EVALUATION OF LOW-TECH CLIENT TRANSFER DEVICES USED BY HOME CARE AIDES

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Home care tasks, such as patient lifting and transferring, involve forceful exertions and awkward postures and may increase the risk of low back injury. Sixteen home care aides completed simulated client transfers between a bed and wheelchair using a manual transfer method and four transfer devices. Findings suggested that high (bed) to low (wheelchair) transfers produced significant lower hand forces than low to high transfers, while the hand forces using the Beasy board and the Tyvek board were less than the manual's during transfers in both directions. Average trunk flexion speeds were significantly slower while using devices than using the manual method during these transfers. The usability survey suggests that the Beasy board required less exertion and would be preferred for future client visits.

Introduction

Home health and personal care aides help people who are disabled, chronically ill, or cognitively impaired. Home health care is primarily engaged in providing skilled nursing services in the home, along with personal care services, homemaker and companion services, physical therapy, medications, medical equipment and supplies, dietary and nutritional services, etc (BLS.2015). Home health and personal care aides suffer from physically and emotionally demanding tasks and had a higher-than-average number of work-related injuries and illnesses in 2010 (BLS.2013). Sprain and strains were the major injury cause lost days away from work for healthcare and social assistance in 2011(BLS.2012). Another important challenge in home care is that the home health aides often work alone with minimal help, or face un-cooperative or aggressive patients. Home care aides have less access to lifting devices than nursing aides in hospitals and other institutional settings (Myers, Jensen, Nestor, & Rattiner, 1993). According to an OSHA report, work-related musculoskeletal disorders cost business $15 to $20 billion each year in workers' compensation costs alone (OSHA.1999). The incidence rate for home health aides of MSD cases with days away from work is 50.8 per 10,000 full time employees, which is higher than the national average injury rate at 38.5 per 10,000 full time employees (BLS.2012).

Patient transfer boards (sometimes called slide boards) are assistive devices that allow a client with mobility challenges to be transferred between a bed and chair, or other similar resting places. A lab-based study that compared three different boards has shown the benefit of using transfer boards in reducing physical workloads while performing patient transfers, although they may be used in different ways (Hess, Kincl, & Mandeville, 2007). Recently, new technology has been embedded into transfer boards, some of which use gliding mechanisms to replace traditional surface transfers in order to minimize the friction between the client and transfer board. It is hypothesized that this special mechanism could reduce physical workloads that are introduced by client lifting and moving activities. Nevertheless, very few studies have focused on the biomechanical evaluation of ergonomic exposures during the usage of different transfer boards among home care aides.

Method

Simulated home care environment (Wheelchair and bed).

The client transfer simulation included a transfer from wheelchair to bed and a transfer from bed to wheelchair. The study used a wheelchair that had removable armrests and footrests and the seat height was 48.2 cm from the floor. The bed was composed of a metal frame with wheels, a box spring, and a twin sized mattress on top. The bed surface height was 56 cm from the lab floor. In order to facilitate the transfer, two metal handles were attached separately to a 152 cm cotton medical gait belt.

The wheelchair to bed transfer was from a lower position to a higher position. The transfer's direction started from the left side to the right side of the home care aide, and was the same for all transfer methods during wheelchair to bed transfer. In contrast, the bed to wheelchair transfer was directed from the right to left side of the aide, and it began at a high position on the bed and ended on the low position on the wheelchair. The transferring task period was defined as the interval between the apparent beginning of the hand force increases and the apparent end of the hand force decreases.

Transfer Boards Selection.

We identified several transfer devices by conducting a comprehensive search on the internet using key words such as patient transfer board and slide board. These devices included a wood transfer board, Roll Easy transfer board, and a Beasy board. The wood transfer board is a conventional board that represents the majority of the products on the market. The Roll Easy transfer board had wood balls installed between parallel grooves. The Beasy board provided a unique sliding feature and a rotatable pad to reduce the friction between the patient's skin and the sliding surface. In addition, we piloted our own method by applying a piece of Tyvek material (Dupont.2014) on the wood board, which could slide over the board along with the client during transfer. As a result, we adopted four transfer devices and used a manual transfer to simulate the patient transfer tasks.

Home care aide and patient recruitment

A total of 16 female subjects were recruited from local home health agencies through the Safe Home Care project. Their ages ranged from 20 to 59 years old, and their work experiences ranged from 1 to 25 years. None of them had been diagnosed with low back injury or low back pain during the past 12 months. Subjects read and signed the IRB form that was approved by the UMass Lowell Internal Review Board before the study. A research staff who weighed about 59.4 kg (131 lb) was asked to serve as a mock patient through all experimental trials.

Camera settings

In order to capture the body angles in the mid-point of the transfer, two cameras were positioned in a fixed angle to each side of the sagittal planes of the aide. The cameras' projection is perpendicular to the aide's sagittal plane in the mid-point of transfer tasks. The height of the two cameras was approximately 6 feet from the ground. A research assistant estimated the body postures and dynamics from the video cameras.

EMG and hand force settings.

A four channel surface EMG system was used to measure the subjects' muscle activities on the right/left Anterior Deltoid muscle (AD) and right/left Erector Spinae (ES). The electrode placement over each muscle was as described by Kendall (Kendall, McCreary, & Provance, 1993). Before the experiments, every aide had their Maximum Voluntary Contraction (MVC) tested for these muscles according to Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM, 2015). The hand forces were measured by two load cell sensors (SSM-50, Interface, Inc) that were attached in-between the transfer belt and the metal handles. The analog data were transferred to an A/D board and were saved on a computer. A lumbar motion monitor (LMM) was used to track the dynamics of the trunk motion. The sampling rate for RMS electromyographic, lumbar motion dynamics and hand force data were 60 Hz.

Usability Survey.

The usability survey was developed based on the Quebec User Evaluation of Satisfaction with assistive Technology (Gelderblom, de Witte, Demers, Weiss-Lambrou, & Ska, 2002) and other studies that evaluate the usage of mechanical transfers (Heacock et al., 2004; McGuire, Moody, Hanson, & Tigar, 1996). The aides were asked to answer 19 usability questions based on 5 point scales (strongly disagree to strongly agree) about the following items: device features, device usage, user and client safety, time used, learnability, and general satisfaction about the device. This survey is the first instrument to evaluate low-tech client transferring devices for home care aides.

Task simulation.

Before the task simulation, the homecare aide received a one-hour training about how to use the five transfer techniques and to follow three transfer principles: 1) Grasp the handles on the gait belt as close as possible to each other; 2) During the transfer, keep the back straight as much as possible, and flex the knees if necessary; 3) During the transfer board based transfers, apply force in a horizontal direction instead of lifting. The client was instructed to have only minimum self-support for balance-keeping and safety purposes and was asked not to use her upper extremities to perform the transfer. The home care aide was randomly assigned with the sequences of the transfer techniques. Each subject completed the wheelchair to bed (W-B) (left-right, low-high transfer) and the bed to wheelchair (B-W) (right-left, high-low transfer) transfer by using five different transfer techniques (manual, Beasy board, Roll Easy board, wood board, and Tyvek material on a wood board). Between the two transfers, each subject was given a two-minute break. The usability survey was administered to the aides after they completed every two-way transfer.

Data analysis.

The RMS EMG data were smoothed (100 ms) prior to statistical analysis (Matlab R2014a Student License). The independent variable in this study was the transfer method, and the dependent variables included: 90 percentile hand force on the both hands, 90 percentile EMG/MVC ratios on shoulders (Anterior Deltoid) and low back area (Erector Spinae), lumbar motion dynamics such as flexion angles and velocity, as well as the usability features during the transfers. Mixed model in SAS 9.2 was used to identify the differences of these outcome variables using different transfer methods. In the survey analysis, a change of one preference level is considered as meaningful difference in the usability rating.

Results

The 90th percentile hand force, electromyographic data and the trunk dynamics during the wheelchair to bed and bed to wheelchair transfers are summarized in tables 1 and 2. In figure 1, the 90 percentile left hand force using the manual transfer technique (94.8N) was significantly higher than for the other transfer techniques, during wheelchair to bed transfer. In figure 2, the 90 percentile right hand force using the Beasy (117.8N) and Tyvek boards (111.7N) were significantly lower than the manual method (131.3N), the Tyvek method significantly lower than wood board transfer 124.6N) and marginally lower than Roll Easy transfer (123.8N) during wheelchair to bed transfer. In figure 3, the 90 percentile left hand force using manual transfer (114.8N) was significantly higher than all other transfer techniques (all less than 100N) during bed to wheelchair transfer. While in figure 4, the 90 percentile right hand force (support hand) using manual transfer (75.4N) was significantly higher than all other transfer techniques during bed to wheelchair transfer. The right hand force using the Beasy board transfer (25.4N) was marginally lower than using the Tyvek transfer. In figure 5, the mean trunk flexion velocity using manual transfer (12.6°/sec) was significantly higher than using other transfer methods, and was higher than the average trunk flexion velocity (11.74°/sec) for high risk group during wheelchair to bed transfer (Marras et al., 1993). The mean trunk flexion velocity using manual transfer (13.6°/sec) was significantly higher than using other transfer methods, and was higher than 11.74°/sec during the bed to wheelchair transfer. In table 3, the usability evaluation shows that the Beasy board was selected as the least effort to use (item 5) and the device aides would use in the future (item 18).

Table 1: Hand force, EMG and Trunk dynamics during wheelchair to bed transfer

	N	Manual	Woodboard	Roll Easy	Beasy	Tyvek
90 percentile left hand force (N)	15	94.8±15.6	49.2±19.4	45.2±20.5	37.1±20.8	45.6±21.9
90 percentile right hand force (N)	14	131.3±16.6	124.6±17.1	123.8±13.6	117.8±11.4	111.7±13.7
90 Percentile EMG on left shoulder (%)	14	59.8±27.4	65.7±65.9	63.7±46.7	76.2±56.9	60.3±49.4
90 Percentile EMG on right shoulder (%)	14	85.5±52.7	90±44.4	80.7±34.5	78.6±41.2	88.5±55.2
90 Percentile EMG on left low back (%)	14	114.6±75.1	105.5±48.1	101.8±68.2	81.3±36.3	102.7±70
90 Percentile EMG on right low back (%)	14	127.1±67	122.9±68.3	118.6±60.3	111.5±49.6	139.4±88.8
Mean flexion velocity (°/sec)	15	12.6±5.9	7.4±3.5	7.2±3.4	7.1±3.2	6.7±2.6
Maximum Left twisting('-' means left) (°)	15	-6.8±7.9	-10.7±6.1	-9.3±6.4	-9.1±5.2	-10±6.4
Maximum Right twisting (°)	15	3.1±7.1	3.5±6.9	5.4±7.2	4.7±5.2	3±7

Table 2: Hand force, EMG and Trunk dynamics during bed to wheelchair transfer

	N	Manual	Woodboard	Roll Easy	Beasy	Tyvek
90 percentile left hand force (N)	15	114.8±18.3	85.8±13.9	80.8±12.9	74.6±18.1	80.8±14.4
90 percentile right hand force (N)	14	75.4±9.7	32.6±13.7	28.3±13.9	25.4±12.1	36.6±18.9
90 Percentile EMG on left shoulder (%)	14	68.8±50.2	63±41.3	54.8±27.9	50.8±27.4	44.1±24.1
90 Percentile EMG on right shoulder (%)	14	96.6±48.1	87.4±64.6	71±38.6	73.4±45.6	76.9±48.7
90 Percentile EMG on left low back (%)	14	144.7±108.9	111.8±41.5	104.8±54	106.1±64	106.4±52.2
90 Percentile EMG on right low back (%)	14	93.2±59.7	80.3±46.5	72.8±49.2	72.9±43.8	92±61.3
Mean flexion velocity (°/sec)	15	13.6±6.5	6.9±2.7	8.2±5.7	4.9±2.9	5.1±2.3
Maximum Left twisting ('-' means left) (°)	15	-2.2±4.7	-4.2±4.9	-5.2±5.1	-2.5±3.7	-3.3±4.8
Maximum Right twisting (°)	15	7.8±5.9	9±6.3	9±5.4	9.7±5.9	10.3±5.8

Figure 1

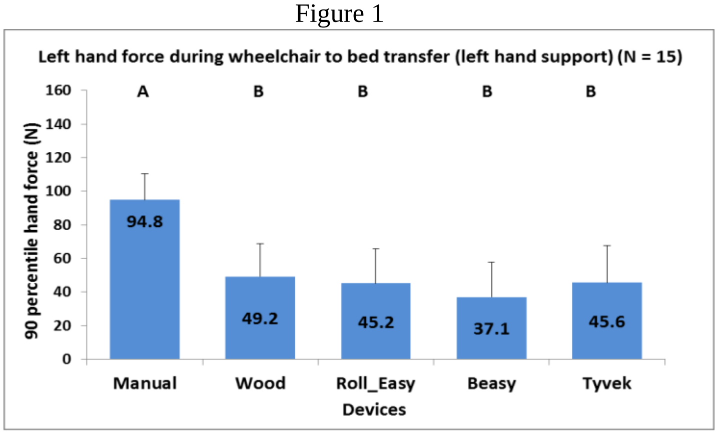


Figure 2

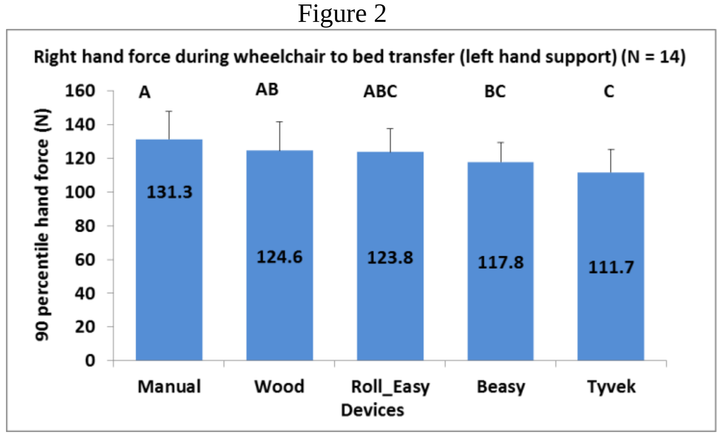


Figure 3

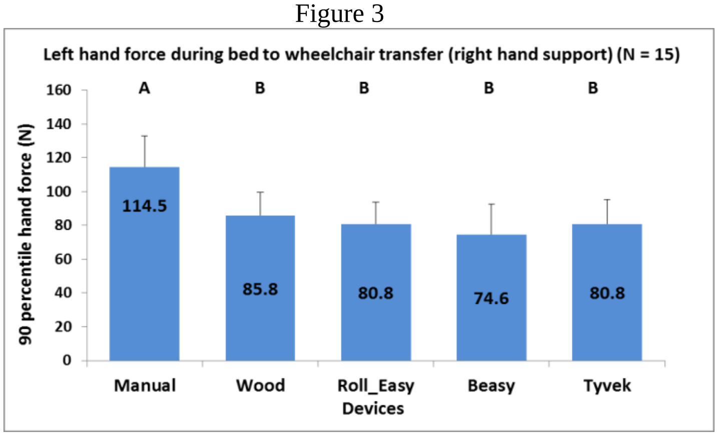


Figure 4

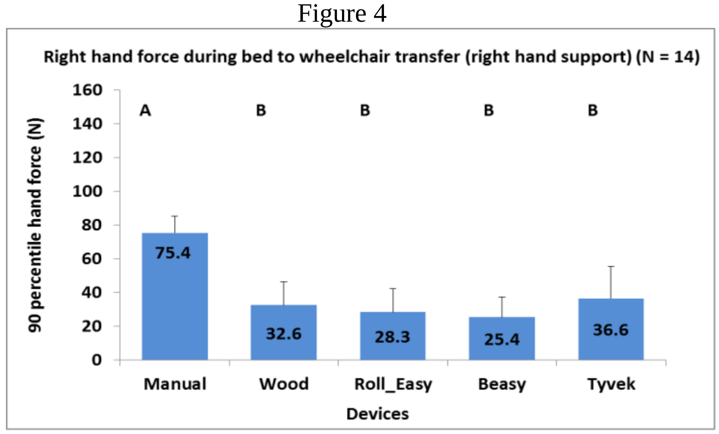
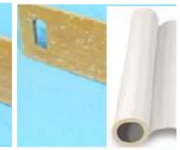


Table 3: Evaluation of transfer devices among home care aides (1 - Strong disagree, 5 - Strongly agree)

Usability Items	Manual	Beasy	Roll_Easy	Wood	Tyvek
					
1. The board is easy to use	N/A	4.38	3.69	4.56	4.06
2.The method is very helpful	4.38	4.56	3.94	4.44	4.25
3.Easy to place under the client	N/A	4.5	3.19	4.38	4.31
4.I can complete entire task myself	4.81	4.75	4.38	4.69	4.56
5.It takes a lot of efforts to use	3	1.81	2.88	2.19	2.25
6.It takes a lot of time to prepare	2.13	2.56	2.5	1.88	2.44
7.The board is safe for me	4	4.5	3.88	4.63	4.38
8.I worry that the client may fall	2.27	2	2.13	1.88	1.93
9.I worry the cleanliness of the board	N/A	3.31	2.75	2.56	2.56
10.It is difficult to learn	1.38	1.75	1.88	1.44	1.81
11.The board would be easier to use with more practice	3.06	3.44	4.13	3.31	3.56
12.I like the appearance of the board	N/A	4.25	3.75	4.13	3.69
13.I feel comfortable using the transfer technique	4.69	4.5	3.93	4.5	4.13
15.I feel the board is high quality	N/A	4.44	4.38	4.63	4.06
15.The shape/size is approriate for the job	N/A	4.44	3.69	4.5	4.06
16.Convenient to store in client's home	N/A	4.5	3.93	4.63	4.63
17.Easy to carry	N/A	3.63	3.06	4.25	4
18.I will use it in the future	4.19	4.25	3.63	4.13	4
19.Overall experiences with the transfer method*	8.5	7.88	6.94	8.38	7.75

* The satisfaction scale ranges from: 1-The worst to 10- The best

Figure 5

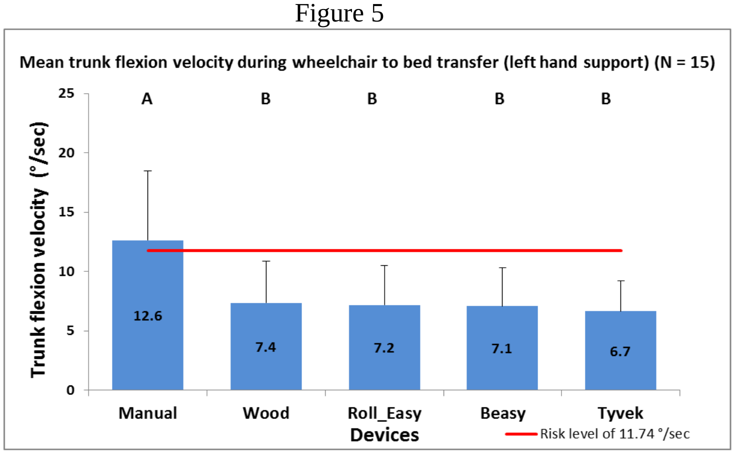
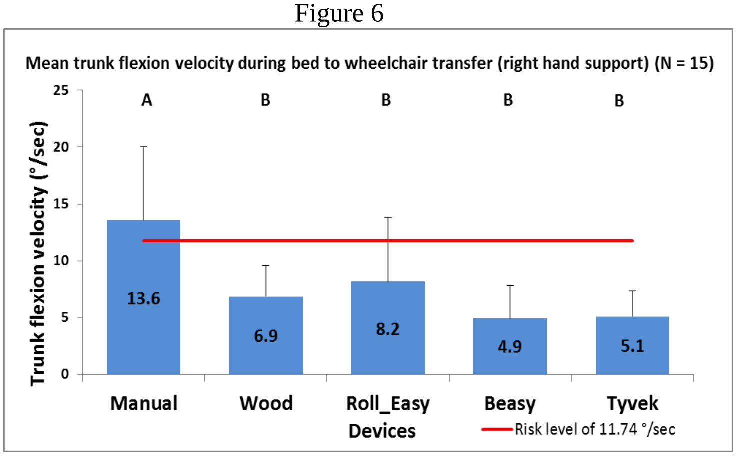


Figure 6



Discussion

Hand Force.

The findings demonstrate that the usage of transfer devices in the simulated client transfer tasks substantially reduced ($p<0.05$) the hand force on the leading hand and supporting hand, except the right hand force while using the Roll Easy board and wood board during the low to high transfer.

The mean two hands forces during the wheelchair to bed and bed to wheelchair manual transfers (226N, 190N) were equal to or higher than the industrial Maximum Acceptable Weight of Lift (MAWL) for females: 186.2N (using both hands lift from knuckle to shoulder, 8hrs, 50 percentile) (Snook & Ciriello, 1991) and was close to or higher than the NIOSH recommended lifting limits (222N for two hands). The mean leading hand forces (131.3N, 114.8N) were higher than the single hand MAWL (Female) and NIOSH limits. Considering the relatively light weighted mock client (59.4kg/131 lbs) in our study, the real two hand forces while transferring a moderate or heavy weighted client may exceed the recommended MAWL or the NIOSH lifting limits of 222N. In addition, our study demonstrated similar findings to the results from Zhuang et al. (Zhuang, Stobbe, Hsiao, Collins, & Hobbs, 1999) where the nursing aide used an average of 194N hand force to lift and reposition a client on the bed (no transferring). The mean two hand forces using Beasy board to transfer heavy (757N) and light (570N) client in Zhuang's study were about 89N and 74N respectively, which is lighter than the correspondent hand force in our study (100N, bed to wheelchair, high to low transfer). This might be due to the difference between the force vector measurement approach in Zhuang's study (force plate on the ground measuring vertical force) and the direct force measurement on the gait belt in our study (integrated vertical and horizontal hand force).

During the wheelchair to bed (Low-High) transfer, the total hand force in the Beasy board (154.9N) and Tyvek material (157.3N) transfer were substantially lower than the hand force in manual transfer. Furthermore, the hand force in the Tyvek method is significantly lower than wood board transfer (173.8N) and marginally lower than in the Roll Easy transfer (169N). This suggests that using the Tyvek transfer board that has movable sliding mechanism (compare to the wood balls in Roll Easy board) has advantages in reducing hand force during low to high transfer. During the bed to wheelchair (high to low) transfer, all of the transfer board techniques show substantially reduced hand force compare with the manual transfer (190N).

The usability result suggests that the Beasy board required less effort to use than other devices and was preferred for future usage. This is consistent with the results from the reduced hand force during the wheelchair to bed and bed to wheelchair direction.

Even though a heavier simulated client would probably result in larger difference in the contrast of the reduced hand force in device-based transfers, the finding suggests that transferring a client from high-low using a slide board substantially reduced the total hand force compared with transferring a client in the opposite direction.

Application.

It is strongly suggested to integrate a sliding mechanism into the patient transfer product design and manufacturing to reduce the friction between the client and the board surface. During the patient transfer study, several lessons that we learned from this study are recommended:

1. Use an adjustable bed or wheelchair to level or to create a downward slope, so that a level or a high to low transfer is available.
2. Train the home care aide to adapt to the sliding activity instead of lifting.
3. Install a handle or a grabbing belt on the gait belt to enhance the maneuverability of the task.
4. When transfer board or devices are available, avoid using manual lifting as much as possible.
5. Use low friction materials, such as Tyvek, and accommodate the material onto a wood transfer board, in order to reduce the sliding friction.

Acknowledgement

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