
<td>621</td>
<td>597</td>
<td>1048</td>
</tr>
<tr>
<td>4</td>
<td>391</td>
<td>606</td>
<td>651</td>
<td>1087</td>
</tr>
<tr>
<td>5</td>
<td>189</td>
<td>319</td>
<td>687</td>
<td>1236</td>
</tr>
<tr>
<td>6</td>
<td>178</td>
<td>284</td>
<td>592</td>
<td>1004</td>
</tr>
<tr>
<td>7</td>
<td>171</td>
<td>307</td>
<td>667</td>
<td>1190</td>
</tr>
<tr>
<td>8</td>
<td>227</td>
<td>380</td>
<td>549</td>
<td>847</td>
</tr>
<tr>
<td>9</td>
<td>181</td>
<td>304</td>
<td>615</td>
<td>1022</td>
</tr>
<tr>
<td>10</td>
<td>175</td>
<td>309</td>
<td>519</td>
<td>825</td>
</tr>
<tr>
<td>11</td>
<td>144</td>
<td>272</td>
<td>521</td>
<td>895</td>
</tr>
<tr>
<td>12</td>
<td>127</td>
<td>214</td>
<td>614</td>
<td>1006</td>
</tr>
<tr>
<td>Average</td>
<td>257.75</td>
<td>418.4166667</td>
<td>612.25</td>
<td>1028.416667</td>
</tr>
</tbody>
</table>