The Usability of a Smartphone-Based Fall Risk Health Application for Adult Wheelchair Users

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BACKGROUND

- Falls are a common and detrimental health concern for individuals who use wheeled mobility devices.
  - Upwards of 75% of this population fall at least once a year.[1–4]
  - ~50% of reported falls are injurious.[3]
- Poor seated balance is an important predictor of falls in individuals who use wheeled mobility devices[4], but such assessments are limited to the clinical setting.
  - Self-monitoring of seated balance and fall risk is needed.
- A home-based, self-administered tool to measure fall risk could provide frequent access to fall risk information.
- One approach that has shown promise in older adults and people with multiple sclerosis is the use of mobile health applications.[5, 6]
  - Ensuring that this tool is easy to use and provides intuitive fall risk score reporting are necessary precursors to its future use in health behavior interventions.[7]

PURPOSE

To determine the usability of a custom-designed fall risk mobile health application, Steady-Wheels™, and identify key technology development insights for aging adults who use wheeled mobility devices.

METHODS

Underlying App Design Considerations

- *Cognitive overload* - Provided one set of written instructions with a large representative graphic immediately preceding each task.
- *Dexterity* - Selection options were made large and typed responses were avoided.
- *Sensory function* - Used black text (size 14) on a white background[8] and provided audio lead cues with simultaneous vibrations.

Components of the Steady-Wheels™ App

- Contains a total of 14 slides and takes ~10 minutes to complete.
- Assessment consists of two main components:
  - *Patient-reported Outcome Section* - 12-item health history questionnaire
  - *Performance Test Section* - Leads participants through a series of three, 30-second, balance tasks (Figure 1).
    - After pressing "Let's Start", an audio and vibratory count-down from five, leading to the word "start", which cued the start of the test, and the completion of the test was auditorily cued with the word "stop".

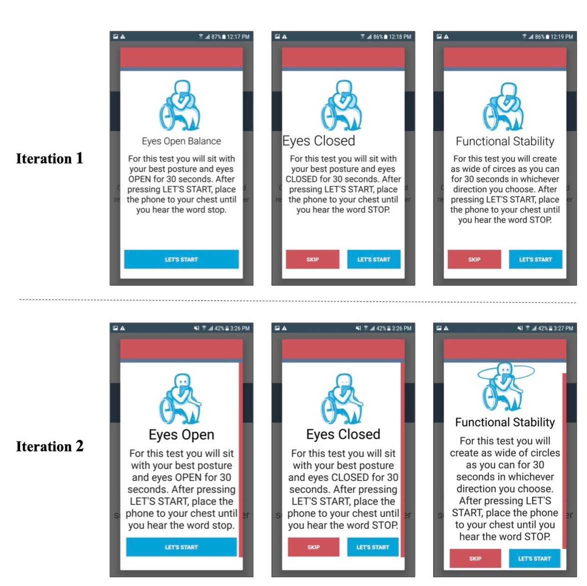

Figure 1. Illustrates modifications made to the onscreen balance task instructions from the first to the second iteration.

Experimental Session

- Two rounds (n=5/round) of usability testing utilizing an iterative design-evaluation process were performed.[9]
- The app's usability was determined through a think-aloud activity while completing the app, follow-up semi-structured interviews, and the completion of the Systematic Usability Scale (SUS). Participants then ranked fall-risk score results options from most to least favorite (Figure 2).
  - Video recordings from the think-aloud activity and interviews were transcribed verbatim.
  - Codes were identified within transcriptions to create themes using the software MAXQDA (Version 12.3.3, Berlin, Germany).
  - Average SUS scores were calculated for each round.

RESULTS

- Participant demographic information including is provided in Table 1.

Table 1. Participant demographic information. Values are reported as mean ± standard deviation.

	First Iteration *(n=5)*	Second Iteration *(n=5)*
Age (years)	59.0±12.2	58.0±13.1
Gender, n (%)		
Males	3 (60)	2 (40)
Females	2 (40)	3 (60)
Smartphone Usage, n (%)	5 (100)	5 (100)
Years Using Mobility Device	25.8±20.3	25±27.4
Primary Mobility Device, n (%)		
Power Chair	4 (80)	2 (40)
Manual Chair	1 (20)	--
Scooter	--	3 (60)
Reason for Wheeled Mobility, n (%)		
Multiple Sclerosis	2 (40)	4 (80)
Paraplegia/quadriplegia	2 (40)	1 (20)
Stroke	1 (20)	--
History of Falls (≥1 falls/year), n (%)	1 (20)	2 (40)
Self-report Fear of Falling, n (%)	5 (100)	5 (100)
Level of Education, n (%)		
High school graduate/GED	--	1 (20)
Some or in-progress college/Associate degree	2 (40)	--
Bachelor's degree	--	1 (20)
Master's degree	3 (60)	2 (40)
Doctoral degree	--	1 (20)

- Overall, participants found the app straightforward, easy to use, supportive of individual preferences, allowed for easy recovery from errors, and appreciated the simple and objective, fall-risk score.

Iteration 1

- The first round of usability testing yielded two themes: *Ease of use & Flexibility of design.*
- SUS scores ranged from 72.5 to 97.5 and averaged 84.5±11.4, indicating 'excellent' usability.[10]
- Primary modifications:
  - increased size of text and radio buttons for multiple-choice responses,
  - improvements to on-screen directions and graphics (Figure 1), and
  - additional response options to demographic questions.
- Strongly favored result option C (Figure 2), due to its color scheme, large fall risk number, brief description indicating fall risk level, and the horizontal layout. Some critiques included where the low, medium, and high cut-offs were located on the sliding scale and that the lower fall risk should be represented by a lower number.

Iteration 2

- The second round of usability testing yielded two themes: *Application layout & Clarity of instruction.*
- SUS scores ranged from 87.5 to 97.5 and averaged 91.9±4.3, indicating 'best imaginable' usability.[10]
- Primary modifications moving forward:
  - further synthesis of instructions or inclusion of more visual aids.
- Strongly favored result option E (Figure 2); stating that it's a "*real obvious one*", and complimenting its representation of low, medium, and high risk. Many related it to their preexisting understanding of a speedometer.

Figure 2. Illustrates modifications made to the result screen options (A-E) from the first to the second iteration.

DISCUSSION

- Steady-Wheels was able to achieve a SUS score of 91.9±4.3, which is particularly noteworthy as *(general)* technology has an average SUS score of 60.[11]
  - Consumers will likely promote a product if it achieves a SUS score of 81 or greater.[10]
    - Steady-Wheels may not only be adopted on a personal level but is likely to be recommended to others at an equal or greater rate as other forms of technology.
- This successful development was made possible through 1) participant feedback, 2) insights from previously developed health apps[5,6, 12], and 3) the understanding of usability heuristics for interface design, such as:
  - visibility of the system,
  - recognition rather than recall,
  - aesthetic and minimalist design,
  - error prevention, and
  - a match between the system and real-world.[13]
- Intuitive fall risk reporting was achieved through the presentation of a single number located on a color-coordinated continuum with low, medium, and high fall risk delineations.

CONCLUSION

The mobile health app, Steady-Wheels, has excellent usability and the potential to provide adults who use wheeled mobility devices with an easy-to-use, remote fall risk assessment tool. Characteristics that promoted such usability were guided navigation, large text and radio buttons, clear and brief instructions accompanied by representative illustrations, and simple error recovery. Intuitive fall risk reporting was achieved through the presentation of a single number located on a color-coordinated continuum with low, medium, and high-risk delineations.

FUTURE DIRECTIONS

- The validity and reliability of the app's fall risk score need to be determined.
- Providing follow-up preventative information may increase the app's usefulness and encourage further engagement.[12]
  - Personalized messaging is an easy and effective strategy in altering patient behavior[14] and could be a feasible way to share such information.

LIMITATIONS

- Nine of the ten participants had received some form of higher education, which may have provided them with more experience engaging with and a better understanding of technology.
- The second round of usability testing required participants to have access to and utilize video-conferencing software (e.g., Zoom, Skype, Facetime). This may have created a biased sample of individuals.

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