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Implementing a Sedentary Behavior Change Smartphone App in Cardiac Rehabilitation

A Qualitative Analysis Guided by the Theoretical Domains Framework and Capability, Opportunity, and Motivation-Behavior Model

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Background: Smartphone apps used in research offer a variety of capabilities to track and influence behavior; however, they often do not translate well into real-world use. Implementation strategies for using apps to reduce sedentary behavior in cardiac rehabilitation are currently unknown. **Objective:** The aim of this study was to explore (1) barriers and enablers for use of a behavioral smartphone app (Vire and ToDo-CR program) for reducing sedentary behavior in cardiac rehabilitation participants and (2) implementation strategies for future smartphone apps aimed at reducing sedentary behavior in this population. **Methods:** In-depth semistructured interviews were conducted with cardiac rehabilitation participants in the ToDo-CR randomized controlled trial. Participants had used the Vire app and a wearable activity tracker for 6 months. Interviews were audio recorded and transcribed. The researchers used thematic analysis and deductive mapping of themes to the Theoretical Domains Framework and the Capability, Opportunity, and Motivation-Behavior model. Sociodemographic and clinical variables were recorded. **Results:** Fifteen participants aged 59 ± 14 years were interviewed. Most were male, tertiary educated, and employed, and had varying experiences with smartphone apps and wearable activity trackers. Five core themes explaining the user experiences of cardiac rehabilitation participants with the Vire app were identified: (1) being tech savvy can be *both* an enabler and a barrier, (2) app messaging needs to be clear—set expectations from the beginning, (3) get to know me—personalization is important, (4) curious to know more instant feedback, and (5) first impression is key. The themes and subthemes mapped to 12 of the 14 Theoretical Domains Framework domains. Improving engagement and implementation of future smartphone apps for sedentary behavior may be aided by building psychological capability, physical opportunity, and reflective motivation.
Conclusions: Shifting to in-the-moment behavioral nudges, setting clear expectations, assisting participants to monitor their sitting time, increasing the frequency of tailoring, and understanding more about the participant as well as their experiences and needs for reducing sedentary behavior in cardiac rehabilitation are important future directions.

KEY WORDS: cardiovascular diseases, implementation science, secondary prevention, sedentary behavior, telemedicine

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All participants provided written informed consent before participating in the study, which included consent to publish anonymous quotes from individual participants.

The data sets generated and analyzed during the current study (which includes individual transcripts) are not publicly available, beyond what is included in this article, due to individual confidentiality.

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Author Contributions

K.P., R.K., R.D., and N.F. contributed to the conception and design of the study. K.P. completed all interviews. K.P. and R.K. completed the analysis, and K.P., R.K., and N.F. contributed to the critical interpretation of the data and provided intellectual content. All authors contributed to the drafting and approval of the final manuscript.
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Cardiac rehabilitation (CR) has the potential to reduce the risk of morbidity and rehospitalizations through targeting positive lifestyle behavior change such as increasing physical activity and reducing sedentary behavior.[1] Nevertheless, most CR participants are not meeting physical activity and sedentary behavior guidelines.[2] An Australian study found that CR participants were spending on average 11 waking hours per day in sedentary behavior.[3] More options are needed to support participants to reduce sedentary behavior.

As CR participants are interested in support via the Internet and mobile phones,[4,5] mHealth technologies such as smartphone applications (apps) may be useful for decreasing sedentary behavior as a supplement to CR. Still, the complexity of implementing such interventions is broad with some concerns for uptake and retention by participants and healthcare providers.[5–7] Enablers to using mHealth interventions in CR and other cardiovascular disease populations include level of personalization,[5,7–10] professional and technical support,[5,7–9,11] behavior change techniques (eg, goal setting),[5,7–11] tracking elements related to cardiac conditions (eg, heart rate),[7,8,10–12] digital literacy (eg, ability to download, use, problem solve),[7,8] psychological characteristics (eg, motivation, self-efficacy),[5,8] social connectedness,[5] and personal preference.[5] Barriers center around technology issues (eg, draining phone battery).[6,8] The influence of participants' previous experience with using technology (eg, apps and wearable activity trackers) is not well established; however, the perceived ease of use may be a contributing factor for uptake and engagement.[13] Having greater app user engagement is associated with better outcomes for risk factor reduction and management[14]; unfortunately, this is not always achieved. Addressing these factors is further complicated by the speed of technology advancements compared with the slow progress of reporting findings from rigorously controlled clinical trials.[15] Therefore, understanding broad components that influence user behavior is key to improving implementation of mHealth interventions for CR participants into real-world practice.

Few study authors have reported on, or targeted, sedentary behavior through apps for CR participants.[16] Furthermore, there are no authors of qualitative studies exploring user experiences of apps for sedentary behavior change in this population. By gaining an understanding of user experiences, implementation could be improved to provide better support to the complex needs of individuals. Therefore, the research questions for this study were the following:

(1)What were the barriers and enablers to using a behavioral smartphone app (Vire and ToDo-CR program) for reducing sedentary behavior in CR participants?
(2)What would help improve the implementation of future smartphone apps aimed at reducing sedentary behavior after CR?

Methods

Study Design

This qualitative study was embedded in the ToDo-CR randomized controlled trial (n = 120) conducted in Canberra, Australia, commencing in 2020.[17] Participants were 18 years or older, were enrolled in phase II CR with coronary heart disease, and had a compatible smartphone.[17] The ToDo-CR randomized controlled trial explored whether a behavioral smartphone app (Vire) and a 6-month online sedentary behavior change program (ToDo-CR), requiring input from a Fitbit Inspire wearable activity tracker, were effective at reducing sedentary behavior compared with usual care.[17] The Vire app and ToDo-CR program have previously been tested for feasibility before the development of the randomized controlled trial. The Vire app used the behavior change techniques of feedback, action planning, displaying discrepancies between current and goal behavior, habit formation, habit reversal, prompts/cues, and social rewards.[17] The Vire app sent short behavior change messages known as "Dos" in the form of push notifications 2 to 3 times per week at random over 6 months. The "Dos" were informed by the Australian Physical Activity and Sedentary Behavior Guidelines.[18] Participants completed a brief initial questionnaire in the Vire app to collect information regarding personality traits and habitual behaviors related to sedentary behavior. For 1 week, baseline data were collected in the Vire app to establish the participant's "typical" week. The baseline data were used to send personalized "Dos," which were driven by the initial questionnaire, Fitbit activity data, and GPS location. The Vire app integrated these data through machine learning models and was updated on a sliding 30-day window to allow for changes in behavior throughout the 6-month program. The "Dos" targeted sedentary behavior by suggesting activities designed to disrupt usual sitting habits and encourage small lifestyle changes. The program was created to influence sedentary behavior indirectly so participants did not feel the burden of making a significant lifestyle change and that their behavior becomes more flexible in response to different situations.[17] Ethics approval was obtained from the University of Canberra Human Research Ethics Committee (HREC-4561). The Consolidation Criteria for Reporting Qualitative Research checklist was used to guide reporting of this study.[19]

Participants

Only those who were allocated to the Vire app plus CR group (n = 60) were invited to participate on completion of their 6-month ToDo-CR program. Fifty participants between July 2020 and July 2022 were invited to participate via email. The remaining 10 were not invited because of researcher unavailability related to the COVID-19 pandemic. Participants provided written informed consent

before participating in the study. All participants were affected by COVID-19 with varying levels of lockdown and restrictions across their 6-month app use.

Theoretical Perspective

A constructionist perspective was adopted based on the assumption that reality is the product of human interaction, knowledge, experiences, and meanings in the real world and the effect this has on operating within society.[20] This perspective theorizes the sociocultural contexts and structural conditions broadly rather than individual motivations and psychologies.[20]

The Theoretical Domains Framework (TDF)[21] and Capability, Opportunity, and Motivation-Behavior (COM-B) model[22] are used to understand barriers and enablers to facilitate identification of areas to improve future implementation of interventions.[7,23–25] The COM-B suggests a behavior only occurs if the person has the capability, motivation to engage, and opportunity to do it.[22] Under each component, there are several constructs: physical and psychological capability, physical and social opportunity, and reflective and autonomic motivation. The TDF, which consists of 14 domains, assesses implementation barriers and enablers, and supports future intervention design especially when aligned with the COM-B to understand the influences of behavior.[21,25]

Semistructured Interviews

Video-call semistructured interviews lasting 30 to 90 minutes were conducted to explore in-depth the CR participants' experiences using the smartphone app to reduce sedentary behavior. The lead investigator conducting the interviews (K.P., accredited exercise physiologist and PhD student) had a relationship with the participants having provided support in delivering the intervention. Although this holds relative biases from the experience, it also allowed the researcher to build rapport to gain rich data. Participants were made aware that the interviewing researcher was not involved in designing or conceptualizing the app. A topic guide including open-ended questions to explore barriers, enablers, and recommendations for a behavioral smartphone app in combination with CR was used (Supplemental Digital Content 1, http://links.lww.com/JCN/A197). Interviews continued until key themes were recurring and considered beyond the point of sufficiency. All interviews were audio recorded and professionally transcribed verbatim. Participant responses were deidentified to ensure anonymity and privacy. The transcripts were sent to the participants for member checking to confirm the sentiments of the interviews were captured correctly.

Participant demographic and descriptive data were collected as part of the ToDo-CR randomized controlled trial (baseline and 6 months). Questionnaires collected gender, age, diagnosis, relationship status, education, employment, and previous experience with smartphone apps and wearable activity trackers. Sedentary behavior and physical activity minutes per day were measured using a triaxial commercial accelerometer (Actigraph wGT3X-BT) over 7 days.[17] To help gain a better understanding of the interaction of participants with the app in a real-world setting (aligned with a constructionist approach), participants were asked how often they engaged with the Vire app. Participants were classified as being an "engager" if they self-reported using the Vire app weekly across 6 months, a "partial engager" if they used the Vire app at times over 6 months, and a "nonengager" if they chose not to use the Vire app after downloading it. This was confirmed with app user logs.

Data Analysis

The researchers followed the 6 phases of thematic analysis to analyze the data set.[26] A latent approach was used to examine the underlying ideas, assumptions, and conceptualizations from a constructionist paradigm.[20] Using the latent approach, the researchers interpreted the data in relation to the broader research question of implementation strategies for future behavioral smartphone apps aimed at reducing sedentary behavior in this group.[26]

A second researcher (R.K., experienced qualitative researcher, psychologist, PhD), who was not involved in the delivery of the intervention, completed thematic analysis of 3 transcripts independently of the lead investigator (K.P.). Each researcher used inductive data analysis, starting with open coding, and then focused coding using constant comparative methods. The identified codes were discussed between the researchers (R.K. and K.P.) to compare understandings of the content and definitions behind each code until consensus was reached and consistent. One researcher (K.P.) continued analysis of the remaining transcripts. After all transcripts were analyzed, codes were discussed within the wider research team (K.P., R.K., and N.F., experienced qualitative researcher, physiotherapist, PhD). Codes were collated into themes using mind maps and further refined until themes and subthemes were clearly defined and classified as either a barrier or an enabler. One researcher (K.P.) deductively analyzed subthemes against the TDF[21] to see whether the framework was fit for purpose in identifying implementation problems related to the Vire app and broader research questions. This fit was discussed among the researchers (K.P., R.K., and N.F.) who decided that subthemes could be adequately mapped to most of the TDF domains (using the prespecified definitions).[21] Themes were then mapped against the COM-B.[22] Using both thematic analysis and framework analysis enabled the researchers to theorize and identify broad strategies for future app development in this area at the macro level rather than micro details only relevant to the Vire app.

Quotes presented by age, gender, experience with apps and/or wearable activity trackers, and whether they engaged with the Vire app were used to illustrate the sentiment of most participants for themes discussed.

To test whether there was a difference in characteristics between those who agreed to be interviewed versus those who declined, independent *t* tests for continuous variables and χ^2 tests for categorical variables were completed with significance set at $P < .05$.

Results

Characteristics of Participants

Fifteen participants aged 34 to 84 years (mean, 59.4 ± 13.53 years) participated in interviews, and 35 declined (Supplemental Digital Content 2, http://links.lww.com/JCN/A198). Majority were male, tertiary educated, and employed, and had varying levels of experience with apps and wearable activity trackers (Supplemental Digital Content 2, http://links.lww.com/JCN/A198). There were no significant differences between participants who agreed versus those who declined for any characteristics (Supplemental Digital Content 2, http://links.lww.com/JCN/A198).

Core Themes

Five core themes were identified that explained the user experiences (barriers and enablers) of CR participants with the Vire app and ToDo-CR program. The themes were as follows: (1) being tech savvy can be *both* an enabler and a barrier, (2) app messaging needs to be clear—set expectations from the beginning, (3) get to know me—personalization is important, (4) curious to know more instant feedback, and (5) first impression is key. The themes were deductively mapped to 12 of the 14 TDF domains and the 6 constructs of the COM-B (Figure and Table). These themes described implementation strategies important for future smartphone apps aimed at reducing sedentary behavior in this group.

Theme 1: Being Tech Savvy Can Be Both an Enabler and a Barrier

Having previous experience with activity tracking apps or wearable activity trackers was identified as being *both* a barrier and an enabler for participants engaging with the Vire app and related to having the physical capability (COM-B) and "practical skills" (TDF). For some, being "tech savvy" or digitally literate meant they felt comfortable with using the Vire app and chose to engage. In contrast, others examined the Vire app and decided they already had other apps fit for purpose and were not achieving any additional benefit by engaging. This was paired with the perception that others in CR who have not had experiences with apps would have the most to gain by engaging.

> It was for me personally, a chore. But I can certainly see the benefit for others that weren't as used to apps or watches… A reminder for people to get up off your seat and stop being so sedentary…. I typically use my Apple watch but people who didn't have access, it's great. (49-year-old man, full-time employed, previous experience using wearable activity trackers, "nonengager" with the Vire app)

In addition, there was assumed digital literacy on behalf of the researchers as participants needed to own a smartphone to participate. The assumption of being digitally literate was noticed particularly by participants who had no previous experience using activity

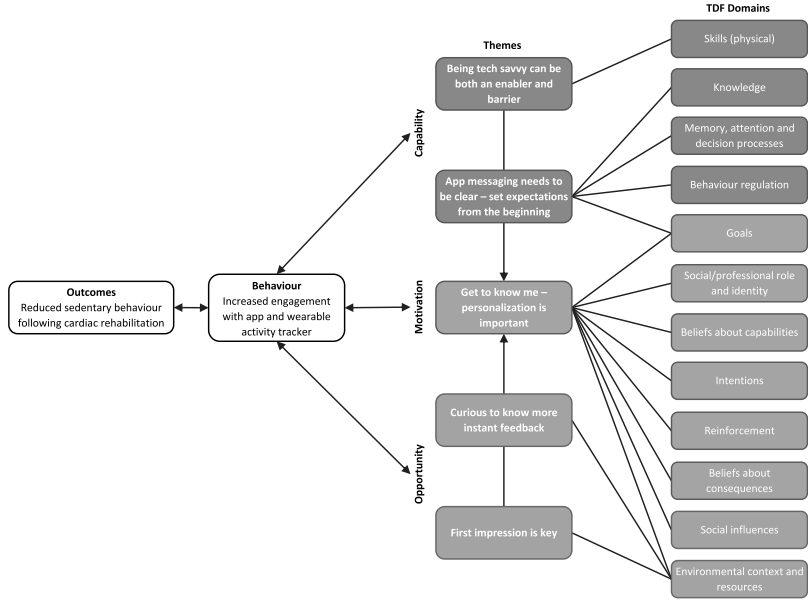

FIGURE. *Thematic map linked to the Capability, Opportunity, and Motivation-Behavior model and the Theoretical Domains Framework (TDF) to improve engagement with a behavioral smartphone app for sedentary behavior change after cardiac rehabilitation.*

TABLE Combined Capability, Opportunity, and Motivation-Behavior Model and the Theoretical Domains Framework Analysis of the Determinants of Using the Behavioral Smartphone App for Sedentary Behavior

COM-B Construct	TDF Domain	Barriers and Enablers to Using the Vire App to Reduce Sedentary Behavior After Cardiac Rehabilitation
Capability		
Physical	Skills	Barrier: Assumed digital literacy of participants on the researcher's behalf
		Barrier: Having previous experience hindered engagement with the Vire app as they already had apps "fit for purpose"
		Enabler: Having previous experience with using activity tracking apps and wearable activity trackers aided some people to use the Vire app as they felt confident and comfortable with technology
Psychological	Knowledge	Barrier: Mismatched expectation of what the app will do and unclear purpose of the Vire app
		Barrier: Unclear that the Vire app was targeting sedentary behavior
		Barrier: Unsure of the specific sitting guidelines to aim for
		Enabler: Knowledge of the importance to shake up sitting habits and reduce sedentary behavior
	Memory, attention, and decision processes	Enabler: Push-notification prompts to check the app and break up sitting
	Behavior regulation	Enabler: Fitbit vibration when hourly step goal not met drew attention to sedentary behavior—prompt to clear movement bar
		Enabler: Prompting the substitution of sitting time with getting up and increasing steps
Opportunity		
Physical	Environmental context and resources	Barrier: Sitting for a purpose such as for work (eg, computer work, meetings) or hobbies (eg, sewing, reading)
		Barrier: Poor first impression led to decision to stop using the app within the first weeks
		Barrier: Frequent technology issues/glitches
		Barrier: Unable to monitor heart rate, blood pressure, and oxygen saturation—future recommendation
		Barrier: Wanting to be able to monitor activity beyond just steps (eg, walking distance, cycling, and other types of exercise)—future recommendation
Social	Social influences	Barrier: Unable to include family or friend as support/companion in the app—future recommendation
Motivation		
Automatic	Reinforcement	Enabler: Setting individual challenges and tracking progress
Reflective	Social/professional role and identity	Barrier: Self-identity as being an "active person"
		Enabler: Self-identity as being an "active person" and/or a nonsedentary person
	Beliefs about capabilities	Barrier: Set at the wrong health literacy level—too low for some and too high for others
		Barrier: Perceived the Vire app and "Do" messages to be geared toward people who are retired and isolated
	Intentions	Barrier: Unable to "opt in" to features
	Goals	Barrier: Wanting clear and specific guidelines or targets for sedentary behavior that were not provided in Vire—future recommendation
	Beliefs about consequences	Enabler: "Health scare" catalyst for change
		Barrier: Underestimate seriousness of heart disease and the need to change lifestyle behaviors

tracking apps. This led to requests for more support in downloading and setting up the app. Needing more support was not necessarily related to age.

> It was harder to connect the watch than expected. (59-year-old man, full-time employed, no previous experience using activity trackers, "nonengager" with the Vire app)

> I'm not averse to technology…. It's the way of life now. (72-year-old woman, retired, previous experience using wearable activity trackers, "engager" with the Vire app)

Theme 2: App Messaging Needs to be Clear—Set Expectations From the Beginning

Understanding the intentions of the app and making this clear from the beginning related to psychological capability (COM-B), "knowledge," "behavior regulation," and "memory, attention, and decision processing" (TDF). A key subtheme was the mismatch between participant expectations of what they thought the app would do. This impacted poorly on engagement and

was frequently acknowledged as a reason to not use the Vire app.

> It didn't do much…. I thought it was supposed to remind me or beep if I was sitting for too long? It didn't, so I got sick of it and cut it off. (84-year-old man, retired, no previous experience using activity trackers, "nonengager" with the Vire app)

This was further complicated with some participants not recognizing that the Vire app's purpose was to target sedentary behavior. For participants who did recognize the app's purpose, they wanted clear messaging around sedentary behavior guidelines to improve their knowledge and for the app to "not be so abstract."

> Make it really obvious. Make that clear distinction between your current sitting behavior and what your goal is. (52-year-old woman, part-time employed, previous experience using wearable activity trackers, "engager" with the Vire app)

There was a general awareness of the need to change sitting habits for their health; however, they lacked practical knowledge on how to do this day-to-day. Many identified themselves as being numbers orientated and finding it relatively easy to increase physical activity (eg, step counts, activity minutes). They instead have difficulty with tracking their progress in reducing sedentary time. Specific targets and ability to track and measure in an app (eg, time guides, activities to check off in breaks) were expressed as being important to enable breaking up sitting time and for monitoring progress.

> Get real-time monitoring…say, by getting up for two-minutes you increased your heart rate by 25% and that break reduces your risk of another heart attack. You basically want to do the minimum to make sure you keep arteries clear. (60-year-old man, part-time employed, no previous experience using activity trackers, "nonengager" with the Vire app)

In contrast, those who understood the app messaging (ie, change sitting habits) were able to engage more with the app and transfer skills learnt across to everyday life.

> I'm standing up talking to you. This whole process of change came, instead of sitting, you do the thing by standing up. (49-year-old man, part-time employed, previous experience using activity tracking apps, "engager" with the Vire app)

Theme 3: Get to Know Me—Personalization Is Important

Fundamentally, participants wanted increased personalization of the app, suggesting more information was needed to be collected about their current and past physical activity levels (specifically the intensity of movement and types of structured exercise they partake in), how and why they are sedentary, work requirements, hobbies, and connections to family and friends. This crossed over with having physical and social opportunity as well as automatic and reflective motivation (COM-B). Addressing "goals," "social/professional role and identity," "beliefs about capabilities," "intentions," "reinforcement," "beliefs about consequences," "social influences," and "environmental context and resources" (TDF) would be required for implementing this level of major personalization.

> I felt it was geared more to people who were at home, isolated, or possibly didn't have a job. I don't spend all day sitting in front of the television. They [app developers] need to have more information about me, tailor it more. (52-year-old woman, part-time employed, previous experience using wearable activity trackers, "engager" the with Vire app)

Whereas some thought the app reinforced what they knew about behavior change, others felt they would need more support than what the Vire app could provide to change their health and lifestyle factors. This also tied into a variance in health literacy and how some participants interpreted their cardiac event as a "health scare" and catalyst for change in opposition to others who were potentially underestimating the seriousness of heart disease.

> It [Vire app] was handy to help get me started however, not for long-term. Maybe if I had serious heart issues, it wasn't a very serious heart attack. (60-year-old man, retired, no previous experience using activity trackers, "partial engager" with the Vire app)

Participants wanted to opt in to features to increase engagement and personalization and the option to include family and friends to assist with motivation and compliance.

> My wife would have checked it and been more rigid in keeping me do it. I'm very habitualized…. Vire challenged me to try do things differently. Including a partner, you're more likely to succeed than battling alone. (64-year-old man, retired, previous experience using wearable activity trackers, "engager" with the Vire app)

A key subtheme was participants self-identifying as being "active people." Being an "active person" was *both* a barrier and an enabler to using the Vire app and was consistent across age, gender, employment, and previous experience with apps. Participants were, on average, meeting physical activity guidelines (ie, 150–300 minutes of moderate- to vigorous-intensity physical activity per week)[18] at baseline and postintervention (Supplemental Digital Content 2, http://links.lww.com/JCN/A198). However, sedentary behavior time in this group was also high (average of >9 h/d; Supplemental Digital Content 2, http://links.lww.com/JCN/A198). This can be linked to the previous theme of participants not understanding that the purpose of the Vire app was to reduce sedentary behavior as opposed to targeting physical activity. Some participants felt the Vire app was not tailored to their physical activity level and that there was a lack of ability to adjust to higher capabilities.

> The easy physical tasks would probably be good for people who are not as active as me. I'm probably not the target. I can see the benefit for others who are not as able…. Getting them up and about is a goal for them. (60-year-old man, retired, no previous experience using activity trackers, "partial engager" with the Vire app)

In contrast, other self-identifying "active people" chose to engage with the Vire app in a way that was complementary to their usual practice and held the attitude of "preaching to the converted." These participants also understood the need to reduce sedentary behavior paired with staying active.

> I liked the reminders, shake up my sitting habits…going outdoors, appreciating nature, scheduling time with loved ones. Not just trying to get my steps. (52-year-old woman, part-time employed, previous experience using wearable activity trackers, "engager" with the Vire app)

Theme 4: Curious to Know More Instant Feedback

Participants of CR were inquisitive about using apps and wearable activity trackers and wanting the physical opportunity (COM-B) of instant feedback they can provide. This relates to providing the "environmental context and resources" (TDF) for the participants to engage in the desired behavior. There was an overwhelming agreement among participants for their preference of the Fitbit over the Vire app regardless of age and previous experience. This was largely due to curiosity for features such as monitoring activity graphs and in-the-moment vibration reminders to get up and move, which were not features of the Vire app.

> I checked the Fitbit more. I'm curious, how far I've walked, my sleep, water intake. I regard them as important and something that I need to maintain. Fitbit is more comprehensive. (78-year-old man, retired, previous experience using activity tracking apps, "nonengager" with the Vire app)

In addition, some participants upgraded or planned to upgrade their wearable activity tracker to be able to monitor heart rate, oxygen saturation, and specific exercise activities such as gym, cycling, and running, which were deemed as important in their recovery and management of heart disease.

> I've upgraded my Fitbit. I want to know more about my body and how it's functioning. (84-year-old man, retired, no previous experience using activity trackers, "nonengager" with the Vire app)

Theme 5: First Impression Is Key

Finally, the decision to use the Vire app occurred within the first couple of weeks of participants receiving access to the app. This related to having the physical opportunity (COM-B) and the "environmental context and resources" available (TDF). A poor first impression of the app led to early disengagement, which did not seem changeable in this group who were generally time poor and with the majority employed full- or part-time.

> I logged into the app. It wasn't giving everything I wanted…. I had other apps fit for purpose so deleted it [Vire app]. (59-year-old man, full-time employed, previous experience using activity tracking apps, "nonengager" with the Vire app)

Not only was it a disinterest of the content and display in the Vire app, but frequent technology issues and glitches (eg, push notifications not coming through) further left participants feeling disappointed and frustrated that it was a poor use of their time.

> It's [Vire app] making me work harder to get them [notifications]. The onus is on me to check the app rather than the app alerting me to things which is disappointing. (52-year-old woman, part-time employed, previous experience using wearable activity trackers, "engager" with the Vire app)

Discussion

In this study, the user experiences of CR participants with the Vire app and ToDo-CR program were explored. Implementation strategies important for future smartphone apps aimed at reducing sedentary behavior relate to the COM-B constructs of building psychological capability, physical opportunity, and reflective motivation. Considering first impressions, providing instant feedback on behavior data, using major personalization, clear app messaging about sedentary behavior, and the digital literacy of CR participants are important for increasing engagement.

Overall, participants were inquisitive about using apps and wearable activity trackers regardless of their previous experience. In addition, having previous experience acted as *both* a barrier and an enabler for interacting with the Vire app (theme 1). This conflicting finding may be attributed to personal preference, and regardless, those who like and want to use technology may have the most to gain by engaging in app-based interventions irrespective of age or experience.[27] Future interventions may instead benefit from tailoring apps that participants are already using. Furthermore, acknowledging personal preference may assist with real-world implementation irrespective of CR participants' digital literacy,[6] especially as more apps and wearable activity trackers infiltrate the market.

Using behavioral nudges[28] through messages can be effective at modifying behavior and enhancing adherence in CR participants.[29] Although participants in the current study found the push-notification "Dos" enabling, there may be more of a need for in-the-moment nudges with clear messages rather than random nudges as delivered by the Vire app—that is, sending "Dos" to remind them to get up when they are partaking in sedentary behaviors rather than at random. Participants expected an alarm or other kind of clear prompt for when to break up sitting (theme 2). Previous research has noted the importance of knowledge and in-the-moment understanding.[5] Future apps could benefit from using this type of nudge especially when considering the habitual nature of sedentary behavior.[30] Shifting to in-the-moment behavioral nudges could be an important enabler for CR participants to engage with sedentary behavior change smartphone apps and may improve the clarity of messaging.

The most complex implementation issue spanning across most TDF domains and the sole contributing

What's New and Important

- Having previous experience using smartphone apps and wearable activity trackers was *both* an enabler and a barrier for engaging with a smartphone app behavioral intervention targeted at reducing sedentary behavior.
- Considering first impressions, providing instant feedback on behavior data, using major personalization, clear app messaging about sedentary behavior, and the digital literacy of CR participants are important for increasing engagement.
- The findings reported can be used to guide future development of similar mHealth interventions in CR by using the identified implementation strategies.

factor identified as responsible for motivation was app personalization (Figure 1, Table; theme 3). This was particularly evident for reflective motivation (COM-B), which requires increasing understanding about the behavioral target of reducing sedentary behavior and creating a form of motivational feedback loop.[22] The Vire app and ToDo-CR program were individualized and adaptive based on the baseline behavior and personality questionnaire, and the Fitbit and GPS data.[17] Despite this, participants in the current study still did not feel it was personalized enough. Interventions shown to be more effective over time use frequent updates and moments of tailoring compared with interventions that ground their personalization off a baseline assessment.[31,32] Increasing the frequency of tailoring and understanding more about the participant and their needs is imperative to improving the user experience and enabling use of sedentary behavior smartphone apps for CR participants.

The current study highlighted that participants were curious for more in-depth feedback about health metrics and their behavior (theme 4). Having a wearable activity tracker included as part of the intervention influenced behavior by creating a physical opportunity (COM-B) and enabled an environment where the participant's attention is drawn to behavior change provided they also had the capability and motivation to use it.[22] However, this inclusion perhaps came as a hindrance to using the Vire app and left some participants not realizing that the overarching purpose was to reduce sedentary behaviors, not maintain and increase physical activity. Another component to behavioral feedback is that participants expressed being able to easily track and increase their physical activity as there is a numerical value frequently assigned to this behavior (eg, steps) (themes 3 and 4). This is a less explored area for sedentary behavior and a behavior change technique that is not readily used to try reduce sitting time in CR participants.[33] A barrier to trialing this is that sedentary behavior guidelines are currently lacking specific details beyond it is important to limit the amount of time sitting and lying down,[18] as the evidence is still emerging. In addition, this is something that needs to be clearly explained and differentiated for CR participants with many self-identifying as "active people" yet still being highly sedentary. Exploring ways to assist participants to monitor their sitting time explicitly through an app would help build their capability and motivation to change sedentary behavior.

Implications

Using the COM-B and TDF was instrumental in gaining a more complete understanding of the determinants for participant engagement with a sedentary behavior change smartphone app. These 2 models allowed the researchers to highlight practical recommendations to improve implementation especially when mHealth interventions date rapidly with technology updates. The current study supports shifting to in-the-moment behavioral nudges, setting clear expectations, exploring ways to assist participants to monitor their sitting time, increasing the frequency of tailoring, and understanding more about the participant as well as their experiences and needs.

Limitations

One of the limitations to this study was the small number of participants who agreed to be interviewed. Those not consenting may have felt uncomfortable disclosing to the interviewer whether they had criticisms for the Vire app, which may have led to missing aspects of the data set. The smaller sample may also limit the generalizability. However, the findings should not be undermined because of the in-depth exploration completed using the COM-B and TDF lens focusing on future implementation strategies. Second, an inexperienced researcher conducted all interviews and most of the thematic analysis and was involved in delivering the Vire app intervention, leading to possible biases. This researcher is, nonetheless, a practicing clinician with 6 years of experience, the analysis process was checked and discussed with other members of the research team who are experienced qualitative researchers, and participants were made aware that the researcher was not involved in the design or conceptualization of the app.

Conclusions

Considering a high level of personalization, participant digital literacy, access to behavioral data for feedback, clear messaging, and positive first impressions are important strategies for future smartphone apps aimed at reducing sedentary behavior for CR participants. Future research would benefit from building on the evidence of this study to improve implementation and engagement with behavioral apps for sedentary behavior in a CR context.

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