Published in final edited form as:

J Appl Gerontol. 2017 August ; 36(8): 915–930. doi:10.1177/0733464815591211.

Older Adults' Perceptions of Fall Detection Devices

Shomir Chaudhuri¹, Laura Kneale¹, Thai Le¹, Elizabeth Phelan¹, Dori Rosenberg², Hilaire Thompson¹, George Demiris¹

¹University of Washington, Seattle, USA

²Group Health Research Institute, Seattle, WA, USA

Abstract

A third of adults over the age of 65 are estimated to fall at least once a year. Perhaps as dangerous as the fall itself is the time spent after a fall if the person is unable to move. Although there are many devices available to detect when a person has fallen, little is known about the opinions of older adults regarding these fall detection devices (FDDs). We conducted five focus groups with 27 older adults. Transcripts from sessions were coded to generate themes that captured participants' perceptions. Themes were identified that related to two topics of interest: (a) personal influences on the participants' desire to have a FDD, including perceived need, participant values, and cost, and (b) participant recommendations regarding specific features and functionalities of these devices such as automation, wearable versus non-wearable devices, and device customization. Together, these themes suggest ways in which FDDs may be improved so that they are suitable for their intended population.

Keywords

fall detection; focus groups; older adults

Introduction

A third of older adults are estimated to fall at least once annually (Centers for Disease Control and Prevention, 2014). Falls are the primary cause of fractures, loss of independence, and injury-related death among older adults (National Institute of Health, 2014). The time spent after a fall can be especially dangerous if one is unable to stand or move. The "long lie" occurs when a person involuntarily remains on the ground for longer than an hour following a fall and can result in several medical or emotional complications such as rhabdomyolysis, fear of falling, or even death (Mallinson & Green, 1985; Lord, Sherrington, & Menz, 2001). Among those experiencing the long lie, half die within 6

Corresponding Author: Shomir Chaudhuri, Department of Biomedical Informatics and Medical Education, School of Medicine, University of Washington, Campus Box 358047, 850 Republican St., Seattle, WA 98195-7240, USA. shomirc@uw.edu.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Supplementary Material

Supplementary materials are available on the Journal of Applied Gerontology website at <http://jag.sagepub.com/supplemental>.

months. It is essential to quickly identify and aid a person who has fallen to prevent further physical or emotional damage.

To address this matter current devices use various methods to detect when a person has fallen (Chaudhuri, Thompson, & Demiris, 2014; Noury et al., 2007; Ward, Holliday, Fielden, & Williams, 2012). Most commercial detectors involve a system where the fallen individual must manually push a button to call for help. More recent devices have the ability to trigger a call automatically ("Life Alert," 2014). Most academic research initiatives associated with fall detection devices (FDDs) use wearable automatic fall detectors in their studies (Bourke, O'Brien, & Lyons, 2007; Tamura, Yoshimura, Horiuchi, Higashi, & Fujimoto, 2000); however, environmental devices such as cameras or microphones have also been used (Auvinet, Multon, Saint-Arnaud, Rousseau, & Meunier, 2011; Belshaw, Taati, Giesbercht, & Mihailidis, 2011). The majority of research to date has focused on improving device accuracy. Fewer research studies examine user perceptions of FDDs. In one study using interviews, older adults felt that FDDs might give them a greater sense of security; however, they also believed that the devices were intrusive and did not feel as though they were in control of triggering an alert (Horton, 2008). In another study also using interviews, although 96% of participants felt favorably toward the system, only 48% indicated they would use the device (Londei et al., 2009).

Although valuable, these studies were limited to exploring individual opinions of these devices and were unable to identify group norms and cultural values as is possible using focus groups. Focus groups also allow for the discussion of potentially sensitive topics and for participants to compare their experience leading to a collective brainstorming of new ideas ("Qualitative Research Guidelines Project," 2006). The one study that used focus groups to explore older adults' opinions on FDDs (Brownsell & Hawley, 2004), only briefly touches on usability issues before focusing on a pilot study designed to see if these devices reduce fear of falling.

To add to the current knowledge in this area we conducted focus groups with older adults to more clearly understand their perceptions of current fall detection technologies and their willingness to use such devices. In this article, we present participants' perceptions of FDDs and specifically examine what factors affect their willingness to use these devices and what suggestions they have to improve this technology.

Method

Setting/Recruitment

We recruited a convenience sample of participants from independent and assisted living communities around the Puget Sound region. We conducted information sessions and posted fliers in the facilities to inform participants of the study. Inclusion criteria were above age 60 and living in one of the targeted communities. Exclusion criteria included unwillingness to be audio recorded, inability to provide informed consent, or inability to speak English. The University of Washington's Institutional Review Board approved this research (Human Subject's application number 43841).

We conducted five focus groups at three independent and assisted living communities from July to October 2013. Focus groups continued until information saturation was reached. In total, there were 27 participants (22 female, 5 male) who attended focus groups of various sizes (2, 3, 9, 3, 10). The communities were selected to provide a range of settings from lower to middle-upper socioeconomic status based on cost of living at the respective facilities. Twenty-one participants were classified as higher socioeconomic (monthly housing cost US \$2,875-US \$4,785) whereas six of the participants were classified as lower socioeconomic (monthly housing cost US \$406-US \$607).

Focus Groups

Each focus group lasted approximately an hour and loosely followed a script (Online Appendix 3). They began with a brief presentation explaining the purpose of FDDs and showing examples of both wearable and environmental devices. A semi-structured interview guide was then used to generate discussion around the participants' thoughts on a theoretical device. Finally, a tangible device was presented that participants could touch, test, and discuss followed by open discussion.

The prototype device (henceforth termed Device A) was donated for the study by a third-party company (Figure 1). This device is similar to past devices in size and the availability of central button to call for help. However, this device also has the ability to automatically detect falls as well as Global Positioning System (GPS) capabilities. It was used to facilitate a discussion of the pros and cons associated with this specific device and to clarify focus group participants' perceptions of an ideal FDD.

Coding

The focus group sessions were audio recorded and transcribed for thematic coding (Strauss & Corbin, 1998). Three researchers experienced with qualitative methods independently reviewed the transcripts and performed open coding to distinguish concepts related to the content. Coding was performed in Microsoft Word using the "comments" and "compare" features. Once coded, researchers met to reconcile codes and develop a master codebook, which was then used to recode the transcripts separately, after which the researchers met again to reconcile the codes. This process was used to code relevant segments of the transcript into various themes.

Results

We have organized identified themes into two separate meta-themes. The first meta-theme describes personal influences on the participants' desire to have such a device. The second describes recommendations given for specific features of these devices. Additional quotes for each of these themes are located in Online Appendices 1 and 2.

Personal Influences

Perceived need—Participants often told stories about past situations they had experienced, witnessed, or heard involving FDDs. These stories appeared to have a large influence on how the participants felt about such devices. Most stories involved either the

failure of these devices to activate when needed, or cases where the devices activated unnecessarily.

Several participants also acknowledged personally experiencing a previous fall that appeared to provide some motivation to use FDDs in the future. One participant saw the benefit in having a device especially when isolated, “I’m fortunate I wasn’t injured very much, but you know, I could imagine ... the last time I fell, I could have been there for quite a long time before anybody came along.”

Perceived isolation or helplessness during a previous or imagined fall event was often stated as important motivators to obtaining a FDD. Participants believed having an automated device would be especially useful in the event that the faller was unable to move or reach the button, “Well, because, a lot of people can’t press a button when they fall ... if it’s automatic it’s much, much better.”

However, several participants across the groups expressed a lack of need or interest in such devices. Some participants did not feel they were the right population for this device instead suggesting it for some of their peers. Participants also cited needing some sort of proof they were in danger of falling before using such a device, “I would probably have to have some kind of a fall related to balance; if it was related to carelessness then I still wouldn’t think I needed one because I would become more careful.”

Many participants expressed being near others or the availability of other options as reasons for not needing a fall detection system. For example, when asked whether a participant was afraid of falling without a device, she responded, “No because I’m here with [participant’s husband]. If I was on my own I would.” In one of the larger focus groups, all participants had access to a wearable manually activated fall detection system provided by their apartment community. However, when asked, no one acknowledged regularly using the device, prompting one participant to sum up her thoughts on how most people felt about these devices, “... we all think it won’t happen to me, until it does, and if people have a couple of falls then we will think about it. But until you do [fall] I don’t think there’s any way to persuade somebody.” Of course there were participants who saw some value in having such a device. As one participant stated, “I mean I think personally I think that every older person should have a fall detection device of some kind or another. I’m not the tiniest bit frail but I would like a fall detection device.”

Values—Most participants valued their independence and autonomy, wanting to avoid the stereotype of being old and a potentially stigmatizing device. Some participants agreed there was stigma associated with wearing the device, but did not think the stigma would affect the use of a FDD, “And the stigma too, probably of having something, ‘oh you’re wearing one of those’ ... I don’t think I’d be affected by stigma.” A common suggestion was to convince other people to wear the device to alleviate the stigma.

Stigma appeared to be closely related to independence, as participants saw having a FDD as an indication of a loss of independence. One participant summed up the overall feeling of being asked to use such devices,

We live in a world where it's, at our age wearing a hearing aid isn't the worst thing that ever happened to you. And of course a lot of people wear hearing aids and we don't even notice that they have them on. But anything that really goes beyond that kind of subtle thing, is very difficult unless you just had the living daylight scared out of you about your own well-being. Yeah, so the first time is the most important time and if you don't have that first time I think there's a lot of reluctance to use something, if its cane or you know ... a cane or hearing aid, hearing aids are so easy. Walker, any of those things, it's really, really hard because it's telling you that, pardon the expression, you're an old poop.

Cost—Another barrier to the adoption of these devices was the perceived initial and ongoing cost of a fall detection system. Many participants agreed that if the device were affordable, they would own one.

Participants across the focus groups, regardless of economic status, suggested having an existing health care payer, such as Medicare, pay for the cost of a FDD. One participant in a higher income focus group stated, "Ideally I think everybody should have ... access to such a device through social security say, or Medicare or, but that, if that's not realistic then I think health insurance plans in general should cover it."

Feature Assessment

Automation—Participants saw benefits to having a device that automatically called for help. This feature was especially seen to benefit helpless participants, "because someone may be unconscious or in a position where they can't get at it [the device]." Participants expressed concerns of false alarms caused by an automated response, and indicated needing the ability to turn off or cancel the device's call.

Call message, volume, usability, battery life—Feedback on FDDs focused on the basic functions associated with these devices, that is, volume, usability, and battery life. As an example many FDDs when triggered, first voice a message indicating its activity before placing a call. Along with desiring a shorter message, some participants complained about the volume of the message, "I can hardly hear and plus you have instructions to what? Hold for 7 seconds, if you're destroyed, you're scared, you are panicking, your arm ... I don't like it, sorry." Some participants indicated it may be helpful to have a way to control the volume especially if they were expected to wear the device around their neck or near their waist.

Another issue with Device A was the usability of the button. Participants in various sessions complained about the difficulty of pressing the button, which appeared to be adequate for a healthy individual but was viewed as being potentially problematic for some of the participants' incapacitated friends or relatives.

Participants were undecided on Device A's battery life but were concerned with having to charge the device. One suggestion was to have two devices so that one could sit on the charger while the other was in use, "... the customer has two of them. One is always here. The other is always on." A participant in a different group had a similar suggestion but instead suggested having two interchangeable batteries that could be charged separately.

Wearable versus environmental devices—Participants had several negative preconceptions of environmental devices. Several participants described environmental devices as, “too much like Big Brother,” claiming them to be invasive. Participants were also concerned with the range of environmental devices, whereas others seemed to view them as an unnecessary nuisance that would take more time to install.

Wearable devices were preferred as they allowed for participants to be monitored at all times. This was especially appealing to participants who enjoyed walking or participating in activities outside the facility. However, participants disliked current wearable devices claiming them to be ugly, cumbersome, or easy to forget.

Most participants agreed that having a wrist-based FDD would be the best option, “Because that’s very convenient to touch, you don’t have to grope for it and it’s quite available.” Watches, although always on the body, were also seen as out of the way and thus more apt to be worn in bed. One participant indicated that a wristwatch could always be worn no matter the clothing of the participant as opposed to a device that needed to be clipped on to a belt.

Alternative functions—Participants often suggested integrating FDD systems with alternative functionality to encourage their use. One of the suggestions involved having a FDD integrated within a cellphone, “It would be much easier if it were in combination with say our cellphones. Because if you already carry your cellphone, it’s gonna be kind of a pain to try to have make sure you’ve got two devices.” Other suggestions included a pedometer or an alarm to alert the individual of an appointment or to manage medications.

The most valued alternative function was a GPS function for tracking users during non-emergent situations. Participants wanted a device that they could use anywhere without restriction and stated the value of having the GPS ability in case you were to fall in an unknown area or were unable to communicate, “I would be concerned about is, what if you are unconscious and you can’t respond, how do they find you?” Participants found this feature to be especially useful for users prone to wandering. In general, there did not seem to be a concern for privacy when discussing GPS functionality. One participant discussed the expected trade-off on having this capability, “Seems to me, that ... in exchange for support, one compromises privacy.”

Customization—Many participants expressed a desire to be able to customize their FDD:

... it would be nice to have a range of devices that fit your situation ... Then it would [be] what I need, and not put on a lot of extra stuff that’s gonna cost me more, cause you know I think it’s essential to keep it within reasonable price range where you can afford it if you need. But if you don’t need it you don’t have to take it.

Customization was discussed for several aspects of the device including deciding who the device would call in the event of a fall and GPS. When discussing GPS, participants wanted to choose exactly when the feature would be active seeing advantages to having a constantly active GPS for someone who tended to wander but also seeing value in having the GPS

feature only activate in the event of a fall thus preserving battery life, and offering more privacy.

Participants also debated who the device should call in the event of a fall with possible contacts being a central call center, 911, or even a friend or family member. The preference of the notification was greatly influenced by the individual's personal life and previous experiences. In one group, participants agreed that there might need to be a tiered cascade of calls made to different individuals/entities.

Fall detection versus fall prevention—Many participants were more interested in devices designed to prevent a fall. Some participants wanted a device that would warn you when you were about to fall instead of working only after a fall, “And the thing I would like better than that is something that detected when I was going to fall that would say ‘Balance up’.”

Discussion

Our focus group study enriches current understanding of older adults' perceptions of FDDs. From the focus group discussions, we found that participants' desire for such a device was often related to the device's effect on participant independence as well as the cost associated with the device. We also found that most participants preferred a device that could automatically detect falls, keep track of their location, and be worn on their wrist. In this section, we make suggestions on how best to incorporate these devices into the lives of older adults and also provide a set of recommendations for characteristics of an idealized FDD as informed from our focus group discussions.

Personal Considerations

In general, participants throughout the focus groups saw some benefit in having a FDD especially given the right situation. However, many participants were unimpressed by current variations of FDDs. As an example, there were negative preconceptions focusing on environmental devices; people were concerned about the expense of these devices as well as the “Big Brother” aspect. Although concerning, past studies have shown that a certain amount of intrusiveness is acceptable as long as the perceived need ameliorates privacy concerns (Demiris, Oliver, Giger, Skubic, & Rantz, 2009; Wild, Boise, Lundell, & Foucek, 2008). Along with providing some assurance of privacy, researchers in this area need to improve the utility of these devices to make them acceptable for older adults.

More generally, several participants did not feel the need for such a device, believing they were targeted for some other person older than themselves (Aminzadeh & Edwards, 1998; Calhoun et al., 2011; Copolillo, Collins, Randall, & Cash, 2001). The great challenge in this arena will be to convince at-risk individuals that FDDs will increase their independence and will be most useful before one ever experiences a fall. Confronting such a challenge will require a significant cultural shift in how these devices are introduced, advertised, and sold to older adults. Rather than portraying the target of these devices as a feeble old woman who has fallen and is unable to get back up, it may be more beneficial to advertise older adults being able to enjoy their independence more with the safety and security of a FDD (Butler,

1989; Nelson, 2004). Advertisements featuring older adults using these devices as they go on walks, hikes, or even grocery shopping could help to change the image that these devices are meant only for people unable to maintain their own independence. It may also be useful to advertise these devices to people of all ages performing activities in which falling or becoming lost is also dangerous, for example, skiing, hiking. In addition, it could be beneficial to first market individualized devices directly to older adults before attempting to sell them to their children or concerned relatives. Doing this will give the intended users of the device a greater sense of control over their own health, encouraging them to use the device more consistently and possibly increase their overall independence and well-being (Mallers, Claver, & Lares, 2014).

Finally, the cost of these devices will need to be greatly reduced or covered by a form of health insurance. The United States spends around US\$20 billion a year on medical care for older adults who have fallen, a number predicted to rise to around 43.8 billion by the year 2020 (Bohl, Phelan, Fishman, & Harris, 2012; Stevens, Corso, Finkelstein, & Miller, 2006). Investing in measures such as FDDs that could prevent further injury would be a way to reduce these costs. Such changes will take time, but are necessary to convince older adults at risk of falling that wearing such a device is beneficial to their well-being.

Device Recommendations

According to our analysis, the ideal FDD is a wearable device located on the wrist of the participant. This finding points to a gap in current FDD research, as to date, there have been few studies involving wrist-worn FDDs (Kangas, Konttila, Lindgren, Winblad, & Jämsä, 2008; Kangas, Konttila, Winblad, & Jämsä, 2007; Mathie, Coster, Lovell, & Celler, 2004; Nocua, Noury, Gehin, Dittmar, & McAdams, 2009). Admittedly, there are increased technical complications with making automatic wrist-worn FDDs due to the constant motion of the arm and the greater distance the wrist is from the person's center of mass. However, our participants felt that a wrist-worn device would ensure that the user could easily wear it, locate it during a fall event, and fit into daily social norms better than existing devices worn around the neck or on the waist.

The ideal device would have the ability to call for help both automatically and with the push of a button. Although most participants found significant value in automatic detection during times when the individual is unable to press the button, participants also wanted to preserve the manual function to increase accessibility of help. However, as discussed above, alerts must be able to be canceled easily to reduce the potential negative consequences of false alarms. Whereas this system should be primarily designed to detect when a person falls, a system that also predicts falls before they happen would be ideal per participant comments. Some systems could combine a fall detector with other tools designed to predict falls by detecting changes in gait over time or even designed to prevent participants from falling or being injured during a fall (Kiselev, Haesner, Gövercin, & Steinhagen-Thiessen, 2015; Staranowicz, Brown, & Mariottini, 2013; "Swedes Develop Invisible Bike Helmet," 2013.)

The ideal device would have GPS capabilities and provide the user with the ability to customize when the GPS function was active. Similarly, this device would also allow the user to have a customized order of notifications in the event of a fall. This device would also

have alternative functions aside from fall detection, which could be added and removed on a case by case basis, including the ability to make phone calls or track the amount of steps the user had taken. One consideration that was mentioned in the focus groups is manufacturers will need to develop rules for allowing end user customization enabling customers to pick and choose their desired features on a case to case basis. Although devices do exist with automatic fall detection capabilities, GPS, or the ability to be worn as a wristwatch, it is difficult to find such a device that has all the features combined (“Medical Alert Systems Comparison,” 2014). This could be a great challenge given the issues with automatically detecting a fall through a wristwatch and the battery constraints presented with the GPS feature. It is also unclear how much end user customization is available for these devices.

This work was limited by selecting a convenience sample of participants residing in the Puget Sound area. Perceptions on FDDs may differ in other regions of the world. Demographic data were not collected directly from the participants making it difficult to understand the exact age group of this sample and compare it with other older adults. Fortunately, two of the three facilities used as recruitment settings required residents to be 65 years or older, and the median age at these facilities is 70 and above increasing our confidence that they are appropriate end users. We also did not identify participants based on their living status (assisted vs. independent) because these facilities provide housing that can move along the continuum from independent to assistive living with individuals staying in same location. Even if we had gathered this information from participants it would be difficult to accurately classify them into these categories. In addition, focus group participants were only able to touch and test a single wearable FDD during the sessions, which may have produced some bias; had there been different kinds of devices physically available to the participants, their opinions might have varied. This concern was minimal as Device A was similar to many other off-the-shelf fall detection products. Future studies should attempt not only to compare different types of devices but to also reach a more socially diverse and geographically varied population of older adults.

Even with these limitations, this study’s sample size was adequate to identify themes and involved participants of varying socioeconomic status and varying living situations. Several findings echoed those of previous studies, which lends increased confidence in our new findings. Most of the participants had either personally experienced a fall or were close to someone who had. Their thoughts and opinions provide meaningful direction that can greatly improve the usability and usefulness of FDDs.

Conclusion

Falls represent a significant threat to the health and independence of the elderly. Existing devices designed to detect when a person has fallen are often poorly designed for older adults and thus, under-utilized. In this study, we used the results of focus groups with older adults to describe characteristics of an ideal FDD. These suggestions provide direction for the design of FDDs in the hopes of increasing appeal and thereby improving use of such devices in the future.

Acknowledgments

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the National Library of Medicine Biomedical and Health Informatics Training Grant Program (Grant T15LM007442).

Author Biographies

Shomir Chaudhuri, PhD received his PhD degree in Biomedical and Health Informatics from the School of Medicine at the University of Washington. During his graduate studies he was a National Library of Medicine predoctoral trainee and his research focused on understanding the usability of fall detection devices with older adults.

Laura Kneale is a National Library of Medicine predoctoral fellow at the University of Washington. Her primary research interest is studying how technology can aid older adult with home care activities.

Thai Le, PhD received his PhD degree in Biomedical and Health Informatics from the School of Medicine at the University of Washington. During his graduate studies he was a National Library of Medicine predoctoral trainee and his research focused on developing visualization solutions for older adults.

Elizabeth A. Phelan, MD, MS, is Associate Professor of Medicine and Adjunct Associate Professor of Health Services at the University of Washington and Affiliate Investigator at the Group Health Research Institute. She is the founding director of the Fall Prevention Clinic at Harborview Medical Center, in continuous operation since 2005. She is a clinically active, fellowship-trained geriatrician who practices in both inpatient and outpatient settings and trains health sciences students in the care of the older adult.

Dori Rosenberg, PhD, MPH is a physical activity researcher at the Group Health Research Institute and is an affiliate researcher with the University of Washington Health Promotion Research Center. She focuses on physical activity promotion and sedentary behavior reduction among older adults in order to prevent, control, and treat chronic health conditions.

Hilaire Thompson is Associate Professor and Vice Chair for Education in Biobehavioral Nursing and Health Systems at the University of Washington, Seattle. She is a core faculty member at the Harborview Injury Prevention and Research Center. Her work focused on geriatric injury prevention and mitigation.

George Demiris is the Alumni Endowed Professor of Nursing, Professor of Biomedical and Health Informatics and Vice Chair for Informatics Education at the University of Washington. His research focuses on the use of technologies to support older adults and their families in home and hospice care.

References

- Aminzadeh F, & Edwards N (1998). Exploring seniors' views on the use of assistive devices in fall prevention. *Public Health Nursing* (Boston, Mass.), 15, 297–304.
- Auvinet E, Multon F, Saint-Arnaud A, Rousseau J, & Meunier J (2011). Fall detection with multiple cameras: An occlusion-resistant method based on 3-D silhouette vertical distribution. *IEEE Transactions of Information Technology in Biomedicine*, 15(2), 290–300. doi:10.1109/TITB.2010.2087385
- Belshaw M, Taati B, Giesbercht D, & Mihailidis A (2011, June). Intelligent vision-based fall detection system: Preliminary results from a real world deployment. Presented at the RESNA/ICTA 2011: Advancing Rehabilitation Technologies for an Aging Society in Toronto, Canada.
- Bohl AA, Phelan EA, Fishman PA, & Harris JR (2012). How are the costs of care for medical falls distributed? The costs of medical falls by component of cost, timing, and injury severity. *The Gerontologist*, 52, 664–675. doi:10.1093/geront/gnr151 [PubMed: 22403161]
- Bourke AK, O'Brien JV, & Lyons GM (2007). Evaluation of a threshold-based tri-axial accelerometer fall detection algorithm. *Gait & Posture*, 26, 194–199. doi:10.1016/j.gaitpost.2006.09.012 [PubMed: 17101272]
- Brownsell S, & Hawley M (2004). Fall detectors: Do they work or reduce the fear of falling? *Housing, Care and Support*, 7(1), 18–24.
- Butler RN (1989). Dispelling ageism: The cross-cutting intervention. *Annals of the American Academy of Political and Social Science*, 503, 138–147.
- Calhoun R, Meischke H, Hammerback K, Bohl A, Poe P, Williams B, & Phelan EA (2011). Older adults' perceptions of clinical fall prevention programs: A qualitative study. *Journal of Aging Research*, 2011, e867341. doi:10.4061/2011/867341
- Centers for Disease Control and Prevention. (2014). Falls among older adults: An overview. Retrieved from <http://www.cdc.gov/homeandrecationalsafety/falls/adultfalls.html>
- Chaudhuri S, Thompson H, & Demiris G (2014). Fall detection devices and their use with older adults: A systematic review. *Journal of Geriatric Physical Therapy*, 37(4), 178–196. doi: 10.1519/JPT.0b013e3182abe779. [PubMed: 24406708]
- Copolillo A, Collins C, Randall NR, & Cash SH (2001). The impact of experience and heuristics on everyday decisions to use mobility devices: The need for control in nine African-American older adults. *Physical & Occupational Therapy in Geriatrics*, 20, 57–74. doi:10.1080/J148v20n02_04
- Demiris G, Oliver DP, Giger J, Skubic M, & Rantz M (2009). Older adults' privacy considerations for vision based recognition methods of eldercare applications. *Technology and Health Care*, 17(1), 41–48. doi:10.3233/THC-2009-0530 [PubMed: 19478404]
- Horton K (2008). Falls in older people: The place of telemonitoring in rehabilitation. *Journal of Rehabilitation Research & Development*, 45, 1183–1194. [PubMed: 19235119]
- Kangas M, Konttila A, Lindgren P, Winblad I, & Jämsä T (2008). Comparison of low-complexity fall detection algorithms for body attached accelerometers. *Gait & Posture*, 28, 285–291. doi:10.1016/j.gaitpost.2008.01.003 [PubMed: 18294851]
- Kangas M, Konttila A, Winblad I, & Jämsä T (2007, August). Determination of simple thresholds for accelerometry-based parameters for fall detection. Presented at the Engineering in Medicine and Biology Society, 2007—Proceedings from the 29th Annual International Conference of the IEEE. doi:10.1109/IEMBS.2007.4352552
- Kiselev J, Haesner M, Gövercin M, & Steinhagen-Thiessen E (2015). Implementation of a home-based interactive training system for fall prevention: Requirements and challenges. *Journal of Gerontological Nursing*, 41(1), 14–19. doi:10.3928/00989134-20141201-01
- Life Alert. (2014). Available from <http://www.lifealert.com/>
- Londei ST, Rousseau J, Ducharme F, St-Arnaud A, Meunier J, Saint-Arnaud J, & Giroux F (2009). An intelligent videomonitoring system for fall detection at home: Perceptions of elderly people. *Journal of Telemedicine and Telecare*, 15, 383–390. doi:10.1258/jtt.2009.090107 [PubMed: 19948704]
- Lord SR, Sherrington C, & Menz HB (2001). Falls in older people: Risk factors and strategies for prevention. Cambridge, UK: Cambridge University Press.

- Mallers MH, Claver M, & Lares LA (2014). Perceived control in the lives of older adults: The influence of Langer and Rodin's work on gerontological theory, policy, and practice. *The Gerontologist*, 54, 67–74. doi:10.1093/geront/gnt051 [PubMed: 23723436]
- Mallinson WJ, & Green MF (1985). Covert muscle injury in aged patients admitted to hospital following falls. *Age and Ageing*, 14, 174–178. [PubMed: 4013905]
- Mathie MJ, Coster ACF, Lovell NH, & Celler BG (2004). Accelerometry: Providing an integrated, practical method for long-term, ambulatory monitoring of human movement. *Physiological Measurement*, 25(2), R1–R20. [PubMed: 15132305]
- Medical Alert Systems Comparison. (2014). Consumer Reports News. Retrieved from <http://www.consumerreports.org/cro/2014/06/what-to-look-for-in-a-medical-alert-system/index.htm>
- Nelson TD (2004). *Ageism: Stereotyping and prejudice against older persons*. Cambridge, MA: MIT Press.
- National Institute of Health SeniorHealth. (2014). Falls and older adults—About falls. Retrieved from <http://nihseniorhealth.gov/falls/aboutfalls/01.html>
- Nocua R, Noury N, Gehin C, Dittmar A, & McAdams E (2009, September). Evaluation of the autonomic nervous system for fall detection. Presented at the Engineering in Medicine and Biology Society, 2009—Proceedings from the 31st Annual International Conference of the IEEE. doi:10.1109/IEMBS.2009.5333165
- Noury N, Fleury A, Rumeau P, Bourke AK, Laighin GO, Rialle V, & Lundy JE (2007, August). Fall detection—Principles and methods. Presented at the Engineering in Medicine and Biology Society, 2007—Proceedings from the 29th Annual International Conference of the IEEE. doi:10.1109/IEMBS.2007.4352627
- Qualitative Research Guidelines Project (2006). Available from <http://www.qualres.org/>
- Staranowicz A, Brown GR, & Mariottini G-L (2013). Evaluating the accuracy of a mobile kinect-based gait-monitoring system for fall prediction. In *Proceedings of the 6th International Conference on Pervasive Technologies Related to Assistive Environments* New York, NY. doi:10.1145/2504335.2504396
- Stevens JA, Corso PS, Finkelstein EA, & Miller TR (2006). The costs of fatal and non-fatal falls among older adults. *Injury Prevention*, 12, 290–295. doi:10.1136/ip.2005.011015 [PubMed: 17018668]
- Strauss A, & Corbin J (1998). *Basics of qualitative research: Grounded theory procedures and techniques* (Vol. 2). Thousand Oaks, CA: SAGE.
- Swedes Develop Invisible Bike Helmet. (2013). Retrieved from http://jalopnik.com/swedes-develop-invisible-bike-helmet-1460189477?utm_campaign=socialflow_jalopnik_facebook&utm_source=jalopnik_facebook&utm_medium=socialflow
- Tamura T, Yoshimura T, Horiuchi F, Higashi Y, & Fujimoto T (2000, July). An ambulatory fall monitor for the elderly. Presented at the Engineering in Medicine and Biology Society, 2000—Proceedings of the 22nd Annual International Conference of the IEEE. doi:10.1109/IEMBS.2000.901393
- Ward G, Holliday N, Fielden S, & Williams S (2012). Fall detectors: A review of the literature. *Journal of Assistive Technologies*, 6, 202–215.
- Wild K, Boise L, Lundell J, & Foucek A (2008). Unobtrusive in-home monitoring of cognitive and physical health: Reactions and perceptions of older adults. *Journal of Applied Gerontology*, 27, 181–200. doi:10.1177/0733464807311435 [PubMed: 19165352]

Figure 1.
Device A resting on a charger.