Supporting Physical Activity in Later Life: Perspectives from Older Adults

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ABSTRACT

The older population, especially those living alone, is less likely to meet recommended physical activity levels than other age groups and deserves more attention in this era of population ageing. However, existing technologies for supporting physical activity have been generally poorly aligned with the needs of older adults. Reasons for such problem are manifold, including the lack of involving older adults in design and evaluation, prevalent technology-driven perspectives, and the complexity of designing behavior change technology. Therefore, this research project aims to investigate how to better design behavior change technology to support the needs of older adults living alone for physical activity, which will address four main aspects: meeting user needs, investigating the rationale of technology design, improving co-design practice, and evaluating designed technology. To this end, this project will employ a human-centered iterative design methodology and actively involve the target group in the design process to let their voices heard and incorporated in design. This research will not only contribute to a deeper understanding towards the needs and preferences of this insufficiently studied group, but also identify implications for improving co-design practices as well as design opportunities for future behavior change technology.

KEYWORDS

Behavior change technology, Persuasive technology, Older adults, Human-centered design, Co-design, Accessibility, Physical activity, Health

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1 PROBLEM STATEMENT

The health and wellness of older adults have drawn our attention more than ever before as our society is going through population ageing. In particular, the older population tends to be less regularly active and thus less likely to meet recommended physical activity levels [1], even less so among those living alone [2, 3]. Although there is a variety of information technologies for health purposes including activity promotion, older adults are less willing to adopt and use them compared to other age groups [4]. One of the most crucial factors limiting older adults' adoption is the mismatch between their unique needs and existing technologies [5, 6]. Given that older adults only intend to use new technology if it is useful [7-9] and that behavior change technology can only be effective if it genuinely supports user needs [10, 11], how could older adults use any technology that is poorly aligned with their needs and thus ineffective?

It is important to ask why existing technology geared towards health behavior change do not meet older adults' needs. One of the reasons is that the older population has been generally overlooked in related research. In prior studies on health behavior change technology (i.e., persuasive technology), older adults not only were less targeted [12], but also were seldom involved in design and evaluation [6]. This is especially the case for older adults living alone.

Even if some studies did target older adults, they often decided a priori what technology would be used to support their physical activity, without first asking what older adults really needed [13]. In the area of health behavior change technology, a "technology-driven approach" has been prevalent since most studies revolve around specific behavior change strategies or system features as well as their applications, rather than centering on the needs of target users. This problem worsens the poor alignment between technologies and users.

Behavior change technology has been inadequately designed also because such technology is inherently complex to design. Since a variety of elements involved are intertwined (e.g., behavior change strategies, system features, context of use, etc.) and their roles in system effectiveness remain unclear, it becomes difficult to choose appropriate elements and connect them properly. Such problem exhibits some characteristics of "wicked problem" [14]—the solution is dependent on how a problem is formulated and what factors are studied.

In brief, the lack of focus on older adults and their needs, coupled with the complexity of behavior change technology design, renders those technology unsatisfactory for this group. Thus, there is no wonder to see older adults' hesitance using such technology.

2 RESEARCH OBJECTIVES

To tackle those challenges and design behavior change technology that is more accessible to and truly benefits older adults, we should predicate our design on the real needs of this group. As older adults' needs can be better learnt through involving them in design process [15], we need to design and evaluate technology with them to let their voices heard and incorporated in the design. Therefore, **this research aims to investigate how to better design behavior**

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change technology to support the needs of older adults living alone for physical activity. Given that physical activity is defined by World Health Organization [16] as bodily movement produced by skeletal muscles that requires energy expenditure, this research will focus on walking since it is one of the most common favorite and frequent types of physical activities among the older population [17, 18].

For the goal of *better design*, the *design* acts as both a noun and a verb—it means a better technology design and a better designing practice. Thus, to achieve this goal, we need to answer the following specific research questions (RQ) from four aspects, i.e., meeting user needs, investigating the rationale of technology design, improving co-design practices, and evaluating designed technology.

1. (a) For inactive older adults living alone, what are their habits, experience, and needs concerning daily physical activity? (b) What are older adults' perceptions and needs regarding technology for supporting activity?
2. (a) What kinds of behavior change strategies and system features do older adults envision to support their activity needs? (b) How can those elements be connected and integrated into a behavior change system design?
3. (a) What are older adults' views towards their involvement in design? (b) What are the implications for involving older adults in design to elicit their needs?
4. How does the designed behavior change system perform, in terms of the effectiveness and user experience?

To address these questions, this research will proceed in two major phases.

Phase 1: User Needs Exploration and Design. This phase consists of three parts.

Part 1: User Needs Exploration. This part aims to understand the needs of inactive older adults living alone in terms of supports in activity and identify design opportunities for behavior change technologies. To this end, I will use diary technique to help participants gain awareness of and take notes about their habits and contextual information regarding physical activity in daily lives. Using these notes as prompts, I will then conduct semi-structured interviews with participants to understand their needs and experience regarding activity and to identify design implications. This part will answer research questions 1-a and 1-b and will underlie the next part.

Part 2: Iterative Design. Building on the identified user needs and design opportunities, this research will move through an iterative design process to explore how the elements involved in behavior change technology could be connected and combined from a design perspective. The particular focus on the design process will help identify where the crux of designing behavior change technology lies in and articulate the rationale for designing such technology for older adults. More specifically, I will conduct a design workshop to discuss, sketch, and design low-fidelity prototypes with a subset of the Part 1 participants.

Part 3: Design Feedback. Based on those initial prototypes, I will build a high-fidelity prototype and bring it back to the Part 2 participants for their feedback via semi-structured interviews. Along with the design process, I will use questionnaires to gather participants' views about their participation in design, which could shed light on an enhanced design process involving older adults. Parts 2 and 3 together will answer the research questions 2 and 3.

Phase 2: Evaluation. While the evaluation methods are dependent on the outcomes of Phase 1, I anticipate conducting a longitudinal user study to evaluate the designed behavior change technology developed based on the final prototype, focusing on effectiveness and user experience.

3 METHODOLOGY

This project will employ a human-centered iterative design methodology including requirements gathering, iterative design, and evaluation. The methodology with expected timeline of this research is shown in Figure 1.

3.1 Phase 1: User Needs Exploration and Design

This phase aims to understand the target group's needs and preferences concerning supports in physical activity, and identify how technologies can be designed to provide such supports.

3.1.1 Participant Recruiting and Research Settings. Participants will be recruited according to the following criteria: (1) are aged 65 or over and living alone, (2) partake in no more than 2.5 hours of moderate- to vigorous-intensity aerobic activity each week [19, 20], (3) have an intention to improve their activity levels, and (4) can communicate in English.

Since prior research has inclined towards people with higher familiarity with technology as well as corresponding high-tech solutions, in this research, I want to hear a diversity of views and especially would like to include those who have intermediate or lower proficiency in digital technology (e.g. computers, smartphones, tablets) in Part 2. Thus, I will measure participants' technology proficiency using a technology proficiency questionnaire in Part 1 and ensure to invite those who get an average score of 3 or lower for Part 2.

Following the suggestion of recruiting 20% more participants to offset possible attrition [21], I anticipate recruiting 15–20 participants for Part 1 to ensure a minimum of 8–10 participants for the Part 2 workshop. Since I have been a volunteer and regularly volunteered at the Yellow Door, a local senior center in downtown Montreal, I plan to recruit participants through these established contacts as well as other Montreal-based senior centers by sending fliers, emails, or word of mouth.

This research will be conducted in person, because otherwise some potential participants with lower technology proficiency would be intimidated away by technologies required for remote research. The participant diary will take place at participants' homes in their daily lives by themselves. The interviews with participants and the design workshop will take place at the activity rooms or offices of the senior center, or meeting rooms at the McGill School of Information Studies. Location will be determined based on participants' preference.

3.1.2 Part 1: User Needs Exploration. It is worth noting that while this part focuses on exploring user needs, understanding the needs

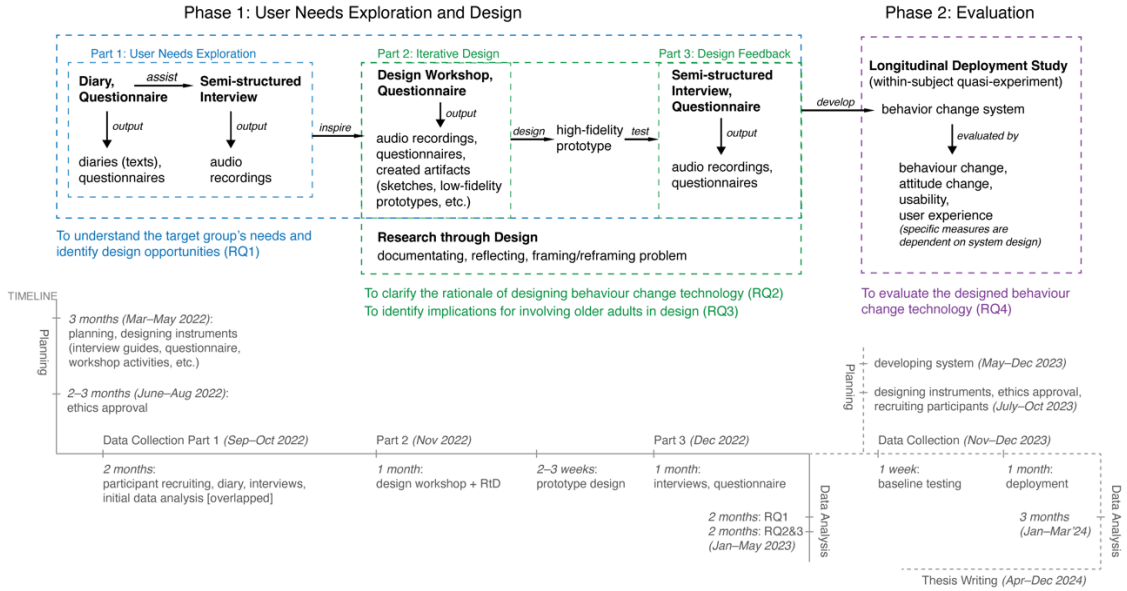

Figure 1: The methodology and expected timeline of this research.

of a heterogeneous group as the older population cannot be completed in a one-off study and is actually an ongoing process throughout the entire research.

At the beginning of this stage and after getting informed consent, a background **questionnaire** will be used to collect participants' demographic data, including age, level of education, financial comfort, overall physical health, physical activity habits, and familiarity with technology. This questionnaire also includes questions regarding participants' intention of behavior change to decide their stages of change [22]. I will also use a technology proficiency questionnaire to measure participants' proficiency in digital technology (i.e., computer and mobile devices). This questionnaire combines the short version of Computer Proficiency Questionnaire [23] and the short version of Mobile Device Proficiency Questionnaire [24], which have been validated in prior studies [25].

To assist interview, the primary data collection technique in this step, I will use **diary** to help participants gain awareness of their habits, experiences, and contextual information about physical activity in daily lives. The exercise notes are neither intended to provide primary data nor to reach data saturation, but to help participants be more prepared for interviews. Though diary is more intrusive and demands more commitment from the participant's side compared to other data collection techniques, it helps record the existence and quantity of user-defined incidents [26]. In this case, diary will help capture the details appearing before/during/after exercising that otherwise might be ignored or forgotten, which also helps reduce potential recall bias in the following interviews. I will distribute to each participant a printed brochure (or booklet) that includes several exercise-related questions for each day (7 days in total). In addition to the activities performed, this diary particularly includes entries about the intention of exercise but giving up halfway. Participants will be encouraged to take notes regarding their daily exercise, rather than being required to complete each entry every day. Such flexible way of implementing diary could alleviate participants' pressure of participation. Collected diaries (i.e., exercise notes) will be used as prompts to expand conversation in the following interviews and provide inspiration for design.

Then, I will conduct **semi-structured interviews** with participants to understand their needs and experience when exercising or intending to exercise, and identify design opportunities. During the interviews, I will not only ask participants a set of predetermined questions regarding general needs and preferences, but also review the completed entries of their exercise notes, if any, with them and ask clarification question to gather detailed and in-depth information. Each interview is expected to take 0.5–1.5 hours and will be audio-recorded. Participants will each receive a $15 cash honorarium for their time.

The processes of participants recruiting, diary, and interviews may overlap and would take two months together. Moreover, initial analysis of collected diary and interview data may also parallel to the data collection process. I expect to use informal analysis techniques (e.g., affinity diagramming) to group ideas appeared in diary and interviews into different categories, which requires less time due to its lower-level attention to details compared to thematic analysis [26]. Based on the findings from the initial analysis, the plan of design workshop activities could be revised to become more detailed and targeted.

This part also allows me to identify appropriate participants for the next part, in that I can ensure that those with intermediate or lower proficiency in digital technology will be invited to participate in Part 2.

3.1.3 Part 2: Iterative Design. Building on the initial findings from Part 1, I will conduct an iterative **design workshop** with participants, where we will brainstorm and mock-up design ideas, moving towards low-fidelity prototypes of potential technology design, which are usually paper-based sketches showing design ideas and basic elements (e.g., visual form and key function). Using the materials from the previous part as prompts, I will rely primarily on paper-based sketches to let participants express their ideas as much as possible. As the leading designer, I will not only encourage participants to discuss what they envision for behavior change technology and comment on each other's sketches, but also feed my analysis back to participants for comments to validate my findings [21]. This iterative design process through the workshop will help deepen our understanding towards target users' needs, while leading to low-fidelity prototypes of target users' preferred technology.

In the workshop I anticipate working with 8–10 participants, considering the level of data saturation as well as the capacity of moderating the workshop by myself. Following the suggestions in literature [21], participants will be divided into two groups, with 4–5 participants per group. The workshop will be scheduled on two days for each group, with each day consisting of one session of no more than 2.5 hours. The Day-1 session will focus on ideation activities, including introduction slides viewing, persona building, scenario generating, and behavior change strategies and system features envisioning. The Day-2 session will focus on prototyping and critiquing, including integrating strategies and features, two rounds of prototyping accompanied by two rounds of critiquing and discussing. Those discussing and critiquing activities in the workshop can be regarded as a series of small-scale focus groups, which, compared to interviews, support more interactivity and provide a more dynamic situation for participants to speak up [26]. Meanwhile, those prototyping activities allow participants to express their needs and ideas by hands-on sketching, rather than relying solely on words.

During the workshop, I will moderate the activities and take notes of design issues using pen and paper; discussion activities will be audio-recorded, and created artifacts (e.g., sketches, notes, prototypes, etc.) will be collected. After each session, I will ask participants to fill in a short five-point Likert-scale **questionnaire** regarding their experience with the design activities in that session [27]. Participants will receive a $15 cash honorarium for each session.

Along with the workshop, I will document and reflect on the design process from ideating, iterating, to prototyping. This step draws on the Research through Design method, which emphasizes that design researchers continually reframe wicked problems during the active design process of attempting to make the right thing [28]. Embedded in the whole design process, this step focuses on researchers framing the design problem of arranging varied elements involved in behavior change technology design, and is expected to generate design knowledge from the codesign process with the target group. I will take reflexive notes right after each workshop session. In addition to documentation, I will compare and combine the designed low-fidelity prototypes from those two workshop groups, and build an integrated high-fidelity prototype (i.e., the 3rd round prototyping), which normally tends be a digital and interactive product with detailed visual design and realistic content, although I am open to lower-tech solutions depending on the outcomes of the workshop.

3.1.4 Part 3: Design Feedback. I will bring the designed high-fidelity prototype back to the participants from Part 2, ask them to explore this prototype, and ask for their feedback via **semi-structured interviews**. Working as a technology probe, the designed prototype would allow participants to complete several sample tasks and help elicit participants' views and reactions to particular design components [26]. I will also ask for their views regarding their involvement in this design via the interview as well as a short five-point Likert-scale **questionnaire**. Each interview is expected to take 0.5–1 hour and will be audio-recorded. Participants will each receive a $10 cash honorarium for their time.

In total, this iterative design process will consist of three rounds of prototyping and critiquing, complemented by documentation and reflection from researcher/designer's perspective.

3.1.5 Data Analysis. Overall, a variety of data will be collected through this phase and will be analyzed to answer RQ1, RQ2, and RQ3 respectively. To understand the target group's needs and identify design opportunities (RQ1), Part 1 interview transcripts will be the primary data, complemented by the discussions in the workshop and the feedback towards designed prototype. To clarify the rationale of designing behavior change technology (RQ2), I will mainly draw on the transcripts of critique activities and created artifacts in the workshop as well as researchers' documentation and reflection towards the entire design process. To identify the implications for involving target group in design (RQ3), I will draw on the collected questionnaires on study activities and the Part 3 interview transcripts.

I will use content analysis technique to analyze data collected from interviews and design workshop (e.g., interview and discussion transcripts, exercise notes, sketches) to identify categories and themes and to answer research questions. Content analysis not only applies to textual information, but also to multimedia materials like drawings [26], which makes it possible to bring those different types of data together and analyze them under the same umbrella. When conducting content analysis, I will use the approach of a priori coding by first drawing on prior related studies to identify major coding categories before proceeding to code the detailed data [26]. I will also use descriptive statistics to analyze quantitative data collected from those Likert-scale questionnaires (i.e., technology proficiency questionnaire, questionnaire on participants' feedback on study activities). Furthermore, findings will be compared to prior studies and also could be connected to models or theories on behavior change. These three segments of data analysis are expected to take four to five months.

3.1.6 Data Storage. Three main types of data will be collected in this phase. I will take care to assure the confidentiality of the collected data during transmission and storage.

1. Fixed choice responses. Participants will be asked to provide their background information (e.g., age, gender, education, profession), their exercise habits, and your familiarity with technology. Participants will also be asked to measure their technology proficiency and provide their feedback on study activities. All of these questions will require either a short

answer (e.g., age) or selection from a small set of options via paper questionnaires. It will not be possible to identify participants from their answers to these questions (either on their own or in combination). Collected paper questionnaires will be scanned, digitalized, and then stored on the McGill OneDrive to support data analysis; the original will be destroyed.

2. Open responses. Participants will be asked to provide open-ended feedback on their needs and experience with exercise via interview, exercise notes, and design workshop discussions. Although the interview, exercise notes, and workshop are designed to avoid gathering personally identifying information, it is somewhat more possible for this data to be linked back to participants as they may describe a unique experience or event that would be familiar to others. Care will be taken to ensure participants' data are edited in publications to protect participants' identity. Audio will be recorded during the interviews and the discussion parts of the workshop to facilitate data analysis and ensure we capture participants' responses fully and accurately. The collected audio files will be uploaded to the McGill provided Word for Web for automated transcription. The audio files and their corresponding transcripts will be stored on the McGill OneDrive. Participants' completed exercise notes in paper format will be collected, scanned, and then stored on the McGill OneDrive, in order to support data analysis; the original will be destroyed.
3. Design artefacts. Participants will also be asked to sketch their requirements for technologies during the design workshop. Although the sketches are not intended to collect their personally identifying information, they might include participants' handwriting that may be linked back to participants. Care will be taken to ensure participants' data are edited in publications to protect participants' identity. Participants' created design artefacts (e.g., sketches, notes) will be collected, photographed, and then stored on the McGill OneDrive, in order to inspire design; the original will be destroyed.

3.2 Phase 2: Evaluation

I anticipate conducting a longitudinal deployment study (within-subject quasi-experiment) involving target users to evaluate the effectiveness of the system for supporting older adults' activity, which will be developed based on the final prototype from Phase 1. Since the specific measures, data collection techniques, and procedures used in the evaluation are depended on the actual system design, the following proposed methods are tentative and drawn from the common practices in prior studies of evaluating behavior change technologies, which mostly were mobile applications that could collect activity-related data via smartphone sensors.

The designed system would be evaluated in four aspects: behavior change, attitude change, usability, and user experiences. During a one-week baseline period, I would use system logs to collect data about participants' regular activity level, and also use questionnaires to measure initial motivation level (i.e., the stages of change) and gather background information. During a one-month intervention period, I would collect (1) activity levels via system logs (e.g., step counts, time, distance, etc.); (2) participants' current motivation level via questionnaires; (3) system usage data via system logs, complemented by the System Usability Scale questionnaire [29]; and (4) participants' feedback via post-study semi-structured interviews. I expect to recruit 30 target users as participants for this evaluation.

If the outcomes of Part 2 turned out to be lower-tech solutions, those four aspects of evaluation could still apply but might be measured by different approaches. For instance, if designed system does not involve smartphones, the automatic system logs of step counts would be replaced by users' self-reports to measure users' activity level, and the system usage data would also be replaced by users' self-reports to measure usability. Whatever the outcomes will be, it is important to use a set of evaluation methods that matches the new design.

This evaluation study is expected to collect both quantitative and qualitative data. I will apply descriptive and inferential statistics to analyze quantitative data such as system log data about activity and system usage data, and apply content analysis technique to analyze qualitative data like participants' feedback from interviews.

4 EXPECTED CONTRIBUTIONS

This research will advance behavior change technology design and accessibility research on older adults in the field of Human-Computer Interaction.

Through actively involving older adults living alone in the both design and evaluation processes, this research will not only contribute to a deeper understanding towards the needs and preferences of this insufficiently studied group, but also identify design opportunities for future behavior change technology. With the special focus on design process, this research will unravel the key elements involved and help explain the rationale of behavior change technology design, identify implications for improving co-design practices, and add a design perspective that is currently scarce in this field. Moreover, the empirical findings accumulated throughout this research can be applied to designing other healthcare technologies and supporting more behavior change goals. In addition to empirical contributions, the methods of involving older adults in exploration and design processes could guide future works towards a further inclusion of target communities in research.

5 CURRENT STATUS

Currently, I am at the early-to-middle stage of my doctoral study in the program of Information Studies. As for the status of this research project, the research proposal has been approved by the committee in my department, and the application for ethics approval has been submitted in June, 2022. While waiting for the approval, I have been working on detailed preparations prior to the initiation of data collection, including practicing my skills of conducting interviews and workshops. Once the approval is issued, I will start recruiting participants, collecting data, and analyzing data.

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