

Case Study: Pilot Test of Virtual Seating Coach Evaluated by Power Seat Function Users

Hsin-yi Liu^{1,2}, Yu-Kuan Wu^{1,2}, Annmarie Kelleher^{1,2}, Rosemarie Cooper^{1,2}, Dan Seiwiorek³, Rory Cooper^{1,2}

¹Human Engineering Research Laboratories, VA Pittsburgh Healthcare System, Pittsburgh PA

²Department of Rehabilitation Science and Technology, University of Pittsburgh

³Human-Computer Interaction Institute, Carnegie Mellon University

ABSTRACT

A Virtual Seating Coach (VSC) is being developed to facilitate appropriate use of power seat functions in daily living. A pilot test was conducted to evaluate the reliability and collect user feedback to improve the system. This paper presents some findings from the pilot test study.

KEY WORDS

Power seat functions; Pressure ulcer prevention; Virtual Coach; Wheelchair users

INTRODUCTION

Power seat functions are important features for power wheelchair users to adjust posture independently. Sitting with a proper combination of tilt and recline angles has been shown to significantly decrease interface pressure and restore skin blood perfusion for reducing the risk for development of pressure sores (Giesbrecht, Ethans, & Staley, 2011; Jan, Brienza, Boninger, & Brenes, 2011). However, with numerous activities and tasks happening during a day, it is very easy to lose tracking of the time and forget to perform pressure relief even when the individual is aware of the importance of pressure sore prevention (King, Porter, & Vertiz, 2008; Vaishampayan, Clark, Carlson, & Blanche, 2011). A survey study shows that less than half of research participants with spinal cord injuries "often" or "always" perform pressure relief following clinical recommendation (Bloemen-Vrencken, Witte,

Post, & Heuvel, 2007). Web-pages, e-mails, short-message service over mobile phones have been widely applied in health management interventions, and positive effects have been shown for smoking cessation, weight loss, and diabetes management (Chatterjee & Price, 2009; Cole-Lewis & Kershaw, 2010). Pressure relief needs to be performed with fairly high frequency (once every 15-30 minutes for manual wheelchair users; once every hour for power wheelchair users) among regular daily tasks compared to most of health behaviors. A study by Yang et al. showed that monotonic ring tone alerts increased the frequency of performing pressure relief by manual wheelchair users, from 9.48 times to 12.30 times per day, but the frequency was still much less than once every 20 minutes set for the alert (Yang, Chou, Hsu, & Chang, 2010). Yang's system is a time-routine reminder. Some participants reported that they felt annoyed, but it is unknown whether they were annoyed by the monotonic ring tone, the frequency of the alert, or the timing of the alerts. There has not been a reminder device optimized for power wheelchair users to perform pressure relief using PSFs.

The Virtual Seating Coach (VSC) is being developed to provide appropriate pressure relief reminders for power wheelchair users (Liu et al., 2011). It provides reminders for the timing of performing pressure relief, as well as the tilt and recline angles to significantly reduce interface pressure. Currently the prototype VSC

is installed on a commercialized front-wheel drive power wheelchair, as shown in Figure 1. This paper presents some findings from the pilot test study conducted to evaluate VSC's performance and collect user feedback to improve the system for a future long-term clinical trial.



Figure 1. Research wheelchair instrumented with the Virtual Seating Coach.

METHOD

Wheelchair users who can operate their power seat functions independently were recruited to participate in this study. The investigators first introduced the VSC, and administered a survey and interview about their first impressions of the VSC. If the clinician identified that the participant could be fitted in the study wheelchair, the participant could decide

whether he/she wanted to take our study wheelchair home and use it for up to three days. The reminders were set by the clinician, based on the participant's preferences and general rules recommended by wheelchair seating clinicians. Participants could dismiss or snooze reminders by pressing a button on the touch screen, and personalize the display effects. At the end of the 3 days, a follow-up survey and interview were administered to gauge the participant's attitude toward the VSC after using it for 3 days. Due to the limit on the length of the paper, only the results about general wheelchair usage, compliance with the pressure relief reminders, and participants' feedback about VSC usage experience are reported and discussed in this paper.

RESULT

Seven participants have evaluated the VSC. Their demographics are listed in Table 1. Five of them participated in the in-home trial. Participants B and D declined to participate in the 3-day in-home trial because our research wheelchair is front-wheel drive, whose maneuver behavior is very different from the two participants' personal wheelchairs. Participant B even expressed his concern with recording seat functions and wheelchair usage

Table 1. Demographics of the participants. Gray fill indicates the participants who declined to participate in the in-home trial or turned off the VSC interface.

Participant	Age	Gender	Diagnosis	Type of Personal Wheelchair	Occupancy Duration (hr/day)
A	24	M	Spinal Cord Injury	Front-Wheel Drive	15.9
B	67	M	Spinal Cord Injury	Mid-Wheel Drive	--
C	31	M	Muscular Dystrophy	Front-Wheel Drive	7.4
D	62	M	Multiple Sclerosis	Rear-Wheel Drive	--
E	56	F	Spina Bifida	Front-Wheel Drive	14.2
F	62	F	Post-Polio	Front-Wheel Drive	7.4
G	62	M	Spinal Cord Injury	Front-Wheel Drive	9.8

for privacy reasons. Although Participant E agreed to enter the in-home trial, she felt that the reminders were very annoying, and chose to turn off the monitor, but keep using the research wheelchair for 3 days. Daily wheelchair occupancy durations are varied among 5 participants, as shown in Table 1.

Participant A was the first wheelchair user to conduct the in-home trial. Although the pressure relief reminder was set to deliver once every 60 minutes, the reminder was actually delivered once every 30 minutes with auto-snooze interval of every one minute (if the participant ignores the reminder, VSC will deliver the reminder again after one minute) because of programming problems. The VSC program was debugged and the reminder was delivered as the frequency set by the clinician for the following trials. The auto-snooze interval was set to be 5 minutes for the participants C, F, and G.

The pressure relief reminder setting for the four participants and their compliance are listed in Table 2. The counts of reminders delivered by VSC include the reminders repeating after the auto-snooze intervals. Participant C performed pressure relief with the frequency matching the reminder frequency setting, and on average the snooze function was activated at most twice before he complied with the reminder and performed an effective

pressure relief. The snooze function was activated at least 3 times for Participants A, F, G before they performed a pressure relief. Participant A dismissed reminders 3-6 times each day. Others rarely dismissed reminders, for example once per day. Only Participant A chose to turn off the audio output all the time. Others kept receiving audio alerts.

Before the in-home trial, all four participants felt that they would not benefit from VSC because they know very well how to use power seat functions. After the in-home trial, Participants A and C reported that they felt more comfortable sitting in the wheelchair because of following the pressure relief regimen reminded by VSC. Participants F and G felt that the position of the monitor is in their way of conducting many daily tasks, and VSC is redundant since they have their own methods of performing pressure relief. However, they recognize the potential benefit of emphasizing pressure relief by consistently repeating for novice wheelchair users to habituate the pressure relief regimen.

DISCUSSION

VSC hardware functioned stably during the 3-day in-home trial. VSC malfunctioned only a few times due to software problems, but the research wheelchair itself functioned normally without impeding participants' daily activities. When the participant received a reminder,

Table 2. Pressure relief reminder setting and participants' compliance.

Participant	Reminder Frequency Setting	PR Position and Duration Setting	Counts of Reminders Delivered by VSC (times/day)	Counts of effective PR (times/day)	Average pressure relief frequency
A	Once every 30 min*	Tilt 30° for 60 s	95	28.5	Once every 33 min
C	Once every 60 min	Tilt 30° for 120 s	19	7.5	Once every 59 min
F	Once every 120 min	Tilt 20° + Recline 120° for 120 s	20	2.5	Once every 171 min
G	Once every 30 min	Tilt 30° for 120 s	43	11	Once every 53 min

he/she might not be able to perform pressure relief immediately. Reminders were snoozed several times before participants performed pressure relief in the study. The snooze function provides a buffer period to allow the user to wrap up her/his current task temporarily before performing pressure relief. If reminders had really annoyed participants, we should have observed frequent use of the dismiss function. It is not clear whether the infrequent use of the dismiss function resulted from the participants wish to be reminded even though they were not available or they just ignored reminders. Although it seems that reminders do facilitate users to perform pressure relief and the subjects recognized the benefit of it, users' compliance could be affected by each individual's attitude toward a constant monitoring system and tolerance toward frequent reminders before starting using the VSC. Besides the appropriateness of the reminder protocol and quality of the interface, belief and attitude of the user toward the technology should be considered when evaluating the outcome of using a tailored monitoring and reminding system.

Because this is a pilot study to evaluate the VSC for further debugging, only 7 participants were recruited in the study. The information gathered in this study is used to refine the VSC and the future study protocol instead of concluding the effects of the VSC on its users.

CONCLUSION

This pilot study shows that a tailored reminding system is potentially beneficial to power wheelchair users who are at risks of developing pressure sores. However, several factors need to be considered when evaluating the effect of this VSC system. The VSC is being modified

according to the findings from this study to improve the acceptance of the participants/users. More information about how users interact with a tailored reminding system and its effects will be collected in future studies.

ACKNOWLEDGEMENTS

This research is supported by Quality of Life Technology Engineering Research Center (QoLT ERC) (EEC-0540865) and the VA Center of Excellence (B3142C). The contents of this paper do not represent the views of the Department of Veterans Affairs or the United States Government.

REFERENCE

- Bloemen-Vrencken, J., Witte, L. d., Post, M., & Heuvel, W. v. d. (2007). Health behaviour of persons with spinal cord injury. *Spinal Cord*, 45, 243-249.
- Chatterjee, S., & Price, A. (2009). Healthy Living with Persuasive Technologies: Framework, Issues, and Challenges. *Journal of the American Medical Informatics Association*, 16(2), 171-178.
- Cole-Lewis, H., & Kershaw, T. (2010). Text Messaging as a Tool for Behavior Change in Disease Prevention and Management. *Epidemiologic Reviews*, 32, 56-69.
- Giesbrecht, E., Ethans, K., & Staley, D. (2011). Measuring the effect of incremental angles of wheelchair tilt on interface pressure among individuals with spinal cord injury. *Spinal Cord*, 1-5.
- Jan, Y.-K., Brienza, D., Boninger, M., & Brenes, G. (2011). Comparison of skin perfusion response with alternating and constant pressures in people with spinal cord injury. *Spinal Cord*, 49, 136-141.
- King, R. B., Porter, S. L., & Vertiz, K. B. (2008). Preventive Skin Care Beliefs of People with Spinal Cord Injury. *Rehabilitation Nursing*, 33(4), 154-162.

- Liu, H.-y., Grindle, G., Chuang, F.-C., Kelleher, A., Cooper, R., Sieworek, D., . . . Cooper, R. A. (2011). User preferences for indicator and feedback modalities: A preliminary survey study for developing a coaching system to facilitate wheelchair power seat function usage. *Pervasive Computing, IEEE, in press.*
- Vaishampayan, A., Clark, F., Carlson, M., & Blanche, E. I. (2011). Preventing Pressure Ulcers in People with Spinal Cord Injury: Targeting Risky Life Circumstances through Community-Based Interventions. *Advances in Skin & Wound Care, 24(6), 275-284.*
- Yang, Y.-S., Chou, Y.-C., Hsu, J.-J., & Chang, J.-J. (2010). Effects of Audio Feedback on Sitting Behaviors of Community-Dwelling Manual Wheelchair Users With Spinal Cord Injuries. *Assistive Technology, 22(2), 79-86.*