Understanding Long-Term Adoption and Usability of Wearable Activity Trackers Among Active Older Adults

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Abstract. Many older adults do not sufficiently engage in physical activity and a sedentary lifestyle may pose a major health risk A recent survey showed that 71% of adults in the United States were overweight and obese between 2015 and 2016. To promote physical activities and reduce the risk of chronic diseases in older adults, an activity tracker is becoming a viable solution. However, adoption and long-term use of activity tracker are far less than a satisfactory level. This study conducted a 14-week longitudinal experiment to identify their adoption behaviors of activity trackers. We recruited 17 active senior adults who had no prior experience of the tracker use. Surveys about prior technology experience, affinity for technology interaction, and the attitude and usability of activity tracker adoption were given to the participants to identify perception on recent technology and to understand the adoption patterns and barriers to the acceptance of activity trackers. In addition, bi-weekly interviews were conducted to elicit older population-oriented usability and design issues. Results indicated that participants have a favorable view and interests of advanced smart technology, but they have not much recognized usefulness of activity data. Quantitative adoption scale also showed a flat or slightly decreasing pattern within two to three weeks before reaching to a satisfactory level. Participants reported major usability issues around activity tracker and interface designs, including data visualization and interpretation.

Keywords: Activity tracker · Adoption · Usability · Long-term use

1 Introduction

Exercise can be hard enough for healthy people, let alone older adults. According to the Behavioral Risk Factor Surveillance System (BRFSS), over 35% of older adults in the United States remain obese [1]. Obesity increases the risk for type 2 diabetes,

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cardiovascular disease, and some cancers [2]. It is recommended that adults engage in at least 2.5 h of moderate or vigorous physical activities per week and in muscle-strengthening workouts two days of a week [3]. However, these guidelines were suggested for both general adults and older population, and older adults are less likely to maintain the same levels of exercise as healthy young adults. Thus, older adult oriented guidelines need to be developed and the monitoring their regular physical activity is crucial to maintain or improve their health status and prevent obesity and other related chronic diseases.

The activity tracker is a valuable tool to assess whether older adults accumulate adequate physical activities [4]. Activity trackers have become pervasive following the miniaturization of sensors like accelerometers. These low-cost sensors are embedded in activity trackers, thereby allowing manufacturers to capture and analyze the wearer's movement data by deploying ad hoc algorithms. Consequently, activity trackers and the information they provide are thought to motivate the user to be more active and healthier [5]. Depending on the types of sensors that are integrated, activity trackers can monitor physical activity and other health indicators such as sleep quality and heart rate. They can also improve the user's awareness of their physical health behaviors by providing goal-relevant information [6]. Considering that only 14.7% of adults aged between 65 and 74 meet the physical activity recommendations for their age group, activity trackers have a huge potential to benefit older adults' physical and mental wellbeing [7].

However, empirical research supporting the long-term use and adoption of activity trackers is still emerging. More than half of activity tracker owners no longer use the device as a health management tool, and approximately one third abandon the devices after less than a year [8]. Ledger and McCaffrey [8] found that 50% of users who adopted an activity tracker stopped using it within the first two weeks, and 62% of users of an activity tracking mobile app abandoned it within six months after purchase. Similar adoption attitudes and patterns have been shown in older adults: previously, only half of 92 older adults intended to use the trackers to help achieve their physical wellbeing goals [9]. Three fourths of the participants stopped using their trackers after four weeks. A recent survey study reported that less than 2% of respondents aged 65 years and older took advantage of current activity logging or monitoring technology [10].

This study aimed to explore the adoption attitudes and usability issues among older adults who had not previously used activity trackers. This study provided free activity trackers to adults over 65 years old who indicated having a regular exercise regimen. Compared to peers who are sedentary, active older adults were presumed more likely to adopt activity trackers to help facilitate their goals related to physical wellbeing. They were also presumed more likely to elicit feedback regarding challenges and usability issues around activity tracker usage. Thus, we recognized informative patterns of the tracker adoption and active behavior changes.

Specifically, we focused on (1) investigating the impact of prior technology experience and affinity on active older adults' perceived acceptance of activity trackers by a longitudinal research approach, and (2) identifying the adoption patterns and usability of activity trackers from the perspective of active older adults. The results could inform design recommendations and yield strategies to educate and improve activity tracker adoption among older adults.

2 Method

A 3-month field study with 17 older adults was conducted to comparing their attitude and perception in pre and post adoption of activity tracker. Four different surveys and interview were given participants. Prior technology experience and the preference of activity tracker were examined at the beginning of the study. An activity tracker adoption survey and a quantitative usability scale were administered three times across the study period among novice active older adult users. Participants also completed bi-weekly interviews on issues around activity tracker usability and design.

2.1 Participants

Seventeen participants were recruited from a senior basic yoga class at a fitness facility in South Texas. The target participants of this study were active older adults who had a regular exercise regime or frequently attended exercise classes. We excluded participants who had previously owned or used an activity tracker or other smart watches with activity tracking or monitoring function. This population was thought to be more likely to find activity trackers beneficial, adopt them, and be actively involved in identifying usability issues. Participants were asked to use the trackers for 14 weeks. The research team provided support for them to setup the device, including creating an account, familiarizing basic functions and features. The same information was also provided within the packaging of the device. The detailed demographic information is shown in Table 1.

Fig. 1. Activity tracker used in this study - Nokia Go

All participants in this study were aged more than 65 years, with an average age of 73.4 ± 4.0 years. Seventy five percent of the participants were female. Each participant received one activity tracker (Nokia Go, see Fig. 1) to wear. The tracker can monitor and measure various activities including walking, running, swimming and sleep quality and duration. It also provides distance data and calories burned. The selected device offers a simple basic function of tracking activity and maintains consistency between participants to avoid errors from device variation. The tracker also has a long battery life that does not require recharge or battery replacement during the experiment.

Table 1. Demographic information of experiment participants

Demographic factors		Number of participants (Percentage)
Gender	Female	13 (75%)
	Male	4 (25%)
Age	65–75	12
	76–85	4
	85 or older	1
Education	High school	2
	Bachelor	13
	Master	2
Race	Caucasian/White	6
	Hispanic	9
	Black	2

2.2 Experiment Procedure and Measures

Prior to use an activity tracker, a prior technology experience and perspective survey and the Affinity for technology interaction (ATI) scale [11] were given to the participants to assess their adoption attitudes and perception of activity trackers. The ATI survey is composed of nine unidimensional items using a 6-point Likert scale to understand why users differ in new technology adoption and provides insights to optimize the adoption process. This scale can quantify the assessment of users' personality in the context of technology interaction, and it provides a tool to discriminate how they engage in technology interaction.

The activity tracker adoption attitude survey was administered at three time points across the study: beginning (week 1), middle (week 7) and end (week 13). The survey was adapted from the survey scale developed for individual adoption of healthcare wearable devices [12]. Some of the language was modified to make the survey more pertinent to an activity tracker adoption context. In addition, a quantitative usability measure was also evaluated on a biweekly basis using System Usability Scale (SUS) [13]. A simple, 10-item scale provides an overview of usability and adoption patterns of activity trackers in an inexpensive and effective manner. This measure can be used by a broad range of population and any types of devices or user interfaces [14].

Interviews were conducted biweekly to identify usability and adoption issues. Each participant participated in an individual in-face interview designed to gather various opinions and user experience regarding the activity tracker usage. The interview lasted approximately twenty minutes per participant and the major questions were about their experiences of activity trackers and they were encouraged to answer in a flexible conversational manner. The entire proceeding was recorded, transcribed for thematic analysis, and reviewed by authors. The codes were independently developed through reviews of the interview transcripts and compared between authors to reach the agreement. Disagreements were resolved through consensus. Texas A&M University – Corpus Christi institutional review board approved the study.

3 Results

3.1 Background for Activity Tracker Adoption - Prior Technology Experience and Affinity Technology Interaction (ATI) Scale

As shown in Table 2, participants' prior experience with technology and their familiarity with various technology devices were assessed. All participants except one (94%) reported owning a smartphone. All participants (100%) reported using the internet or email. In addition, most (82%) participants reported frequently accessing social media. On average, participants were confident about using modern technology. They also showed neutral views of societal impacts of the technology.

Table 2. Technology experience and perspective

Experience questions	Number of participants	Percentage
Do you use the internet or email, at least occasionally?	17	100%
Do you have a smart phone?	16	94%
Do you access the internet on a cellphone, tablet or other mobile handheld device, at least occasionally?	17	100%
Do you ever use social media sites like Facebook, Twitter or LinkedIn?	14	82%
Please tell me if you happen to have each of the following items, or not. Do you have…		
- A desktop or laptop computer	17	100%
- A tablet computer like an iPad, Samsung Galaxy Tab, Microsoft Surface Pro, or Amazon Fire	11	65%
Perspective questions	**Mean***	**SD**
How confident do you feel using computers, smartphones, or other electronic devices to do the things you need to do online?	5.7	0.46
Would you say technology has had a mostly positive effect on our society or a mostly negative effect on our society?	4.7	1.05

*Strongly positive 7, Positive 6, Somewhat positive 5, Neutral 4 Somewhat negative 3, Negative 2, Strongly negative 1

In this study, the term "technology" in the original ATI scale was displaced with "activity tracker." Responses to the three negative items need to be reversed, and mean score is calculated over all items per each participant. Table 3 shows the mean ATI scores and standard deviations for all participants. In addition, Cronbach's alpha was computed to assess internal consistency and the results are excellent (α = 0.93). The outcomes of ATI scale support the notion that the dimensions of respondents' personality are associated with successful adoption of a technology in terms of problem solving and learning processes [15]. Based on the previous empirical results, the dimensionality, reliability and validity of the scale was confirmed [16].

Table 3. Technology experience and affinity for technology interaction

Affinity for technology interaction (ATI) scale	Mean	SD
1. I like to occupy myself in greater detail with activity trackers	4.3	1.22
2. I like testing the functions of new activity trackers	3.1	1.01
3. I predominantly deal with activity trackers because I have to	3.3	0.87
4. When I have a new activity tracker in front of me, I try it out intensively	3.5	1.33
5. I enjoy spending time becoming acquainted with a new activity tracker	4.3	0.91
6. It is enough for me that an activity tracker works; I don't care how or why	5.2	1.42
7. I try to understand how an activity tracker exactly works	4.9	1.01
8. It is enough for me to know the basic functions of an activity tracker	5.3	1.23
9. I try to make full use of the capabilities of an activity tracker	3.8	0.82
Average ATI score (all participants)	4.2	1.09

*6 Likert scale was used (6: Completely agree, 5: Largely agree, 4: Slightly agree, 3: Slightly disagree, 2: Largely disagree, 1: Completely disagree)

Mean and standard deviation (SD) of the ATI scores are shown in Table 3. The average ATI score in the sample is 4.2 which is higher than 3.5, the center of the response scale. This indicated that participants were moderately positive in learning and using an activity tracker. The average ATI score indicates that the participants moderately prefer the activity tracker. However, relatively high scores in item 6, 7, and 8 imply their interests in functional aspects of the activity trackers.

3.2 Attitudes and Perception Measures of Activity Tracker Adoption

Table 4 presents the results of the activity tracker adoption survey. We measured the constructs with 5-point Likert scale with anchors ranging from 1 'strongly disagree' to 5 'strongly agree'. Kruskal-Wallis test showed a difference of continuous dependent survey outcomes for each categorical construct ($p = 0.0445$).

Table 4. Integrated technology adoption survey results

Constructs	Beginning (1st week)	Middle (7th week)	Ending (13rd week)
Health information sensitivity	3.83	3.97	4.07
Personal innovativeness in IT	3.10	3.00	3.13
Legislative protection	4.30	4.27	4.30
Perceived prestige	3.97	3.93	4.00
Perceived informativeness	4.00	3.43	3.30
Functional congruence	3.83	3.53	3.53
Perceived privacy risk	4.07	4.07	4.10
Perceived benefit	3.97	3.77	3.60
Adoption intention	3.97	3.97	3.93
Actual adoption behavior	1.00	5.00	4.43

*5 Likert scale was used (5: Strongly agree, 4: Agree, 3: Neutral, 2: Disagree, 1: Strongly disagree)

There were moderate positive trends toward adopting and using activity trackers in the current sample. Most participants had favorable attitudes toward activity trackers on health information sensitivity, legislative protection, perceived prestige, perceived benefit and adoption intention, with scores well above the midpoint of 3 across all three time periods. However, the changes in perceived informativeness, functional congruence, and actual adoption behavior were notable. Average scores of perceived informativeness and functional congruence decreased by 22% (from 4.00 to 3.13) and 16% (from 3.83 to 3.23) respectively, in the first half period. Perceived informativeness and functional congruence decreased from week 7 to week 13 indicate that both scores remained relatively consistent over the second half of the study. Actual adoption behavior was lowest at the beginning, because participants had not received activity trackers.

3.3 Quantitative Usability Measure - System Usability Scale (SUS)

Figure 2 shows the results of System Usability Scale (SUS) analysis. To report results, a scoring template is adopted which turns the raw individual ratings across the participants into a single score based on Brooke's standard scoring method [13]. The results can be valid for both user interface designs or implementations [17].

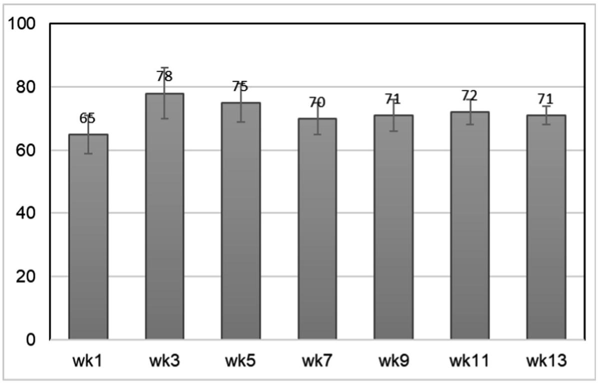

Fig. 2. System Usability Scale (SUS) scores for activity tracker

The SUS scores (mean 71.7) show that activity tracker usability did not reach the "Good" level, while 68 is widely considered as an average SUS score (Fig. 3). The SUS is not diagnostic and does not address specific problems, but it provides a measurable status of how users perceive usability of a system. Scores initially increased from week 1 to week 3, but were continuously maintained at "Marginal" levels thereafter.

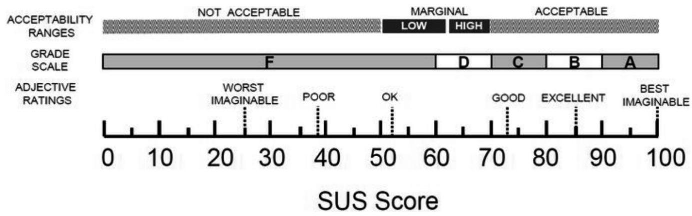

Fig. 3. SUS score evaluation criteria Image [18]

3.4 Usability Interviews

There were two major usability issues raised from the participants' interviews. Several participants reported that the number of steps provided by the activity tracker inaccurately represented their level of physical activity. Specifically, exercises such as cycling, swimming, and strength training, were either partially tracked, mis-tracked, or completely untracked. As one participant commented, *"The tracker was good at running and walking step count, but it wasn't for all exercises. For example, yesterday I rode a bike for an hour, and it didn't register anything for that entire time."* Conversely, all steps measured by an activity tracker are counted equally, yet they do not necessarily require equal effort. A participant denounced that, *"I can make many small steps to get to the same distance that can be reached by just taking a few big steps. This was not considered."* This lack of effort levels in activity actually discourages vigorous physical activity. Other participants mentioned that they often needed to supplement their activity measurements with additional information to appreciate the perceived exercise amounts and associated benefits. Sometimes, even when the measurement accurately displayed the daily step counts and activity levels, activity tracker data did not reflect participants' health conditions or specific exercise environments.

Another issue identified from the interviews was the lack of recognition and utilization of past activity history. Though exercise activity histories and trends are available in activity trackers or associated apps in a tablet or a smartphone, most older participants did not seem to be aware of how to integrate them for future exercise planning, including goal-setting. One participant mentioned that *"I like knowing what days I was getting what amount of activity, rather than just thinking. But, I don't know how my performance was and how I can use it."* Another participant explained how the previous exercise history impacted his goal setting, *"I had a really good work-out on Monday, but it's now Thursday and I haven't done any exercise. I don't know how much good exercise will be."* In addition, several participants suggested that although they could access their activity tracker data history, they hoped to find the patterns of success and failure that could help them plan for a more successful future.

Other usability issues around activity tracker device and mobile app interactions emerged from our interviews. Participants made various usability or user experience suggestions such as adopting large and easy to press buttons or icons at least on the main screen, adding options to allow users to start, pause, and terminate data recording and options to save the data to the cloud and send the data and/or feedback to the users.

4 Discussion

4.1 Active Older Adults' Willingness of Activity Tracker Adoption

This study focused on examining active older adults' activity tracker adoption attitudes and user experience for three months in free-living environment. We assumed that prior experience and affinity of technology facilitate activity tracker adoption and use. The results from the technology experience and perspective survey and ATI scale indicated that participating older adults have a favorable view of activity tracker. They were willing to adopt and use activity trackers.

The surveys indicated that despite demonstrating sufficient affinity (see Q. 6 and Q. 8 results in ATI), participants were more interested in utilizing basic functions of an activity tracker comparing to a tendency to engage in general interaction with activity tracker. Though the distinction between them is not clearly conspicuous, active seniors are more likely to be aware of those functions and not much attentive to operating activity trackers beyond basic functions. This suggests that the activity tracker design for active senior adults needs to be more concentrated on simple main function, tracking activities. In addition, designers or developers of a new technology device for older adults need to be aware the distinction between interests and understanding of technology. Simple design to basic functions rather than additional features are crucial to improve the device adoption and user experience.

4.2 Theoretical and Practical Implications for Long-Term Use

The integrated technology adoption survey found that participants have not much perceived usefulness of activity data, falling below 3 in their "Perceived informativeness" after usage and "Functional congruence." Additionally, no participants initially scored a 5 in "Adoption intention". However, after usage, four participants scored a 5. Therefore, most participants initially perceived activity trackers moderately favorably, but after using the trackers, participants became more polarized in their adoption of activity trackers. These outcomes point out that specific design factors that need to be considered and the importance of early training and detailed instructions when the tracker targets the elderly population. High scores which were initially at or above the midpoint of 3 on the 1 to 5 scales in "Health information sensitivity" and "Legislative protection" would represent their interests and concerns about the adoption of health information technology.

A quantitative SUS was administered to obtain a rapid and distinctive assessment of the adoption and/or usability of an activity tracker. Though the scale does not offer a full scale of diagnostic results and may not address what specific problems users face, it presents clear and simple criteria to know how much the usability needs to be improved. Though some measuring errors and individual differences by experts were reported, a commonly accepted average SUS score is estimated to be 68 [17, 19]. The average SUS score for the activity tracker across the study period is 71.7, which is slightly higher than the average score. It demonstrates that the participants' adoption and usability had not been reached enough to the satisfactory level, and the usability issues emerged in earlier periods had not been solved.

For a longitudinal score pattern, similar to adoption survey outcomes, the score was increased at early period and slightly decreased through the rest of study periods. This pattern implies that interests and expectation for the tracker positively affect the score, and some usability issues and lack of motivation for long-term use would be reflected in the decreasing score patterns. Considering the participants' positive perceptions on new technology and their regular exercise routine, the SUS scores were expected to be much higher and to show at least increasing patterns in the activity tracker adoption period. SUS scores indicated the direct experiences with the tracker usage and inform how usable the tracker actually is. Maintaining early expectation and motivation and user-oriented design are key aspects to encourage active older adults to maximize the benefits of activity trackers.

To investigate the reasons behind intention to use, and the roles of barriers and facilitators for long-term adoption, we examined the interview. Comfortability for continuous wearing, design comparability considering older population's mental and physical constraints, and utility of historical activity data were identified as major usability issues. Current activity trackers may need to be improved to accurately capture data during exercises like cycling and yoga, which are commonly adopted by older adults. The optimal tracker placement for data reliability and comfortability also need to be explored, especially during extended wear. In addition, historical data without any interpretation displayed in the tracker or associated apps may not be useful for older adults. The data needs to be more informative and deliver more meaningful and empowering directions for long-term use. For example, machine learning algorithm could be deployed to analyze historical data and determine more sustainable incremental physical activity goals for older adults. There is no appropriate and adaptive approach to set up individual target. Our results showed that more work is needed to further understand activity tracker usage patterns and the design issues that may constrain long term adoption among older adults who are already moderately active.

5 Limitation

A limitation of this study is the generalizability of the results due to small sample size. The number of participants in this study was limited to 17 older adults who were regularly exercising. Though they well understood the needs of activity trackers and were more apt to actively engage using it, their adoption attitudes and patterns would be biased and other older populations who have different life develop more conclusive and representative outcomes. Additionally, the outcomes of this study were mainly derived from subjective measures of surveys and interviews. Subjective measures are highly associated with the variables that are designed to capture but they are also damaged from many cognitive biases. Importantly, subjective measures are often complemented to objective measures. Thus, the attitudes and perception of activity tracker adoption can be more strengthened with quantified objective measures such as actual physical activity changes. Finally, three months would not be enough time to explore longitudinal implications of activity tracker adoption. Comparing other previous studies, three months is a quite lengthy period but may not enough time to draw conclusive adoption or usage patterns of suspended use.

6 Conclusion

This study investigated the adoption pattern and usability issues of activity trackers for active older adults. Active participants were recruited, because they were presumed more likely to adopt and use the activity tracker and provide feedback related to its usability. Longitudinal adoption surveys and interviews related to activity tracker adoption were administered. Survey and interview questions also addressed participants' backgrounds, prior technology experience, and perception and technology affinity. Contrary to conventional thought, older adults in the current sample reported being well exposed and familiar with modern and smart technological devices. It is concluded that active older adults appear to have favorable impressions of activity trackers. However, the adoption of activity trackers showed a flat or slightly decreasing pattern within two to three weeks before reaching to a satisfactory level. Participants identified major usability issues around activity tracker and interface designs, including data visualization and interpretation.

Future studies should recruit a more diverse and larger sample. Additionally, actual exercise data should be explored as they may provide practical insights on activity tracker adoption and long-term use in older adults.

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