Elderly Fall Prevention: a cadence walker with alarm system

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Introduction

Falls are the leading cause of injury and death for older adults. In fact, falls are five times more likely to bring elderly people to the hospital than any other condition. These falls can occur in a number of ways, but one of the most common causes is when an older adult who requires a walking aid forgets his or her aid when walking. One out of three adults over 65 years old experiences a fall annually, with 25% of the incidents resulting in moderate to severe injuries. The risk of a fall due to forgetting walking aids increases in elderly who also suffer from some form of dementia, which affects more than 60% of the elderly population over the age of 85 [1]. Economic impact of these falls is estimated at $237 million annually in Wisconsin, and near $20 billion annually in the United States [2].

Due to the demand of the above market, a device was created in aims to help prevent falls from occurring. The device utilizes a microcontroller and Bluetooth technologies to both record walker usage through a speedometer and to alarm the user when they have moved an unsafe distance from the walker. The alarm alerts the user immediately, reminding them to practice safe walking habits by detecting the distance between the device and a clip-on receiver worn on the user. This alert function of the device informs not only walker users but also their care providers to enhance fall prevention. In addition, usage data including distance, average speed, and time used can be acquired from the microcontroller to assess the daily health of the patient and encourage walking related health changes. The device with its two-folded functions, is depicted in Figure 1.

Methods

Data Acquisition Testing

The walker moved a set distance with the speedometer activated. The time to move this set distance was also tracked and recorded for each trial. The manual data logged was used to compare to the data recorded by the microcontroller. Accuracy testing of distance measured were repeated for 12 trials at a 10 ft. distance. Testing of speed was repeated in 40 trials at a set 13 ft. distance

Alarm System Testing

The alarm portion of the device was measured by what distance apart between the transmitter and receiver would trigger the alarm to sound. The transmitter was attached on the plastic side of the walker stationary, and the distance toward the receiver was measured. The receiver was gradually moved away from the transmitter until the alarm sounded for 10 trials.

Human Test Subjects

Three human test subjects used the walker for two nonconsecutive days. On the first day each subject used the walker with only the data acquisition portion of the device activated. On the second day the alarm was attached and activated, with the data acquisition portion of the device still turned on. Each test subject had the walker and device in their position for 6-8 hours total on each day. The usage of the walker was conducted in each test subjects own home or apartment. The device and the walker were collected from the test subject at the end of each day's testing to avoid any none testing use or acclimation to the walker.

All three test subjects were 21 years of age. Two subjects were female and the one was male. All subjects were healthy individuals that did not require the use of any kind of walking aid to avoid existing acclimation to daily use of a walking aid.

Results

The resulting differences between the device recorded and manually recorded distance and speed are shown in Figures 2 and 3 respectively. The distance comparison was the most accurate. The average difference between the device and manual recording was 2.2 in. with a standard deviation of less than an inch. This standard deviation is less than 1% of the total 10 ft. distance, indicating the difference is reliable. The distance trials were conducted at a constant 10 feet, meaning that 5% accuracy is within plus or minus 6 in. The average 2.2 difference is well within the 5% accuracy mark, suggesting that distance measurement is reliable and fits the design specifications. The speed comparison had an average difference between the device and manual recording of 0.156 ft/s and a 0.13 ft/s standard deviation. The speed trials used a set 13 ft distance and averaged manually recorded speed at 1.50 ft/s, making 5% accuracy equal to 0.07 ft/s. The resulting average difference was higher than double of this accuracy value, as was the standard deviation. However, this difference is actually less significant, and therefore more reliable, than it appears due to the effect of human error during accuracy testing. The manually recorded speed was dependent on manual time recordings, which are based on the nature of human reaction time. Therefore, it is reasonable to assume that a large portion of the speed inaccuracy is due to human error, and we can solidly assume that the device is within the 5% specification for speed as well.

Individually, all three test subjects increased their total distance and time usage on day 2 when the alarm system was activated from their day 1 usages as seen in Figure 4. More specifically, subject 1 had a 328 second time increase and 191.8 ft. distance increase, subject 2 had a 73.5 second time increase and 37.9 ft. distance increase, and subject 3 had a 160 second time increase and 104.2 ft. distance increase. This averaged to a 187 second time increase with a 129 sec. standard deviation and a 104.2 ft. distance increase with a standard deviation of 79.1 ft.

The resulting measured distance of the alarm is shown in table 1. The average distance which triggered the alarm was 4.4 ft, with a standard deviation of 0.5 ft.

Discussion

The data acquisition portion of the device is meant to help doctors and other health care professionals evaluate patient health on a regular basis. Fall risk can increase by walking too fast or by not walking enough on a daily basis. The device allows the monitoring of these daily walking levels, thereby enabling health care professionals to encourage safer walking habits by the walker user. Because the information recorded by the device is going to be used in this diagnostic context, it is important that the information is accurate within at least 5% of the daily totals for distance and speed.

The advantage of using test subjects that did not require usage of any kind of walking aid is that a person who does not need to use the walker is most likely to forget about using it. A student's t-test was used to evaluate the significance of the increased walker usage seen on day 2 of human subject testing. The test resulted in t-values of 1.32 and 1.27 for distance and time respectively. The degree of freedom for the t-test is 4 due to the three test subjects and two different days of testing for each. The t-values for a 4 degree test are higher than the 0.15 α-value. This means that there is a less than 0.15 probability that these differences are due to chance. Due to the fact that the test subjects are not the population meant for this device, these results are promising. Upon IRB approval for testing on elderly adults, we hope to be able to report a t-value greater than the 0.05 α-value to show that the alarm system is making a significant and valid difference.

The device received an enthusiastic response when demonstrated to a variety of staff at an assisted living facility focused on caring for elderly adults with cognitive impairments. With the help of the facility and an approved IRB the device could later be used to test its effectiveness at increasing elderly adult usage, especially in those suffering from cognitive impairments, making them more likely to forget their walker. Additionally, the device should be tested as a conditioning tool for these types of elderly walker users. A variety of designs other than the current panda transmitter could make the device more personal and recognizable. This will help the user to remember their device and potentially enhance usage as well. We discussed with the facility staff the benefits of replacing the beeping of the alarm with a personalized voice. This would involve having the alarm recorded by someone close to the walker user and include the use of his or her name in the alarm. This will help the users respond more thoroughly to the alarm rather than ignoring it as one of the many alarms going off on a daily basis in these types of facility settings.

Helping prevent falls suffered by the elderly is an important issue to address. This device has great potential to help elderly walker user to use their walking aid more often via the alarm system and in a safer way via the data acquisition system.

Acknowledgement

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Reference

[1] Anderson, L. (2011). *Dementias and Their Impact on America*. Retrieved on October 23, 2012, from http://health.burgess.house.gov/blog/?postid=240727

[2] Centers for Disease Control and Prevention (2012). *Cost of fall among Older Adults.* Retrieved on October 23, 2012, from http://www.cdc.gov/homeandrecreationalsafety/falls/fallcost.html

Graphics

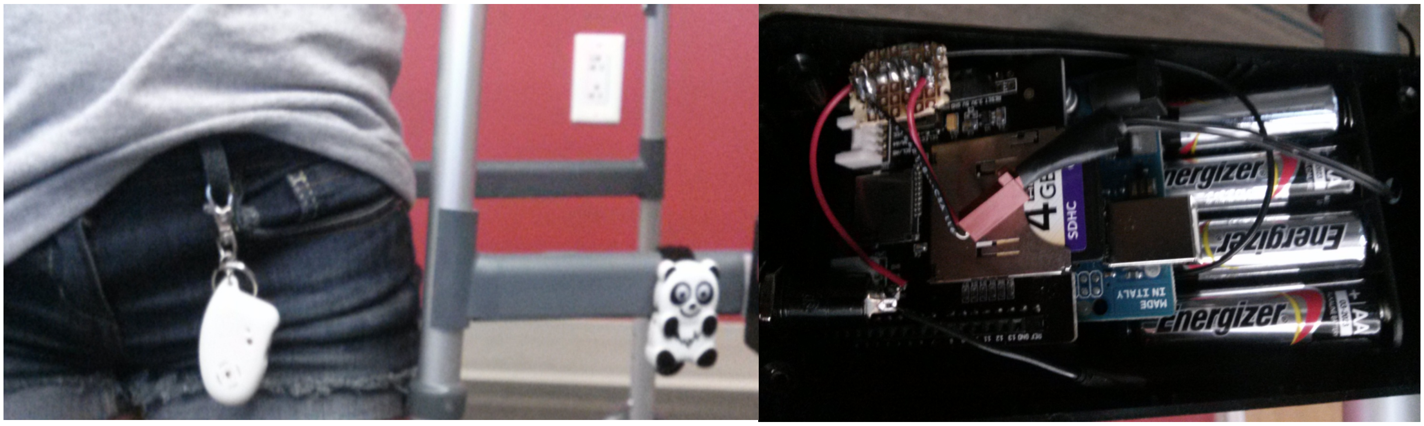

Figure 1. The device with the alert function (left). Receiver was worn by user and transmitter attached to the walker. Certain distance apart from the receiver and transmitter triggered the alarm. The data acquisition portion of the device (bottom), composed of a microcontroller, SD card storage device, and power supply.

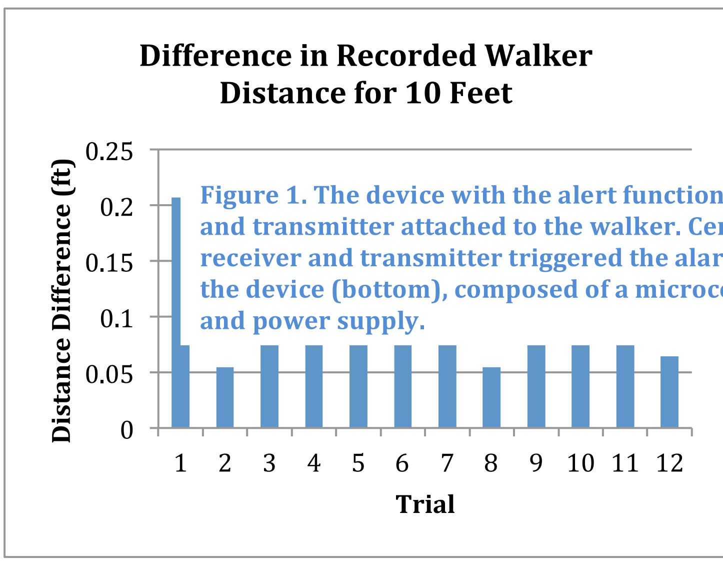

Figure 2. Difference in distance between the device and manual recordings

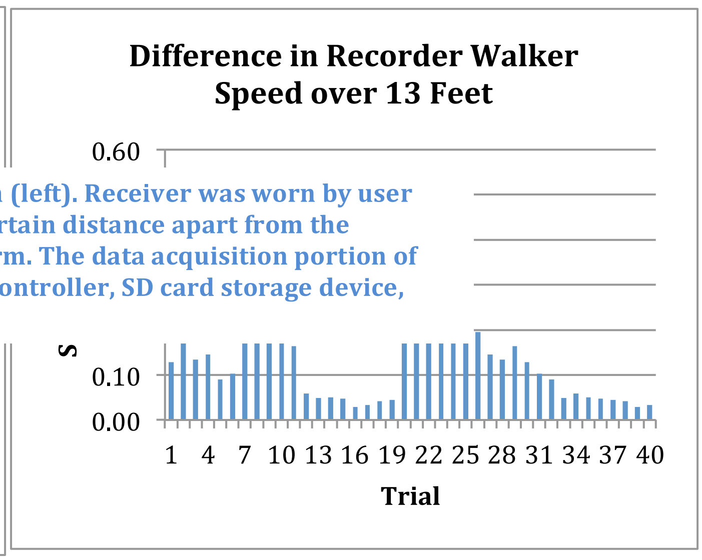

Figure 3. Difference in speed between the device and manual recordings

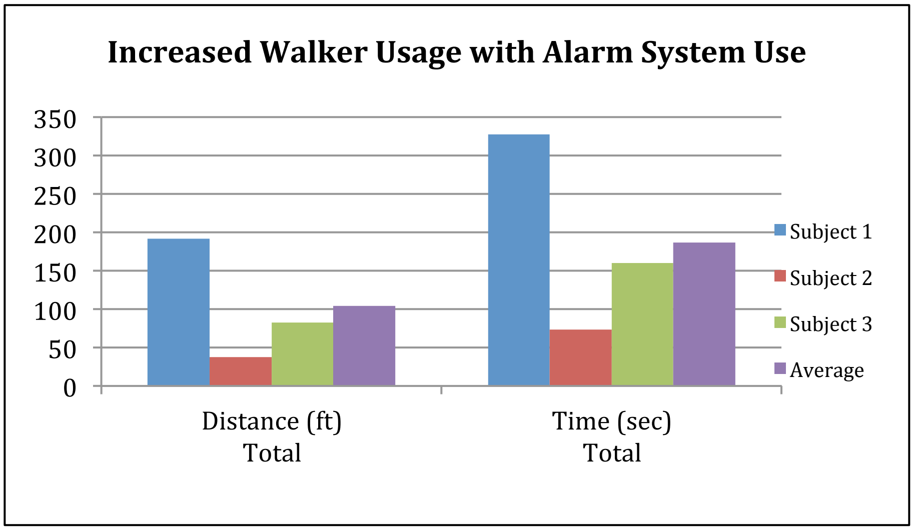

Figure 4. Difference between day one (baseline) and day two (alarm system) total usage in time and distance. Each subject saw an increase in both usages with the alarm system.

Trial	Alarm Distance (ft)
1	4.33
2	4.08
3	5.29
4	3.62
5	4.96
6	3.92
7	4.71
8	4.25
9	4.25
10	4.58
ave	4.40
stdev	0.50

Table 1. Distance measurement when alarm was triggered. Determinant whether the alarm itself is consistent and reliable.