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Article

Development of an Android Mobile Application for Reducing Sitting Time and Increasing Walking Time in People with Type 2 Diabetes

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Abstract: Breaking up prolonged sitting by short bouts of light physical activities including standing and walking has been shown to be beneficial for people with type 2 diabetes (T2D). This paper presents the development of an android mobile app to deliver a just-in-time adaptive intervention (JITAI) to reduce sedentary time in people with T2D. A total of six design workshops were conducted with seven experts to identify design requirements, a behavioural framework, and required contextual adaptations for the development of a bespoke mobile app (iMOVE). Moreover, a focus group was conducted among people with T2D as potential end-users (N=10) to ascertain their perceptions of the app. Feedback from the focus group was used in subsequent iterations of the iMOVE app. Data were analysed using an inductive qualitative thematic analysis. Based on workshops, key features of iMOVE were developed, including simplicity (e.g., navigation, login), colours and font sizes, push notifications, messaging algorithms and a triggering system for breaking up sitting time and moving more. Based on the user testing results, a goal setting tab was added, font sizes were made larger, the brightness of colours was reduced, and a colour indicator was used to indicate device connectivity with an activity tracker. A user-centric app was developed to support people with T2D to transition from sedentary to active lifestyles.

Keywords: sedentary behaviour; smartphone; mobile app; just-in-time adaptive intervention (JITAI)

1. Introduction

Sedentary behaviour (SB) refers to any waking behaviour characterised by an energy expenditure of 1.5 or less metabolic equivalents (METs) while in a sitting, reclining or lying posture [1]. Device-based data from the 2011-12 Australian Diabetes, Obesity, and Lifestyle Study (AusDiab) showed that, on average, Australian adults spend 8.8 hours per day sitting [2]. Using device-based measures of SB, it has been documented that people with type 2 diabetes (T2D) spend around 65% to 75% of their daily waking time sedentary,

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which is higher than other population groups [3]. In addition to physical inactivity, excessive time spent sitting is now acknowledged as being a distinct risk factor for all-cause mortality and incident of non-communicable diseases including T2D and cardiovascular disease [4]. Moreover, prolonged sitting among people with T2D is associated with poor glucose homeostasis [5]. SB adversely affects mental health outcomes including depression and cognitive function as well as health-related quality of life [6].

Breaking up sitting time with activity is encouraged for maintaining good health in adults and older adults including those with chronic conditions [7]. Interrupting sitting by standing and light walking has been shown to improve markers of cardiometabolic risk (e.g., insulin sensitivity, lipid profile and diastolic blood pressure) in overweight adults [8]. In people with T2D, reducing and breaking up prolonged sitting time via light-intensity physical activity (e.g., slow walking) has been shown to improve glucose homeostasis and insulin sensitivity [5, 9, 10]. It is recommended for people with T2D to regularly break up their sitting time with activity in order to progress toward a more active lifestyle [11]. Recently, Dunstan and colleagues introduced the concept of a staircase approach for transitioning from SB to a more active lifestyle for cardiovascular health [12]. As a starting point to reduce overall sitting, this approach initially involves increasing standing and moving followed by increasing light-intensity activity [12]. Sitting less and moving more can provide an important initial foundation for the longer-term transition to higher-intensity activity and improved cardiorespiratory fitness [12].

Digital health behaviour change interventions have been shown to be effective in reducing SB [13]. Digital interventions using smartphones and wearable sensors (i.e., mHealth) offer unique opportunities for delivering interventions at more temporally salient moments and therefore maximise the potential opportunity for sustained behaviour change [14]. Referred to as just-in-time adaptive interventions or JITAIs, these interventions utilise collected data (I.e., sensor data) to adapt components of the intervention to a person's changing context (where) and status (when) [14, 15]. In the context of PA and SB research, more evidence based JITAIs are needed, including those informed by theory and effective behaviour change techniques [16].

This paper describes the development of an android mobile application (iMOVE app) to deliver a JITAI aimed at reducing sitting time and increasing physical activity in people with T2D. For the proposed JITAI, a mobile app was required to connect to a wearable sensor (called SORD) to provide near/real time data on people's SB and PA, and to provide contextual information using smart phone sensors and Internet-connect information (e.g., GPS for location, weather forecast, accelerometers, etc.) [17]. Here we describe the development stages of the iMOVE app. Specific aims include (1) to describe the user-interface including app content, data collection, wearable sensor integration, theory and behavioural content; and (2) describe user-design with the target user group (adults with T2D).

2. Materials and Methods

2.1. Overview

A dual-stage mixed methods study was conducted. Stage one consisted of interdisciplinary workshops and meetings to design a bespoke mobile app (iMOVE). Stage two involved focus group with end-users and subsequent modifications of the app based on user feedback. Ethical clearance was granted by The Deakin University Human Research Ethics Committee (DUHREC).

2.2. Stage one: Designing iMOVE

A series of six workshops were conducted to develop a specification document for iMOVE, which included defining design requirements (such as activity tracker, system, etc.), behavioural framework and contextual adaptations (e.g., weather, etc.). Workshops comprised of public health experts, exercise scientists, digital health experts, computer and information technology scientists, and engineers. In this phase, discussions were centred on app features, navigation and functionalities, aesthetics aspects (e.g., colours) and

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content including framework and messages. After agreeing on the app features, content, contextual information and behavioural framework, the team ideated and created an app workflow (Figure 1). A logic flow was created by the computer scientists for designing the backend, frontend, user interface and machine learning algorithms (Figure 2). Based on the logic flow, the main features were specified and then a mock-up was created using Adobe XD [18], a platform that enables designers to design the layout of the app pages while connecting these to navigation structure. At the end of stage 1, a beta version mobile app was designed (See results for detail).

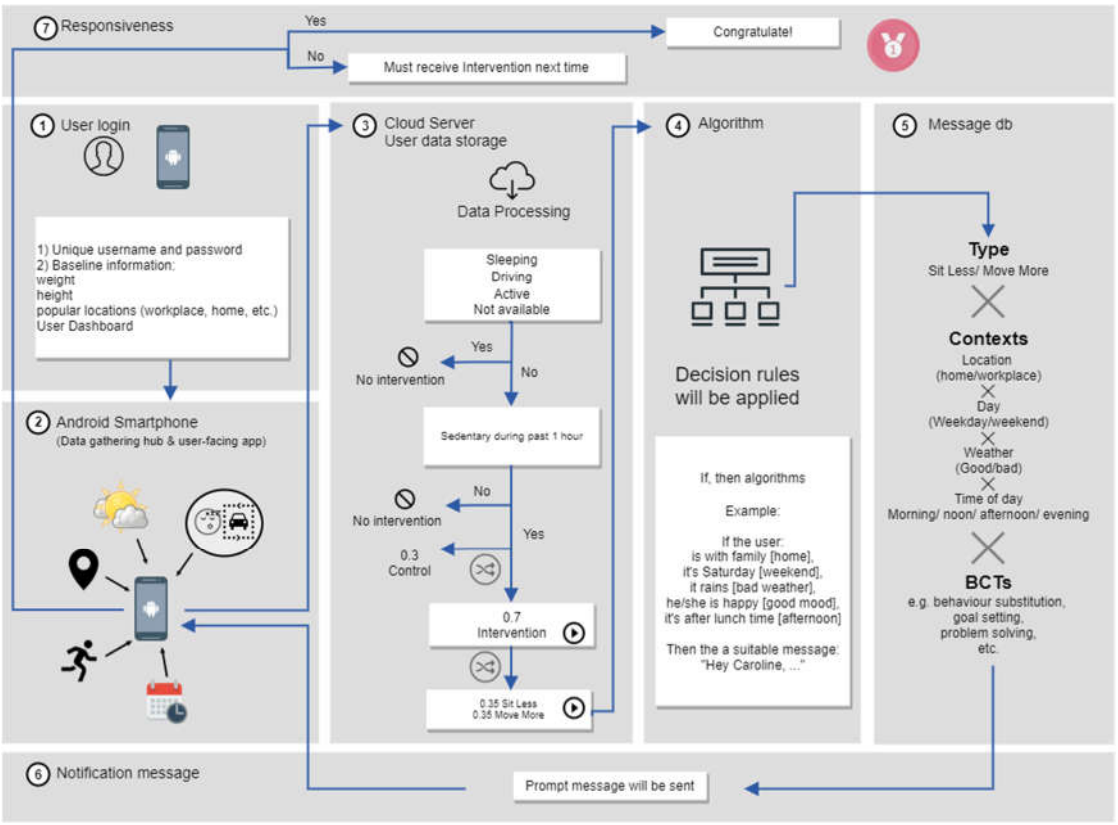

Figure 1. Workflow of the iMOVE app.

db, database; BCTs, beahviour change techniques.

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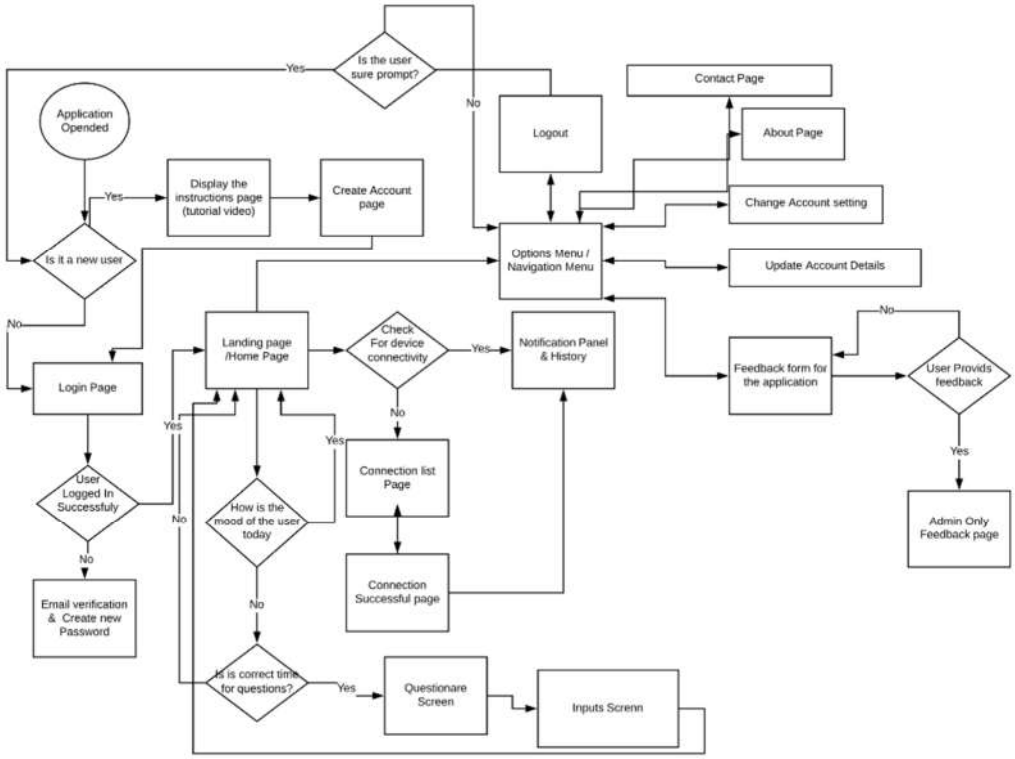

Figure 2. Logic flow of the iMOVE app.

2.3. Stage two: Focus Group

The second stage involved an online focus group conducted via Zoom with people with T2D (N=10; mean age=49.0 ± 8.6 years). Participants were provided with a beta version of the iMOVE app to install on their mobile phones and provide feedback. Study researchers (BM & RD) used structured questions (see Supplementary File 1) to guide discussions. First, an introductory group discussion was conducted to obtain information about users past and current experience with health apps. Then, participants were asked to provide feedback about the functional features, aesthetic (i.e., look), and content of iMOVE. Moreover, participants were asked whether they are willing to have each feature on their own mobile phone. The app features were subsequently revised by the healthcare research and information technology team, based on findings from the focus group.

2.4. Analysis

For stage two, an inductive qualitative thematic analysis [19] and quantification of participants' preferences was undertaken. Sessions were recorded, transcribed verbatim and analysed using NVivo 12 (QRS International Pty Ltd., Melbourne, Australia).

3. Results

3.1. Stage one

3.1.1. App features

Key findings from the design workshops included the need for simple navigation of the app, with a limited number of tabs to scroll through. The iMOVE app required a Bluetooth connectivity function to connect with the SORD wearable sensor. Other features identified were the colours of the app, the registration and login structure, security protocols, the need for a cloud server, data storage, messaging (or notification) algorithms and a triggering system for delivering notifications. Workshops also discussed the feasibility of obtaining important contextual information including, location information obtained

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using the smartphone's GPS, weather information using OpenWeather representational state transfer (REST) application programming interface (API) (London, UK), and time using Android LocalTime API. Based on the detailed specification document, we developed a Beta version of the app, which required 10 weeks for development. The Beta version was then utilised in Stage 2.

3.1.2. Notification messages

Findings from our previous systematic review on JITAI identified the need to ensure push notifications from the app, and include effective behaviour change techniques (BCTs) to reduce SB and increase PA [20]. BCTs including behaviour substitution [21], social support [22], problem solving/ barrier identification [22], instruction on how to perform the behaviour [21, 23], providing information on the consequences of PA specific to the individual [22], prompts/ cues [23], prompting generalization of a target behaviour [22], goal setting [22], self-monitoring [21] and feedback on behaviour [21] were found to fit with the JITAI concept of the current app. These BCTs were used to create two set of messages including Sit Less and Move More. Four researchers with content knowledge assessed the messages in terms of relevancy and clarity and provided feedback for improvement. Messages were further modified and then categorised into relevant contexts and then transferred into a database (See Supplemental Table 1 for example messages). A set of decision rules (algorithms) was defined for triggering micro-randomisation and intervention delivery at certain times and contexts (See Figure 3 for detailed example).

3.1.3. Wearable sensor/ physical activity tracker integration

Sedentary behaviOR Detector (SORD)– a prototype physical activity sensor, which has been validated in a previous study [24]– was used to communicate with iMOVE app for real-time measurement of sitting, standing and walking. It is noteworthy that iMOVE can potentially connect to the other third-party activity devices with Bluetooth capability, even though some minor backend work will be needed to implement the activity recognition of other devices.

3.2. Stage two

Participants' demographic information are presented in Table 1. Results of focus group including experience with health apps, task-specific feedback about iMOVE and feedback about aesthetic aspect, functional features and content of iMOVE are summarised in Table 2.

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Table 1. Demographic information of study participants.

Variable	Mean ± SD	Range
Age (years)	49.0 ± 8.6	36-61
Years diagnosed with T2D (years)	7.9 ± 8.3	0.25-29.0
	N	**Percentage (%)**
Gender		
Female	7	70
Male	3	30
Ethnicity		
Australian	6	60
Indian	3	30
Italian	1	10
Education Level		
Degree higher than Bachelor (Bachelors with honours, Masters, PhD)	2	20
Bachelor's degree	5	50
TAFE/ University course below Bachelor's degree	3	30
Job Status		
Full-time salary or wage earner	9	90
Retired	1	10
Marital Status		
Married/ Living with partner	8	80
Single/ Never married	2	20

T2D, type 2 diabetes; SD, standard deviation

3.2.1. Past and current experience with mobile apps

Most participants liked apps that offered multifunctionality and included reminders (e.g., Samsung Health app). Tedious sign-up and sign-in process was disliked by most. Also, participants were concerned about their data privacy and felt their data is being sold to other companies.

3.2.2. General feedback, aesthetic, functional and content of iMOVE

Most participants liked the information on the home tab of iMOVE, which includes a donut chart illustrating sitting, standing and walking time for the current day and historically (see Figure 3). They were concerned about their privacy regarding the personal information presented in the profile tab. Participants liked the overall colours and colour distinction in the donut chart, however they thought some colours were too bright. Also, participants encountered problems in using the activity tab and found it unclear. Considering the functional aspects of iMOVE, most participants found the app easy to navigate but stated that functionality of Bluetooth icon was unclear. Most participants liked the intervention messages especially the real-time nature of notifications.

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Table 2. Results of the iMOVE app focus group including domains, feedback (frequencies) and example quotes.

Domain	Feedback (frequency)	Example quotes
Past and current experience	Apps mentioned in the discussion: Samsung health app (4) Sonny Lifelog app (1) Healthy mummy app (1) Zombies, Run! (1) Red tomatoes app (1) MyFitnessPal (1) Fitbit: Health and Fitness (1) Likes and dislikes about these apps: ***Likes:*** Already installed (3) Easy to navigate (2) Multi-functional (5) Connects to watch (3) Congratulate or reward (5) detect activities (1) automatic record of data/ not requiring user input (4) reminders (e.g., to stand up and move) (5) setting reminder frequency (2) ***Dislikes:*** sign-in process (3) apps that do not count short activities (1) receiving repeated information repackaged in different forms (2) Issues about these apps: ***Privacy:*** advertisement/sharing personal information with other companies (4) asking non-relevant information (e.g., access to camera and gallery) (1) felt big companies (e.g., Samsung) might handle personal data better/more secured (1)	"I use a Samsung health APP as well, and I mean it records your steps you can record what exercise you do while walking. I mean that's all I'm using it for is walking and you can put it in your blood sugar levels, you can track keep track of your weight, so it automatically records the exercise you're getting and then you can put in important information, so I found that good." "The best part about the Sony one that I was using was; it could determine whether I was riding my bike or walking or I was in the car." "You need something that is easy to log into so that the signing process needs to be seamless. To either connect to your Facebook account or your Google account some sort of other authentication." "With my android watch, you could set whatever frequency wanted, say 20 minutes 30 minutes 40 minutes, but for some reason they did away with that so function, now there is something in between, with the Samsung watch, but you can't choose the time. It'd be nice to have something that will remind you at frequency, you would like to set." "The problem I had with a mobile app was that you had to walk for at least three to four minutes for it to start counting your steps so if you're just doing a short like two minutes' walk, I know it's not much, but it would not count those steps at all." "It is a big killer for me so some of the Apps will give you repeated information and repeated notifications. They are just repackaging it in different forms, like today, you walk 10 kilometres more than last week, you are working this more than this so that kind of takes away the joy because it's there just for selling things to you." "Why do they ask us to allow access to camera and gallery and stuff because they just make no sense to me, I mean location, I understand, because they want to capture kilometres or meters whatever you want, but I don't understand why access to other pieces of information." "…some time you know I've talked about something, and I've not done a Google search or anything and then suddenly all beginning ed's for whatever it is so I'm pretty sure my phones listening to me, even when it's not theoretically doing anything."
General feedback	Task-specific feedback about iMOVE: ***Likes:*** Simple and easy login (3) overall simple app and user-friendly (6) information on home tab (8) ***Dislikes:*** Select activity not working (4) [worked for 2 participants]	"I like the donut and I was really happy to see that even cracks how many minutes are you standing for." "Look once I was able to login it's pretty simple it's pretty quick, I'm using a very old Android phone, but it is not very data-heavy in this, it is never getting quite quickly."

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	Activity details are limited (4) did not understand the purpose of select activity/ how to use it (4) didn't understand the purpose of current job status and education level (in the profile tab) (5) concerned with privacy of information in profile tab (e.g., birth data, etc.) (5) set wake up time (they wanted separate wake-up time selection for weekend and weekdays) (3) didn't understand the purpose of sleep time (3) ***General suggestions to improve iMOVE:*** Guide/instruction on how to select activity in the activity tab (4) put age rather than date of birth in the profile tab (1) provide a clear explanation of where these PA data are used for (2) calculate BMI (2) and calorie (4) wanted their historical data to be used and to set goals (3) wanted to see other activities (e.g., cycling) as donut chart (2) wanted percentage of daily sitting/standing activities (1) alarm for sitting (1) there seems to be other similar names as iMOVE in App store/Google play (2)	"I think the label for that tab (select activity) needs to be clear that it's actually reporting your activity as opposed to selecting it so sort of a trigger there what you're expecting the user to do." "… so, you can put a blurb if you want in there to say you know once you've completed the activity just you can report it here, whatever the wording, but there is quite a bit of space that you can use to put a blurb." "Just I mean if it's what I guess the relevance (of date of birth information) is how old you are, so I mean you just if you ask the year, rather than the birth date or something." "The installation process had a few hiccups but I'm sure your mind is around. There were instances where I had to close the APP and then come back the next time." "The only uninteresting part for me was the profile page because it was not giving me any data-driven analysis I just didn't I didn't even know why was there, but other than that, I like the other two pages."
Aesthetic	<u>Feedback about the aesthetic aspect of iMOVE:</u> ***Likes:*** Colour of donut chart (sitting: red, standing: blue, walking: green) (5), font of the main tabs (e.g., Home, etc.) and headlines (4) icons (2) ***Dislike:*** Small fonts within the pages (writings) (3) red colour in donut chart is too bright/ not suitable for sensitive eyes (3) small font in Home and Notification tabs (2)	"The font for the tabs and that sort of thing is clean and clear and the contrast between the tab you selected, and the rest is a clean user experience." "The font at the bottom for the home and the activity notifications is a bit small."
Functional	<u>Feedback about functional features of iMOVE:</u> ***Likes:*** Quick and not heavy (4) easy navigation (6) ***Dislike:*** Login issues (4), Bluetooth icon is unclear (5) worried that Bluetooth device connection needs to be checked frequently (2) ***Suggestions to improve iMOVE:*** Put colours (red/green) for the Bluetooth (6)	"The login process with your app was clunky so the registration process. Then it wouldn't let me login." "I find it strange that, on the landing page, you have a little icon on the top that says Bluetooth what's that for?" "Do you foresee that that kind of research connect disconnect function will be happening frequently. Now my thought process was that you have a nice simple interface, and the homepage if there is something that is not frequently used why Keep it up there, why don't you embedded somewhere inside. Or, if you want to keep it up on the front page maybe you can have a change colours if it's if it's green and you don't care about it, if it does rain, then you have a problem that you need to go and have a look into it."
Content	<u>Feedback about the content of iMOVE:</u> ***Like:*** Personalised messages (5) real time messages (6) ***Suggestions to improve iMOVE:*** Profile picture can be an Avatar (1) Personalisation (1) self-monitoring (1) instant reaction (3)	"…why not build that functionality in your message, where you get an instant reaction from people, so people can, like you, they can you know, like put thumbs down, they can say salsa and then so you're getting a continuous loop of feedback from people."

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	"Yeah, I think the ability to personalize their whether you do want those prompts or that."
	"Self-comparison is important so yeah I think that would be nice but in terms of your data it's nice to know where it's going."
	Suggested messages: "Maybe pick up the kids from school whatever you know, take the dog for a walk I don't know there's things where you wouldn't do that if you're in the office basically."

3.2.3. Modifications

Based on user's feedback, potential modifications were further discussed with the research team and decisions were made to iterate the iMOVE app. A goal-setting tab was added to the app to enable users set personal weekly "Sit and Move goals". General modifications involved increasing font size, reducing the brightness of colours, replacing the term "Bluetooth" with "Device", and inserting colour indicators for the Bluetooth connectivity (red, not connected; green, connected). Further, technical issues were resolved "e.g., problems with select activity tab", and some notes were added on the activity tab to guide users (e.g., "select date/time and activity here"). Date of birth was removed from the profile tab and, instead, age was presented. See Figure 3 for the iMOVE app images.

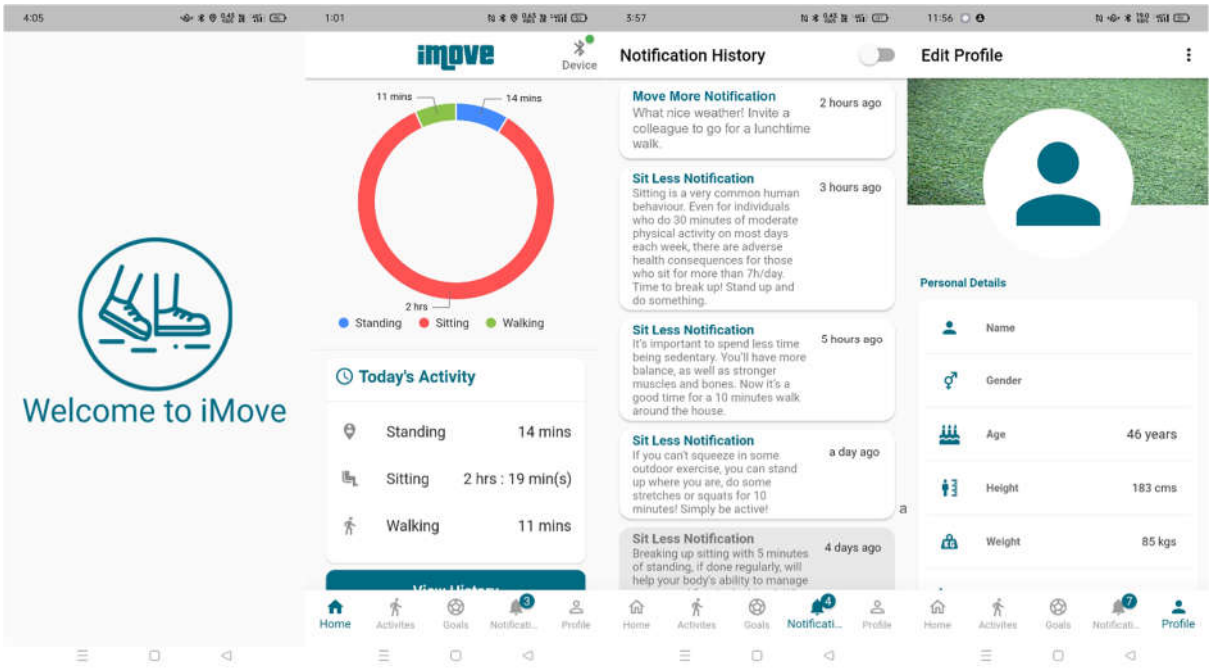

Figure 3. iMOVE app images after modifications.

4. Discussion

The purpose of this study was to describe the development of an Android mobile app for delivering a real-time and adaptive intervention to reduce sitting time and increase non-sitting time i.e., standing and walking among people with T2D. The initial selection of features for the iMOVE app was based on a review of literature to deliver a JITAI, in addition to considering other features such as simplicity and aesthetic. The research team developed a basic app for delivering a JITAI and presented the app to the end-users for feedback. Overall, the app was found to be simple and useful by potential users. A few amenable areas and new essential features were identified (e.g., goal setting

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tab). The app and its content were revised based on the feedback on general, aesthetic and functional aspects.

The iMOVE app is designed to help people transition from a sedentary to an active lifestyle by initially breaking up prolonged sitting time using activities such as standing or taking a short walk inside or outside the home. These are small, yet significant changes in behaviour that can provide a preparation base for the individual to pursue further behaviour change to achieve an activity goal. Available evidence has highlighted that apps are effective in reducing SB, however there's scarcity of mobile apps for SB reduction among adults including people with T2D [25]. Moreover, delivering JITAIs by utilising either sensors or apps to reduce SB and promote PA is in its infancy [26]. It is argued that most JITAIs that have targeted PA are not truly adaptive and have used generic messages delivered at pre-set times [27].

Contextual information is important to provide more specificity on correlates of SB and PA, which will result in better targeting of intervention [28]. Evidence suggests that variations in weather reduces PA of people with T2D [29, 30], and therefore accounting for weather in the interventions can help overcome this barrier. Strategies including adaptations to weather conditions (e.g., wearing tight clothing, short bouts of PA, etc.) and shifting to more indoor activities have been recommended for unfavourable weather conditions [29]. Also, in general, PA level is higher during weekdays and lower in weekends among people with T2D [3] although individual responses may vary. Locations such as home and workplace are key environmental factors for determining PA [31]. Evidence suggests location is the most important factor in receptiveness of SB intervention [27]. The iMOVE app uses GPS to tailor the intervention messages to individual's home and workplace locations.

Previous JITAIs developed in the context of PA and SB have lacked a theory basis, which is necessary to support behaviour change [26]. iMOVE app push messages were informed by a range of established BCTs to test the effectiveness of individual BCTs and generate new evidence.

4.1. Strength and limitations

Strengths of the present study include a focus on both standing and moving to reduce SB. A prototype activity tracker enabled iMOVE to collect real time data about standing in addition to sitting and walking. Testing iMOVE will generate new behavioural and contextual evidence about sitting, standing as well as walking. A limitation of the study is the lack of mood assessment and inclusion in the contextual data collection. Psychological state i.e., mood is found to be associated with SB [33, 34]. Another limitation is the adaptation of iMOVE intervention was limited to a number of settings (home and workplace) and did not include locations such as recreational sites and neighbourhood parks, etc. Also, we did not employ a full co-design methodology, which would have involved end-users from the beginning of the app development. Moreover, due to the online nature of focus group users did not have a SORD device with them to check for connectivity. However, they could use the device connectivity function and scan for devices.

5. Conclusions

In this paper, the development of an android mobile app (iMOVE) to deliver a JITAI to reduce SB and increase PA among people with T2D is described. Future research will involve a micro randomised controlled trial to evaluate iMOVE in people living with T2D.

Author Contributions: RD, RM, SMSI, DD, and MA designed the study and attended the workshops to discuss the design requirements. MA programmed the app. RD and BM conducted the focus group sessions. RD has performed the data analysis. RD drafted the paper. All co-authors—RM, SMSI, DD, MA, and BM—contributed to the critical revision of the manuscript and approved the final manuscript. All authors have read and agreed to the published version of the manuscript."

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical mandates.

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Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Tremblay, M.S., et al., Sedentary behavior research network (SBRN)–terminology consensus project process and outcome. International journal of behavioral nutrition and physical activity, 2017. 14(1): p. 1-17.
2. Healy, G.N., et al., Replacing sitting time with standing or stepping: associations with cardio-metabolic risk biomarkers. European heart journal, 2015. 36(39): p. 2643-2649.
3. Kennerly, A.M. and A. Kirk, Physical activity and sedentary behaviour of adults with type 2 diabetes: a systematic review. Practical Diabetes, 2018. 35(3): p. 86-89g.
4. Biswas, A., et al., Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. 2015. 162(2): p. 123-132.
5. Paing, A.C., et al., The associations of sedentary time and breaks in sedentary time with 24-hour glycaemic control in type 2 diabetes. Preventive medicine reports, 2018. 12: p. 94-100.
6. Saunders, T.J., et al., Sedentary behaviour and health in adults: an overview of systematic reviews. Applied Physiology, Nutrition, and Metabolism, 2020. 45(10): p. S197-S217.
7. Bull, F.C., et al., World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British journal of sports medicine, 2020. 54(24): p. 1451-1462.
8. Duvivier, B.M., et al., Benefits of substituting sitting with standing and walking in free-living conditions for cardiometabolic risk markers, cognition and mood in overweight adults. 2017. 8: p. 353.
9. Dempsey, P.C., et al., Sitting less and moving more: improved glycaemic control for type 2 diabetes prevention and management. Current diabetes reports, 2016. 16(11): p. 1-15.
10. Duvivier, B.M., et al., Breaking sitting with light activities vs structured exercise: a randomised crossover study demonstrating benefits for glycaemic control and insulin sensitivity in type 2 diabetes. 2017. 60(3): p. 490-498.
11. Dempsey, P.C., et al., Managing sedentary behavior to reduce the risk of diabetes and cardiovascular disease. 2014. 14(9): p. 522.
12. Dunstan, D.W., et al., Sit less and move more for cardiovascular health: emerging insights and opportunities. Nature Reviews Cardiology, 2021: p. 1-12.
13. Stephenson, A., et al., Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis. International Journal of Behavioral Nutrition and Physical Activity, 2017. 14(1): p. 1-17.
14. Spruijt-Metz, D., et al., Innovations in the use of interactive technology to support weight management. J Current obesity reports, 2015. 4(4): p. 510-519.
15. Intille, S.S., et al. Just-in-time technology to encourage incremental, dietary behavior change. in AMIA Annual Symposium Proceedings. 2003. American Medical Informatics Association.
16. Hardeman, W., et al., A systematic review of just-in-time adaptive interventions (JITAIs) to promote physical activity. International Journal of Behavioral Nutrition and Physical Activity, 2019. 16(1): p. 31.
17. Brusse, C., et al., Social media and mobile apps for health promotion in Australian Indigenous populations: scoping review. Journal of medical Internet research, 2014. 16(12): p. e3614.
18. Schwarz, D., Jump Start Adobe XD. 2017: SitePoint.
19. Willig, C. and W.S. Rogers, The SAGE handbook of qualitative research in psychology. 2017: Sage.
20. Daryabeygi-Khotbehsara, R., et al., Smartphone-based interventions to reduce sedentary behavior and promote physical activity using integrated dynamic models: systematic review. Journal of medical Internet research, 2021. 23(9): p. e26315.
21. Gardner, B., et al., How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. 2016. 10(1): p. 89-112.
22. Avery, L., et al., Changing physical activity behavior in type 2 diabetes: a systematic review and meta-analysis of behavioral interventions. 2012. 35(12): p. 2681-2689.
23. Howlett, N., et al., Are physical activity interventions for healthy inactive adults effective in promoting behavior change and maintenance, and which behavior change techniques are effective? A systematic review and meta-analysis. Translational behavioral medicine, 2019. 9(1): p. 147-157.
24. Daryabeygi-Khotbehsara, R., et al., Validation of A Bluetooth-enabled Device for Real-time Detection of Sitting, Standing and Walking. Journal of Sports Sciences (Under-Review), 2022.
25. Ueno, D.T., et al., Mobile health apps to reduce sedentary behavior: a scoping review. Health Promotion International, 2022. 37(2): p. daab124.

 doi:10.20944/preprints202208.0356.v1

26. Hardeman, W., et al., A systematic review of just-in-time adaptive interventions (JITAIs) to promote physical activity. International Journal of Behavioral Nutrition and Physical Activity, 2019. 16(1): p. 1-21.
27. Saponaro, M., et al. Contextualization and individualization for just-in-time adaptive interventions to reduce sedentary behavior. in Proceedings of the Conference on Health, Inference, and Learning. 2021.
28. Loveday, A., et al., Novel technology to help understand the context of physical activity and sedentary behaviour. Physiological Measurement, 2016. 37(10): p. 1834.
29. Dasgupta, K., et al., Walking behaviour and glycemic control in type 2 diabetes: seasonal and gender differences-Study design and methods. Cardiovascular Diabetology, 2007. 6(1): p. 1-11.
30. Dasgupta, K., et al., Daily steps are low year-round and dip lower in fall/winter: findings from a longitudinal diabetes cohort. Cardiovascular diabetology, 2010. 9(1): p. 1-9.
31. Kelso, A., et al., Locations of physical activity: where are children, adolescents, and adults physically active? A systematic review. International journal of environmental research and public health, 2021. 18(3): p. 1240.
32. Michie, S., M.M. Van Stralen, and R.J.I.s. West, The behaviour change wheel: a new method for characterising and designing behaviour change interventions. 2011. 6(1): p. 42.
33. Richter, M., The association between Sedentary Time, Physical Activity and Mood: an experience sampling study. 2021, University of Twente.
34. Yoshiuchi, K., et al., Yearlong physical activity and depressive symptoms in older Japanese adults: cross-sectional data from the Nakanojo study. The American journal of geriatric psychiatry, 2006. 14(7): p. 621-624.