

# Designing Health and Fitness Apps with Older Adults: Examining the Value of Experience-Based Co-Design

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## ABSTRACT

Identifying useful features of health and fitness technologies has the potential to lead to more effective pervasive technology interventions. Through collaborative creative processes, co-design provides useful insight and direction for the design of these technologies from populations such as older adults who are often neglected in design. Additionally, extensive technology experience prior to co-design may elicit richer feedback from users that may otherwise be unfamiliar with the intervention of interest. In this paper, we examine the value of experience-based co-design among older adults. We report on seven design sessions conducted with a total of 25 older adults, following a 10-week study of fitness app effectiveness. Sessions were grouped into users and non-users of the assigned app following the study. We found that continued use with the assigned application led to more robust, detailed feedback in design sessions, suggesting that long-term, prior use of sample technologies is an important prerequisite to ideating useful features for new health technology. We draw on these findings to make design recommendations, and discuss the values and guidelines of implementing experience-based co-design.

## CCS CONCEPTS

- **Human centered computing** → **Interface design; Interaction design process and methods; Participatory design**
- **User characteristics** → **Seniors**

## KEYWORDS

Older adults; co-design; mobile applications; behavior change; physical activity; health

## 1 INTRODUCTION

There has been an emergence of mobile health (mHealth) technologies aimed at addressing health deficits among adults in later life as the concern for management of chronic diseases and illnesses becomes more prevalent. For older adults, technologies such as mobile fitness applications have the potential to not only improve physical activity levels, but to also increase social interaction, brain functioning, and support performance of activities deemed instrumental to their daily living (medication management, diet and hydration) [4]. Over 100,000 mHealth applications across the iPhone, Google Play, and Android stores exist that range in function from physical activity and calorie tracking to managing of medications and other aspects of illness treatment. Despite the ubiquity of these offerings, utilization is low, particularly among older adults [24]. Consensus survey data indicate that these applications are often abandoned prematurely, as early as three months after download [29], primarily due to user perception that these applications have little motivational value or usefulness. Engaging older users in creative processes such as Co-Design when creating mHealth applications could lead to applications that better meet the needs of this population. However, we know very little about which approaches are most effective when engaging older users in these processes.

We examine how older adults can be supported in co-design activities that focus on ideating and brainstorming concepts for health and fitness applications. To do so, we conducted seven design sessions with older adults following a semi-longitudinal deployment of three mobile fitness

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applications. Participants were categorized as *Users* and *Non-users* of the assigned application following the study. Based on qualitative analysis of results of these sessions, we make the following contributions to the pervasive health community:

- Design recommendations for mobile fitness technologies for older adults.
- A discussion of the value of *experience-based co-design*, in which prior use of a sample mHealth technology enables older adults to engage in the co-design of mHealth and fitness application features.
- Recommendations for engaging older adults in participatory design of health and fitness applications.

## 2 RELATED WORK

### 2.1 mHealth and Fitness Applications: the Need for Participatory Approaches to Design

Previous research efforts in human-computer interaction (HCI) have examined factors related to the adoption of mHealth technologies, capturing both the appeal and perceived effectiveness of these technologies. These efforts have identified that individuals may initially adopt a fitness application due to factors such as the desire to improve physical fitness and weight, or to be more aware of the state of their health [21], and that many users often sustain use as a way of keeping track of their health. Existing taxonomies and guidelines [20, 31] have categorized and structured these motivational factors as behavior change strategies which address and motivate an intended behavior. However, we still know very little about which strategies are going to be most relevant to older users [11]. Furthermore, we have yet to identify how to effectively incorporate these strategies into the design of mHealth technologies for older adults.

Establishing an in-depth understanding of older adults' needs and preferences for the design of health technology is an active research topic. A commonly used design approach within Pervasive Health and HCI is co-design (also referred to as participatory design), which enables end-users to be directly involved in the decision-making process of product conception and centers their input. Davidson and Jensen [5] and Lee et al. [17] suggest that involving older adults as co-creators, as opposed to just consumers of technologies, is valuable to increasing the likelihood of technology use. Additionally, this method can advocate the voices of users in a creative environment. However, prior co-design studies on engaging older adults in design are limited, particularly for mHealth technologies. To date, older adults have had limited direct influence on the design of health technologies.

### 2.2. Behavior Change Strategies in Health and Fitness Applications

Behavior change strategies such as positive reinforcement, social influence, and goal support may have a positive impact

on older adults' physical activity levels. Studies conducted by Chen et al. [3], Direito et al. [6], King et al. [15], and Rodriguez et al. [26] have shown that implementing various behavior change strategies in mHealth technologies for physical activity promotion have had some success, highlighting social engagement and system feedback among key contributing factors to older adults' temporary adherence to routine physical activity and exercise. The ReadySteady application designed by Vankipuram et al. [30] as well as the CAMMInA system [27] utilized motivational messages and trended historical data to increase the frequency and duration of older adults' physical activity. By utilizing self-monitoring, feedback, and social support, a physical activity application was found effective in increasing older adults' step count by 14% over the course of six weeks; however, this study was conducted with a relatively small sample size ( $N=8$ ) [23].

We look to these strategies to identify design features that have been deemed effective among the older adult community, and as a baseline to see what new features and resulting strategies emerged from our study.

### 2.3 Co-Design of mHealth and Fitness Technologies with Older Adults

As the use of co-design for conceptualizing and brainstorming consumer products is now well-established, researchers have begun to apply co-design techniques to design pervasive health technologies. Several research teams have worked specifically with older adults by leveraging co-design as a collective creation method, exploring various approaches to how designers can sustain collaboration during co-creation with this population [2, 9, 10, 19]. Studies examining the co-design of technologies aimed at health management, fitness, or in-home wellness [5, 9, 10, 13, 17, 19, 28], have acknowledged the need to revamp methods of co-design to be more inclusive of older adults as co-designers. These approaches are novel in their own way, and each highlight various benefits of the co-design approach. For instance, in co-creating a diet and nutrition app with older adults with age-related macular degeneration, Hakobyan's work [9, 10] utilized a longitudinal participatory method wherein older users contributed to the iterative design process of creating the prototype interface, and then tested this application over the course of six weeks to determine effectiveness. From this study, researchers were able to outline methodological concessions to make the co-design method accessible and friendly to older adult participants, such as mutual learning and empowerment which participants expressed as result of the co-design experience.

### 2.4 Informing Participatory Design with Technology Exposure

Participatory design as influenced by technology exposure presents a unique approach to the co-creation method. From Hutchinson et al.'s work [12] we know that "seeding

technologies” or technology probes present the opportunity to not only collect data on the use and user of the technology, but also to inspire newer innovations to a technology to fit the needs of a particular user group. This study demonstrated that the communication and expression of technology desires and needs can be supported, if not enhanced, by participants’ prior interaction with technology. The probes were designed to be functional, yet they were constrained enough in their functionality that they allowed for users to appropriate them in new ways, encouraging the ideation process. Similar to Hutchinson’s work, several other studies demonstrate the value in some form of technology exposure for co-design participants, whether during co-design activities [8, 25] or before these activities [28]. These studies also depict prior technology exposure as a way to initiate conversation and spark ideas for concept generation.

Scandurra’s work is one of the few studies that highlights the participatory or co-design method specifically focusing on older adults, engaging participants in design workshops following exposure to a stationary display in a local senior center to inspire new features for eHealth services for older users. Older adults were able to easily communicate their use of existing technologies with regard to certain wellness activities (physical and cognitive brain exercises), and suggest improvements for new eHealth services to be implemented in their center. Engagement with medical technologies over an extended period of time has been shown to facilitate many types of patient feedback in co-design that would not have been possible otherwise [22, 25].

Previous research suggests that older adults are valuable as co-designers of innovative technology concepts and there is potential benefit in co-designers having prior interaction with the technology of interest to aid in the design ideation process. Although there is well-established precedence for leveraging this method of co-creation with older adults, there are no previous projects to our knowledge that examine the impact of technology use and experience on the types of feedback among older participants in co-design activities.

Through Experience-Based Co-Design sessions (Fig. 1) held with older adults participating as co-designers, we explore and identify the ways in which mobile fitness applications could be better tailored to meet the needs of older adults. These sessions focus on gaining a more in-depth understanding of older adults’ experiences with existing mHealth technologies that are promoted to fit all, and brainstorming concepts that would be effective in promoting physical activity and sustained use.

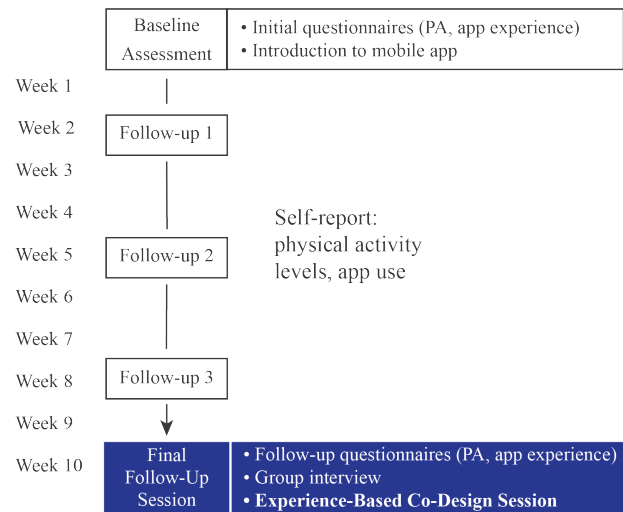
### 3 METHOD

#### 3.1 Study Design

We first conducted a semi-longitudinal comparative study to assess the effectiveness of various behavior change strategies on older adults’ physical activity levels, and to identify the

factors that contribute to use of mHealth technologies. Thirty-nine older adults were randomly assigned to use one of three off-the-shelf mobile fitness applications for 10 weeks to assess the effectiveness of certain behavior change strategies in increasing physical activity levels over time. Applications were selected based on a thorough systematic screening process in which researchers examined iTunes, Android, and Google Play stores for applications that were free, used English as the primary language, promoted physical activity only with no diet or nutrition component, did not require a specific tracking device or hardware, and were not primarily for a specific type of training such as marathon running [11]. Based on this screening process, the three applications chosen were *Endomondo* [32], which utilized social influence and connected users through their online social networks; *Burn’emDown* [33], which utilized goal support and assessed progress towards a pre-defined health status; and *StepFit* [34] as a control application which tracked a user’s daily and weekly minutes of exercise without a behavior change strategy.

Follow-up sessions were conducted throughout and at the end of the ten weeks, surveying physical activity levels, use or non-use of the assigned application, and perceptions of the application. Data collection ran from May until August 2017. Fig. 1 gives an overview of the larger study design. This paper focuses on the results of the co-design activities, for more details about the overall study, see [11].



**Figure 1: Research design of larger study. Final Follow-Up Sessions included questionnaires assessing usage and experiences with the assigned mHealth application, followed by a group interview, and co-design activities.**

#### 3.2 Participants

Twenty-five older adults age 65 to 80 (*mean* = 72.1, *SD* = 4.25) participated in the final follow-up sessions to qualitatively assess their experiences. This participant sample

was 68% female ( $n = 17$ ), 65% were educated with a bachelor’s degree or higher, 33% were married, 45% Caucasian and 48% African-American. Table 1 gives a demographic overview of the participants, by study session.

**Table 1: Demographic Overview of Participant Sample in Experience-Based Design Sessions**

Group	User/ Non-user	Older Adults	Age Range	Sex (m/f)	# with Prior Fitness App Experience
1	Non-user	3	69-70	M=1 F=2	1
2	User	3	70-79	M=1 F=2	1
3	User	4	68-77	M=2 F=2	0
4	Non-user	5	65-80	M=2 F=3	2
5	User	3	68-73	F=3	0
6	Non-user	4	72-78	M=1 F=3	0
7	User	3	65-79	M=1 F=2	2

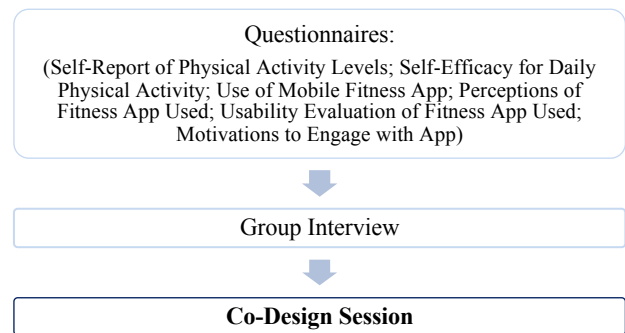
### 3.3 Procedure

Following a 10-week interaction with an assigned mobile application, participants engaged in a 2-hour final follow-up session that consisted of individual questionnaires, a group interview, and co-design activities. Follow-up sessions were conducted at the end of week 10. Participants were assigned to a User or Non-user group design session based on their reported trajectory of use of their assigned application (those who reported still using the application ( $n = 13$ ), and those who reported that they had either never used the application or discontinued using it before the midway point of the study ( $n = 12$ ), respectively). Groups were structured solely based on application use, independent of the application assigned. Groups were organized with no more than 5 participants per group for clarity of individual responses and overall management of the group.

Participants individually completed six questionnaires: self-report of physical activity levels and app use, perceptions of application usefulness and usability, and subjective ratings of a taxonomy of engagement strategies. Following completion of the questionnaires, participants were guided through a semi-structured group interview about their experiences with the mobile fitness application (barriers and facilitators of interaction). Groups were then guided through a design activity to brainstorm and ideate ideal features for health and activity promotion.

Prior to the start of each co-design session, instructions were given following a script designed by researchers.

Participants were encouraged to draw on their recent experience with the mobile application they were assigned, as well as any broader, previous experience with mHealth and fitness applications. During the design session, participants were asked to individually brainstorm and ideate application features based on four prompts: “features that would encourage your physical activity”; “features that would encourage you to want to use the application”; “features that you found unnecessary”; and “things that designers should consider when designing for older adults”. Participants were provided with sketching paper, pens, markers, and colored pencils to aid with visualizing ideas, and given 10 minutes to individually ideate their concepts for each prompt before a larger group discussion. Design features were organized on a large flipchart to facilitate collaboration and sharing during the discussion. Final follow-up sessions followed the protocol shown in Fig. 2.



**Figure 2: Protocol for final follow-up sessions (Week 11-12).**

### 3.4 Data Analysis

Data captured during Experience-Based Design Sessions included audio recordings of each session, researcher notes, and photo composites of flipcharts with sticky notes. Audio files from group interviews were transcribed verbatim. Analysis of these data consisted of qualitative, inductive coding with iterative rounds of categorizing responses to design prompts, conducted by two researchers. Codes for some data were pre-defined based on categories of established behavior change strategies [20, 31] – social influence (the influence of peers or family for behavior change), goal support (helping a user work towards certain metrics of behavior change), and task support (simplifying the completion of smaller tasks towards a larger behavior), as we felt these might be the most relevant to older users.

To analyze data from co-design activities, researchers coded transcriptions of audio data, along with observation notes, and the design content generated by participant designers (i.e., primarily sticky notes and sketches we collected) and identified themes among the data guided by session prompts, as well as patterns that emerged inductively from each transcript. Codes were organized into categories of:

1) application likes, 2) barriers to application use, and 3) ideal features of an application. Here we report on the features that participants identified as being ideal. We discuss the patterns among each session prompt, emergent design themes, and an analysis of contributions of Users and Non-users.

## 4 FINDINGS

In this section, we present our analysis of emergent themes among older adults' brainstormed ideal features in design sessions. Quotes used are identified by participant group and number. In addition to results of the design sessions, we discuss higher level design recommendations that emerged during sessions, and an analysis of the types of design feedback from the two groups, Users and Non-users.

### 4.1 Activities and Metrics Tracked in Health and Fitness Applications

A primary theme that emerged during group interviews and co-design sessions were the types of activities and metrics that are currently tracked by health and fitness applications versus what would be valuable for older adults to know. Participants expressed a desire for more fluidity in the ways moderate-to-vigorous physical activity is defined among these applications, including more routine instrumental activities of daily living such as house and yardwork, or organizational and volunteer activities. Participants felt that everyday activities such as cleaning and yardwork (specifically mowing grass and gardening) and completing errands should be tracked and considered as physical effort as they were equally physically demanding for older adults.

In regard to metrics tracked, most conversations centered around the benefit of these systems being a holistic assessment of overall health. Participants in both User and Non-user groups suggested other areas of health that could be tracked outside of physical activity such as sleep patterns, hydration and water intake, and pain levels.

Additionally, health vitals such as blood pressure and heart rate were discussed as fundamental things that should be collected. Although knowing their physical activity history was seen as beneficial, participants in both the User and Non-user groups expressed the desire to want to use something that is more holistic to their overall health status and that would be supportive of interactions with medical professionals. The ability to track other health-related data that could feed into a user's medical records was considered especially beneficial in older age. Capturing these vitals were mentioned as something that would entice older users to use mHealth and fitness applications more frequently by providing a more valuable health tracking experience. Participants expressed value in the ability to easily report a holistic evaluation of health to their doctor: *"I would like an app that shows me what the state of my health is. Like where my blood pressure is, heart rate. To let me know how much [physical activity] I've done. Collectively show the impact and separate out the*

*activities like 'Oh overall this number or count says that I did well and my health is in a good state'. So that when I go to the doctor I can tell the doctor"* (Group 4 – Non-user, P103).

Tracking and assessing pain was also mentioned among the Non-user groups. Participants suggested that a helpful metric to track would be their perceived pain on any given day or moment: *"I mean a start would be to just have something that once or twice a day you could go in and say that 'my average pain today was a 7'"* (Group 1 – Non-user, P102). This metric was discussed as an additional component of overall health, and reported to be valuable when looking back to see how well physical activity helped with the perception of pain or pain management.

### 4.2 Ideal Features to Encourage Physical Activity

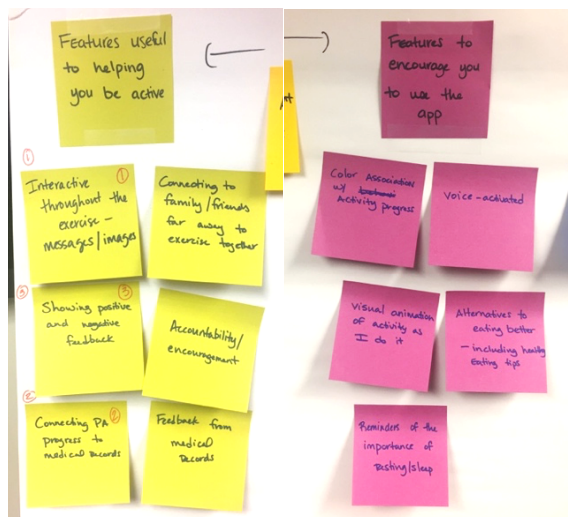
There was frequent mention among Non-user groups of older adults' desire to have a system that assessed pain and flexibility as a motivator for them to be more physically active. Comparatively, individuals in User groups reported more of an interest in knowing other health vital signs (blood pressure, heart rate, glucose) to be able to communicate to healthcare professionals. As a novel idea, individuals in User groups felt that having an application that helped them to schedule activities based on the calories they wanted to burn would be beneficial, detailing an experience where they could have exercise placed into their weekly schedule, or identifying the number of calories they want to burn in a week and having the application suggest nearby activities that would meet their schedule and calorie goal. *"Maybe having some kind of schedule of things that we're interested in doing. Like, I want to burn this amount of calories and I like spinning or I like swimming, I like yoga, walking, playing with my dog. And, then, the app would suggest activities and you can plug it in on a schedule for yourself that week. That's a very cool idea."* (Group 7 – User, P207).

Additionally, User groups discussed the necessity of rewards and encouraging messages being present in the application as something that would encourage physical activity. Here, individuals expressed the desire to know that their activity is on the right track for their fitness goal, and potentially be rewarded through fitness related gift cards or discounted fitness memberships.

### 4.3 Ideal Features to Encourage User Engagement

Individuals in both groups discussed the ways in which they interacted with the system that is tracking their activity. Older users felt that physically keeping up with a mobile phone as the primary device to track their physical activity and exercise was cumbersome and not fitting to their lifestyle. Non-user groups tended to discuss alternate forms of the tracking and data collection device itself, such as the possibility of a wearable device on the wrist or ankle or around the neck. Among these groups there was more emphasis on having the process of tracking be more passive as opposed to having to

actively enter the beginning and end of an exercise: “*What really upset me was I had to actively engage the app. Whereas the FitBit is passively functional at all times. And, it was frustrating me to have to have the app running and have my phone run out of juice*” (Group 4 – Non-user, P107). In contrast, User groups focused more on the design of simple, usable interfaces for health and fitness applications. Fig. 3 shows examples of concepts brainstormed during co-design sessions.



**Figure 3.** A sample of the brainstormed concepts from co-design sessions. Yellow sticky notes captured features to encourage physical activity, pink sticky notes captured features to encourage sustained use of the application.

Individuals in User groups discussed the actual interface features of the application as things that would encourage sustained use, with a great emphasis on simpler and alternate forms of visualization for 1) seeing activity progress, 2) personalized recognition, and 3) healthy behavior suggestions in application content. The concept of speech-enabled interfaces was mentioned among several groups as an easier way for older users to get exercise reminders as well as hear their progress and overall health status. This interaction was detailed as being more personalized than on-screen messages, similar to in-home voice devices such as Amazon Echo or Alexa. “[I’d like] an application that would talk to me and tell me, “How are you this morning? Have you walked, are you gonna walk, and, if you are, let’s go for a walk at 10:00” (Group 6 – Non-user, P211).

#### 4.4 Implementation of Behavior Change Strategies in Health and Fitness Applications

Within the larger discussion of ideal features and application functionality, social influence arose during each Experience-Based Design Session. We report here on participants ideas for the implementation of social influence as there was very

little discussion of goal or task support with mHealth and fitness applications.

Connection to others was reported as being an appealing feature when a user is being connected to people they know and are familiar with. Many participants saw the value in being connected in general, and saw physical activity performance as a way to achieve this connection: “*You need a connection. We as seniors we need connections. And one of the things that happens when we don’t connect, we become depressed. So it may be good to make sure that they have the same app. And they can call you up that morning and say, ‘Hey you wanna go walk or run or something?’*” (Group 2 – User, P220). Although several participants commented on the hesitation to want to connect to strangers, or to be urged to aggressively compete with people they do not know, they found that social connection with those they are familiar with would make physical activity fun: “*It’s good to have a partner for me. At least somebody that you would be accountable to, make it fun. ‘You know I did such and such today, what about you?’ See if you can top that. They really enjoy each other and stay in contact. It’s a good social outlet*” (Group 4 – Non-user, P217). Knowing the physical activity behaviors of strangers or even Facebook friends who may not be intimately close was a deterrence from using mHealth and fitness applications: “*Yeah, [at] this point in my life, I don’t do that. I don’t want to be connected to strangers. We want to be disconnected. Just leave me alone. I think it’s an older adult thing. You know, we’re not big Twitters or Facebookers*” (Group 7 – User, P109).

#### 4.5 Design Themes

Based on the themes that emerged from participant discussions, we present several design recommendations for health technologies for older adults. Although there is an evidence base for these recommendations, we propose them as recommendations as opposed to guidelines because there is future work needed to validate their effectiveness. These design recommendations should be applied generally to the design of technologies for health-related behavior change among older adults, as opposed to just fitness applications, as many participants felt that wearable options would be conducive to tracking health data.

##### 4.5.1 Comprehensive Metrics of Health and Wellbeing.

The design of fitness and activity tracking technologies for older adults should be considered an opportunity to provide a holistic health assessment tool as opposed to just physical activity promotion. Health management in older adulthood is a task that can be demanding and hard to accomplish without the help of reminders and organizational tools. Designing technology tools that collect data on other areas of health management may prove more useful to older adults, resulting in increased and sustained use. Participants in both the User and Non-user groups identified that tracking metrics such as sleep behaviors, hydration, blood pressure, heart rate, and

other symptoms may be useful functionality when considering health and wellness. Although existing health applications cover an extensive set of individual health concerns and chronic illnesses [4], there are few if any that present a holistic assessment of user health data that might be relevant to the communication between older adults and their doctors. Allowing users to communicate feedback of this assessment in a holistic way (e.g., total health score or comprehensive data visualization) can provide an aggregate of vital sign readings and health history that older adults have to keep up with daily.

**4.5.2 Simplified and Accessible Feedback and Data Entry** One significant finding from the design sessions was the association of usability with duration and frequency of application use. As many older adults face impairments in areas such as vision or memory, usability barriers such as small print or poor contrast for functional interface components have a negative impact on perceptions of ease-of-use [7]. Applications that require long set-up times, extensive routines of data entry or that are otherwise confusing to older adults have been seen as inefficient, presenting a barrier to not only use of the application but negating motivation to be active [14, 16].

To anticipate these variable needs, technologies should incorporate simplified, alternate modes of feedback and reminders, such that the actual use of the technology does not become a barrier to physical activity adherence. For example, a simplified way of notifying users of their overall walking or hydration could appear as a single number, combined with a color designation or icon to inform the user of whether this progress is on track for their goals. Minimizing the number of screens that users have to go through to get to their history and progress can ultimately make for a better interaction experience, and reduce the time a user spends reviewing information. Speech-enabled interfaces or auditory reminders present new approaches to notifying users of their progress or schedule. Having this as a manual feature would allow users to customize feedback and reminders based on context of use or personal needs.

**4.5.4 Social Support on a Personal Level.** The alleviation of social isolation is incorporated in the consideration of health and wellness among older adults [18], and that being connected to someone while being active is effective in encouraging physical activity behaviors [1]. Currently, many health and fitness applications allow users to connect to their social network to share fitness progress, statuses, images, etc. As this form of social connection may not be as attractive to adults over the age of 65 with regard to physical activity behaviors, it is necessary to refine the ways in which social connection is implemented in health technologies for this population. Supporting connection between older adults and familiar social groups (friends and family) might be a more advantageous approach for this population. This finding is consistent with previous research assessing telehealth

technologies for older adults [1]. An effective approach to social support may be connecting individuals directly to another user of the technology through video conferencing or messaging, allowing users to share their activity status, overall health progress, or engage in activity with others.

**4.5.5 User-Defined Activities and Goals.** Health technologies to promote and support physical activity and health among older adults should allow users to identify activities that are relevant to them and track everyday activities. Use of health and fitness technologies may provide a novel opportunity for older adults to participate in activities they may not otherwise be aware of, and may also provide them with information about the health benefits of activities they normally engage in.

Supporting progress towards user-specified goals should be a major objective of any health and fitness technology. These technologies should promote activities that fit a user's overall goals, as compared to activities that are deemed traditionally rigorous or have no justification for suggestion. Additionally, health technologies should provide users with the option of identifying whether their goals are aligned to beating a certain performance metric, keeping a particular health vital at a certain level, weight management, or simple maintenance of activity. Engagement with health and fitness technologies should be meaningful for the end user - algorithms should suggest convenient approaches to activities, by both type and physical difficulty level, feeding into user goals.

## 4.6 Contributions of User vs. Non-user

The larger semi-longitudinal study found no significant correlation between participants' previous application experience and sustained use of the application during this study [11]. However, those who continued to use the assigned application and who also had previous experience contributed robust (more detailed concepts with examples of implementation and why the concept might be useful) ideas to brainstorming and ideation sessions. Groups that included participants who had previous application experience in addition to that provided during the study often came up with more concepts for features, even among Non-user groups. Whereas participants in User groups seemed to ground of build their ideas upon current application features, participants among Non-user groups seemed to brainstorm more out-of-the-box concepts for features such as assessments of pain and flexibility, or imagery of their local environment. For example, one participant with prior fitness application experience suggested the use of interactive visuals as something that would encourage physical activity among older adults: "*I'd like to see pictures of what I'm missing outside, the trees, the grass... It would motivate me to actually want to get out and see what I'm missing*" (Group 4 – Non-user, P217). This suggests a valuable impact of experience and usage on the novelty of brainstormed features in the co-

design process among older adults. Table 2 details the design features that were brainstormed by each subset of user.

**Table 2. Design Concepts by Subset of Participant**

No Experience/Non-User (n = 9)	No Experience/User (n = 10)
<ul style="list-style-type: none"> <li>Hydration reminder</li> <li>Passive tracking</li> <li>Automatic reminders</li> </ul>	<ul style="list-style-type: none"> <li>Calculate calories I need to burn</li> <li>Automatic reminders</li> <li>Speech-enabled interfaces</li> <li>Holistic health data collection</li> <li>Goal-setting/tracking</li> <li>Meaningful rewards/incentives</li> <li>Competitive challenges</li> <li>Interactive media as encouragement</li> <li>Colors to indicate progress</li> <li>Social connection to family/friends</li> </ul>
Experience/Non-User (n = 3)	Experience/User (n = 3)
<ul style="list-style-type: none"> <li>Passive tracking</li> <li>Historical record of progress</li> <li>Holistic health data collection</li> <li>Automatic reminders</li> <li>Interactive media as encouragement</li> <li>Sync progress with other health apps</li> <li>Incentives</li> <li>Goal-setting/tracking</li> <li>Wearable device</li> <li>Assessment of pain and flexibility</li> <li>Imagery of local environment</li> </ul>	<ul style="list-style-type: none"> <li>Activity scheduler</li> <li>View local activities</li> <li>Holistic health data collection</li> <li>Speech-enabled interfaces</li> <li>Incentives</li> <li>Personalized messages</li> <li>Connecting physical activity progress to medical records</li> <li>Social connection to family/friends</li> <li>Interactive media as encouragement</li> <li>Colors to indicate progress</li> </ul>

## 5 DISCUSSION

Co-design extends the benefits of user-centered design, providing a voice and input to a demographic typically neglected in technology development. Although there have been design efforts focused on defining ideal features for health and fitness technologies, there is a great advantage in exploring co-design with participants who have extended durations of exposure with the technology of interest [22, 25]. Our findings suggest that this method provides for more robust and novel concepts being brainstormed among older adults as co-designers, even those who may initially express a disinterest in utilizing the technology. Participants who had extended interaction with mHealth and fitness applications (previous experience prior to the study, sustained usage during the study, or both) provided a beneficial foundational basis for design ideas and thus a wider range of design concepts during the co-design sessions. Oftentimes, the

mention of a new feature or the improvement of an existing feature was followed by an anecdote of participant experience, suggesting that older adults were able to leverage experience and longer-term use for the ideation of new technology features.

### 5.1 Value of Experience-Based Co-Design

We propose the concept of **experience-based co-design as an innovative approach to co-creation of health-related technology targeting older users**. Previous research establishes that there is a unique value in leveraging exposure to a technology in co-design [22, 25], this analysis posits that providing exposure to a technology may be particularly valuable when working with older adults. Older users often lag in proficiency with newer technology platforms, potentially limiting their participation in co-design efforts. Structuring user engagement with a technology for a longer span preceding co-design efforts allows for insightful contributions to group design sessions.

Our approach to co-design had several benefits on the flow of the design sessions themselves. Participants were able to easily articulate how features should be changed to better fit their actual physical activity behaviors. Through extended use of the technology, participants were also able to report on the features they felt were barriers to use and thus should be removed from the design of future health and fitness applications. Prior engagement with the technology being discussed led to very informed perceptions and opinions of what aspects and features of health and fitness applications were useful and effective to older adults as users, as well as the interaction challenges that they faced that led to abandonment. Participants were able to draw inspiration from their own challenges and successes during the use of their assigned application, and speak more directly about older users' needs for health technologies.

### 5.2 Insights and Lessons Learned

Exposure to a technology intervention prior to ideation or co-design has both benefits and limitations to the feedback elicited during co-design. Benefits include the ability to contextualize design ideas and system features for older adults by providing familiarity with the technology. Participating in a co-design session without some exposure to the technology of discussion might leave many older adults unaware of what these systems are capable of. Although this exposure allowed participants to easily communicate potential future improvements, this also presents the possibility of participants becoming fixated on what a technology currently does and not being able to detach from that existing functionality. This presents a **methodological tension between the need to not bias a participant with the benefit of grounding a participant in technology familiarity**. Future research efforts may want to look at examining participant feedback from co-design sessions

before exposure to a technology intervention compared to that of co-design after exposure. In doing so, researchers can discern any bias that technology use might place on a participants' design ideas. Additionally, Hakobyan [9, 10] expressed a value in collecting reflections and closing thoughts of the participating co-designers at the conclusion of the design session. This may contribute to the designers' understanding how the co-design method can be improved when working with older adults.

Based on our findings and experiences with conducting experience-based co-design sessions with older adults, we provide the following insights for implementing this method in the future:

*5.1.1 Leverage Pre-Study Experience.* Building on pre-study experiences is just as valuable as building from experiences facilitated through the study. Previous research shows the importance of using older adults' knowledge and experiences in product design [28], suggesting that there are a range of ways to initiate the experience-based method. Being inclusive of participants that have previous technology experience, and encouraging recollection and personal sharing during co-creation may be ways to support this approach.

*5.1.2 Facilitate Longer-Term Technology Use.* In addition to the benefit of the types of feedback given for ideal features, utilizing experience-based co-design helped participants better articulate how technology would integrate into their normal lives. By implementing a study design that involved deployment of the health technology intervention, participants were able to experience the natural progression of technology use and thus detail areas of unmet need or technology improvement.

*5.1.3 Use Varied Materials and Instruments for Co-Creation Engagement.* One area that was not explored in this study but that may provide uniqueness in design ideas was the types of materials and instruments provided to participants and whether this had an impact on the types of concepts they came up with. Despite the availability of typical co-design materials in each design session of our study, most participants elected to write out their ideas and build upon each other's concepts through discussion. This approach could be altered to examine whether more structured materials, concrete examples or instrument templates might elicit visual concepts among older adults.

*5.1.4 Establish a Collaborative and Comfortable Approach to Reviewing Brainstormed Ideas.* Similar to previous findings [5, 10], we found that group collaboration during co-design has the benefit of inspiring elaboration on individual ideas among older adults. Utilizing the experience-based co-design approach, participants most notably built off other individual experiences when discussing the justification or reasoning behind a concept that was brought to a larger group. During our co-design sessions, this process was done through open dialogue about brainstormed ideas, where

participants were encouraged to share ideas and concepts in an informal way. This ensured that participants didn't feel pressure to share from the researcher administering the session but would rather be encouraged by their peers to engage in discussion.

*5.1.5 Stratify Group Participants by Experience Levels.* In our design of the follow-up groups there was no systematic assignment of participants with different levels of previous experience to groups. One way to further explore the types of feedback that result from experience-based co-design would be to stratify the number of participants with technology experience and no experience in each group such that there is equal representation of each subset of user.

## 6 CONCLUSION

Designers face the challenge of developing health and fitness technologies that are well accepted and consistently used by older adults. Previous research suggests that co-design with the intended user may benefit the design process, leading to more relevantly designed health technologies. To establish this middle ground, we utilize experience-based co-design with older adults to help inform brainstorming of ideal features for health and fitness technologies. Although this approach to co-creation is unorthodox, benefits of extended technology interaction appear to outweigh the potential risk of biasing this audience.

Positioning older adults as the co-designers of these technologies highlights the needs of this community from a user-centered design standpoint. Leveraging previous experience of the user during the co-design provides a foundational reference point for which older adults can draw on when involved in co-creation for a technology they may not otherwise be familiar with. Utilizing co-design following exposure to a technology intervention may lead to a richer perspective of technology needs that is experience-driven. Thus, designers can benefit from understanding where individuals fall in the matrix of technology experience and exposure, and facilitating technology experience based on the type of intended design outcome.

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