Ergonomic comparison between formal and informal caregivers performing device assisted transfers using a mechanical lift and a robotic assisted transfer device

J. Hoydick[1,2], M. Greenhalgh, B.S[1,3], R. Cooper, PhD[1]

[1]Human Engineering Research Laboratories, Veterans Affairs Pittsburgh Health Care System, University Drive, Pittsburgh, PA, [2]Department of Biomedical Engineering, Duquesne University, Pittsburgh, PA,

[3] Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, PA

INTRODUCTION

Figure 1: Hoyer lift

Caregivers are essential resources in healthcare, as over 39 million adults in the United States provide care to a person who is disabled, ill, or elderly. [1] Informal caregivers, which include family and friends, provide approximately 87% of long-term care. [2] Formal caregivers, including home health aides, nursing aides and personal care aides, are expected to increase by 47% from 2010 to 2020. [3] Caregivers perform a variety of tasks, some of which are physically demanding, such as transferring patients to and from wheelchairs. [4]

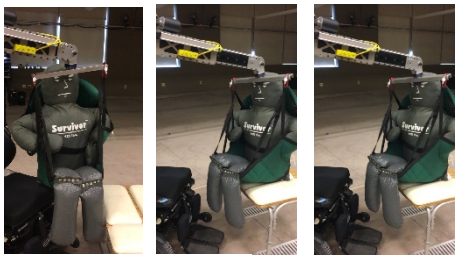

Figure 2: StrongArm

Mechanical lifting devices such as the Hoyer lift are an improvement compared to manual lifting, yet still have limited use in crowded spaces and leaves a risk for shoulder and back injuries. [5] In contrast, the StrongArm RATD has a more compact design, making it more suitable for tight spaces, and uses an electronically controlled joystick to perform the transfer. A recent cross-sectional study showed that caregivers favored StrongArm over the Hoyer lift for both task load demand and transfer usability. [6]

As informal caregivers are more prevalent than formal caregivers, it is important to determine which type of device is more suitable in a home setting. [7] This study aims to determine whether there is a significant difference in muscle activation between formal and informal caregivers when using assisted transfer devices, including the Hoyer lift and StrongArm, and to compare usability, demand, and muscle activation between both devices. It is hypothesized that formal caregivers, or those with more formal experience, encounter less muscle activation using assisted devices for transfers than informal caregivers. Additionally, it is hypothesized that both groups experience reduced muscle activation and task demand using the StrongArm compared to the Hoyer at three distinct surfaces and phases to and from a wheelchair.

METHODS

Eight formal caregivers and nine informal caregivers were recruited for this study from the 2018 National Veteran's Wheelchair Games in Orlando, FL, the University of Pittsburgh's School of Health and Rehabilitation Sciences, the University of Pittsburgh Medical Center's Center for Assistive Technology, the U.S. Department of Veterans Affairs Pittsburgh Healthcare System, and through local research registries from the University of Pittsburgh Clinical and Translational Science Institute and the Human Engineering Research Laboratories. Caregivers, who were paired with mobility device users, were required to meet the following criteria to participate in this study: (1) over the age of 18, (2) able to volunteer four hours of their time, and (3) over one year of experience performing transfers. Caregivers were excluded if they had a history of pain or injury that could be aggravated during the study, or if they were pregnant. After signing consent, participants completed a sociodemographic survey and also completed the Oswestry Back Pain Scale and the Occupation Fatigue Exhaustion Recovery scale, which evaluates back pain and occupational fatigue, respectively. [8,9] Electromyography (EMG) sensors provided by Noraxon (Telemyo) were used to collect muscle activation by placing electrodes on the caregiver at the erector spinae and latissimus dorsi. During the manual muscle tests, the caregiver voluntarily contracted their target muscle for five seconds to determine the baseline muscle activation, or maximum voluntary contractions (MVC). Participants were then provided a video explaining appropriate use of each transfer device. The experimental protocol was identical for both the formal and informal caregivers. Transfers were conducted using a powered wheelchair to and from three different transfer stations: a rehab bench, standard tub chair, and a standard toilet in a simulated bathroom

compliant with American Disability Association standards. [10] Care recipients were transferred to and from each station three times with both the Hoyer and the StrongArm, or a total of 36 transfers per caregiver. Each transfer was divided into three distinct phases: lift, transfer, and placement. Following each transfer station with each device, caregivers completed two surveys to assess each device. The USAT assesses the device's ease of use, efficiency, appeal, safety, and ability to reduce transfer induced fatigue and discomfort on a ten-point scale. The NASA-TLX survey assesses task demand on a 0-100 scale and a matching scale assessing the more demanding domain. [11]

Biomechanics code was previously developed on MATLAB to calculate both the peak and integrated muscle activation of muscles of interest. EMG data was cleaned and rectified using a fourth order bandpass and lowpass Butterworth filter. Peak %MVCs >100% were not included as they were not measured by true MVCs. All statistical analysis was performed using IBM SPSS. A 5-way repeated measures between-subject ANOVA was performed. A p-value of less than 0.05 was considered significant.

RESULTS

USAT

StrongArm had a significantly more positive impact on caregivers with regards to fatigue ($p = 0.024$) and pain frequency ($p = 0.003$). StrongArm was favored with respect to reducing transfer related fatigue at both the rehab bench ($p = 0.023$) and the tub chair ($p = 0.042$), as well as reduce physical discomfort frequency at the standard toilet ($p = 0.001$), rehab bench ($p = 0.009$), and tub chair ($p = 0.034$) when compared to the Hoyer lift. Back pain responses showed no significant difference. The type of caregiver, formal or informal, showed no significant difference in survey responses in all four categories.

Table 1: USAT survey p-values

	Back Pain	Fatigue	Pain Intensity	Pain Frequency	NASA-TLX
Caregiver Status	0.861	0.699	0.198	0.198	**0.035**
Device	0.151	**0.024**	0.355	**0.003**	0.258
Surface					
Toilet	0.178	0.050	0.573	**0.001**	0.244
Rehab Bench	0.063	**0.023**	0.322	**0.009**	0.421
Tub Chair	0.313	**0.042**	0.395	**0.034**	0.172

NASA- TLX

The NASA-TLX survey showed no significant difference in total task demand on the device used ($p = 0.258$). However, formal caregivers experience significantly less task demand than informal caregivers performing device assisted transfers ($p = 0.035$).

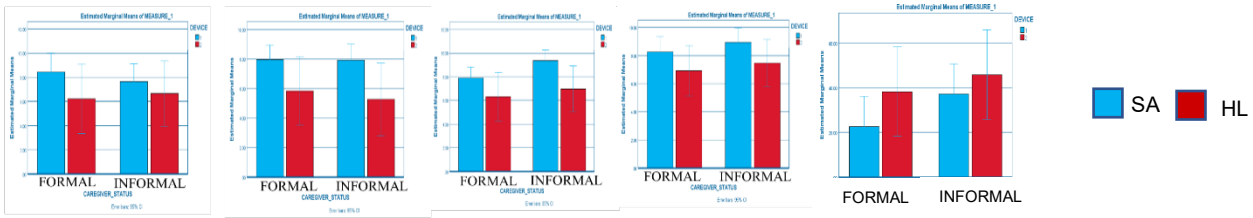

Figure 3: back pain, fatigue, pain frequency, pain intensity, and NASA-TLX (L to R) scores

Peak %MVC data

StrongArm was favored over the Hoyer lift for both the right ($p = 0.005$) and left ($p = 0.016$) erector spinae, and the right latissimus dorsi ($p = 0.003$). For the right erector spinae, StrongArm was favored at all three transfer surfaces: standard toilet ($p = 0.002$), rehab bench ($p = 0.010$), and tub chair ($p = 0.019$). It was also favored during the lift ($p = 0.009$) and transfer ($p = 0.006$) phases. Additionally, StrongArm was also favored in both directions: to the surface ($p = 0.005$) and to the wheelchair ($p = 0.007$).

Muscle activation was lower in the left erector spinae using StrongArm at the rehab bench ($p = 0.003$) and the tub chair ($p = 0.020$), as well as in the lift phase ($p = 0.006$). StrongArm was again favored in both directions, to the surface ($p = 0.016$), and to the wheelchair ($p = 0.017$).

Strong Arm transfers also required less muscle activation in the right latissimus dorsi at all three surfaces: standard toilet (p = 0.003), rehab bench (p = 0.005), and tub chair (p = 0.010), as well as in the lift (p = 0.010) and transfer (p = 0.004) phases. Similar to the right and left erector spinae, StrongArm was also favored in both directions at the right latissimus dorsi: to the surface (p = 0.002) and to the wheelchair (p = 0.005).

No significant differences in peak percentage muscle activation were reported at the left latissimus dorsi. In all four muscles, the type of caregiver showed no significant difference in the muscle activation.

Table 2: peak %MVC data p-values

	Right Erector Spinae	Left Erector Spinae	Right Latissimus Dorsi	Left Latissimus Dorsi
Caregiver Status	0.056	0.947	0.619	0.579
Device	**0.005**	**0.016**	**0.003**	0.982
Surface				
Accessible	**0.002**	0.071	**0.003**	0.909
Toilet	**0.010**	**0.003**	**0.005**	0.649
Rehab Bench	**0.019**	**0.020**	**0.010**	0.482
Tub Chair				
Phase				
Lift	**0.009**	**0.006**	**0.010**	0.996
Transport	**0.006**	0.100	**0.004**	0.811
Placement	0.133	0.050	0.350	0.875
Direction				
To Surface	**0.005**	**0.016**	**0.002**	0.812
To Wheelchair	**0.007**	**0.017**	**0.005**	0.746

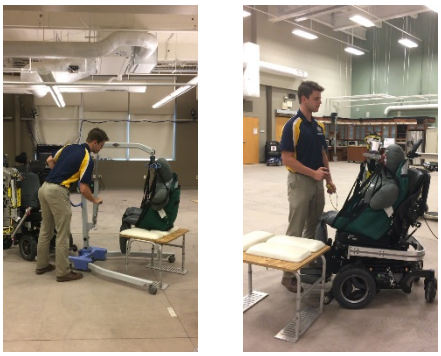

Figure 3: Hoyer and StrongArm transfer to tub chair

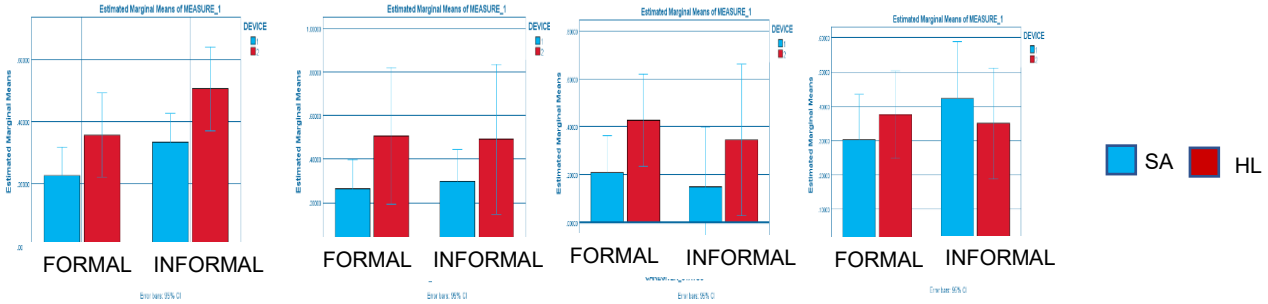

Figure 4: right erector spinae, left erector spinae, right latissimus dorsi, and left latissimus dorsi peak %MVC (L to R)

DISCUSSION

This study analyzed both the muscle activation and survey responses of formal and informal caregivers while using assistive transfer devices, including a mechanical lift and RATD.

StrongArm required less muscle activation in three of the four muscles tested, proving that it is less physically demanding than the Hoyer Lift, supporting the hypothesis. However, the type of caregiver, formal or informal, showed no significant difference in muscle activation in the caregiver. This insignificance may have been because the transfer devices are straightforward to operate, so all caregivers used the same muscle exertion to complete the transfers.

According to the results of the surveys, StrongArm was proven to reduce transfer related fatigue and physical discomfort frequency in parts of the transfer. StrongArm only requires the use of a joystick to perform the transfer, reducing both the time and muscle exertion needed to complete the transfer as opposed to the Hoyer lift. Therefore, StrongArm would be suitable for both a home and clinical setting because it reduces the muscle activation in both formal and informal caregivers. The NASA-TLX survey was the only instance where the caregiver status proved to be significant. Formal caregivers experienced significantly less task demand than informal caregivers. This may be because they feel more comfortable handling assistive transfer devices from extensively using them at their jobs.

Limitations and future work

Results from this study were based on a convenience sample of caregivers which may not accurately portray the caregiver population as a whole, and could lead to sampling error. Future studies should recruit

caregivers that more accurately represents the entire caregiver population. Additionally, this study focused only on two back muscles. Shoulder injuries are also common in caregivers, so future studies should focus on muscle activation in the deltoid.

CONCLUSION

The type of caregiver, formal or informal, showed no significant difference in muscle activation when using assistive transfer devices. StrongArm was favored over the Hoyer lift in reducing muscle activation in all caregivers, making it suitable for both a home and clinical setting.

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REFERENCES

[1] Yuen, E. Y., Knight, T., Ricciardelli, L. A. and Burney, S. (2018), Health literacy of caregivers of adult care recipients: A systematic scoping review. Health Soc Care Community, 26: e191-e206. doi:10.1111/hsc.12368

[2] The Scan Foundation (2012) http://www.thescanfoundation.org/sites/thescanfoundation.org/files/us_who_provides_ltc_us_oct_2012_fs.pdf

[3] Jeannis, H., Grindle, G. G., Kelleher, A., Wang, H., Brewer, B., & Cooper, R. (2013). Initial development of direct interaction for a transfer robotic Arm system for caregivers. 2013 IEEE 13th International Conference on Rehabilitation Robotics (ICORR). doi:10.1109/icorr.2013.6650390

[4] Garg, B. Owen, D. Beller & J. Banaag (1991) A biomechanical and ergonomic evaluation of patient transferring tasks: wheelchair to shower chair and shower chair to wheelchair, Ergonomics, 34:4, 407-419, DOI: 10.1080/00140139108967325

[5] Burkman, J., Grindle, G., Wang, H., Kelleher, A., & Cooper, R. A. (2017). Further Development of a Robotic- Assisted Transfer Device. Topics in Spinal Cord Injury Rehabilitation, 23(2), 140-146. doi:10.1310/sci2302-140

[6] Greenhalgh, M., Landis, J. M., Brown, J., Kulich, H., Bass, S., Alqahtani, S., . . . Cooper, R. A. (2019). Assessment of Usability and Task Load Demand Using a Robot-Assisted Transfer Device Compared With a Hoyer Advance for Dependent Wheelchair Transfers. American Journal of Physical Medicine & Rehabilitation, 98(8), 729-734. doi:10.1097/phm.0000000000001176

[7] Solé-Auró, A., & Crimmins, E. M. (2012). Who cares? A comparison of informal and formal care provision in Spain, England and the USA. Ageing and Society, 34(3), 495-517. doi:10.1017/s0144686x12001134

[8] Fairbank JC, Pynsent PB: The Oswestry Disability Index. Spine 2000;25:2940–53

[9] Winwood PC, Winefield AH, Dawson D, et al: Development and validation of a scale to measure work-related fatigue and recovery: the Occupational Fatigue Exhaustion/Recovery Scale (OFER). J Occup Environ Med 2005;47:594–606

[10] ADA Standards for Accessible Design (2010) https://www.ada.gov/2010ADAstandards_index.htm, accessed June 11, 2019.

[11] Hart SG. NASA-task load index (NASA-TLX); 20 years later. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2006;50(9):904-908.