SoleMate: A Detection and Reminder App to Reduce Sedentary Behaviour At Home

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Abstract

Prolonged sitting can lead to serious physical and mental health problems. However, current intervention studies predominantly focus on workplace sedentary behaviour, neglecting its prevalence at home. To address this, we conducted a mixed-method study with a diary study (5 participants), an online questionnaire (56 responses), and interviews (5 participants). Our findings revealed a lack of motivation and awareness about the long-term risks of sedentary behaviour. Participants expressed a desire for real-time data and non-invasive, engaging reminders. Using an iterative design process, we created SoleMate, an app featuring contextual reminders, a customisable avatar, educational quizzes, data visualisation and data-monitoring slippers. In controlled experiments with 11 participants, combined with Nielsen's 10 usability heuristics, users found context-aware reminders ineffective but appreciated educational interactions through the avatar and the slippers' ability to track sitting time. Based on feedback, we added gradual reminders with exercise guidance from the avatar and a monthly history of sitting data. Aligned with Sustainable Development Goal 3: Health and Well-being, SoleMate integrates non-invasive live tracking with an engaging avatar interface to promote healthier habits and long-term behaviour change.

CCS Concepts

• **Human-centred computing** · **Human computer interaction (HCI)** · **Interaction design**;

Keywords

Sedentary behaviour; behavioural change; home

ACM Reference Format:

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1 INTRODUCTION

Sedentary behaviour, characterised by low-energy activities (1.5 METs or less) like sitting or lying down [19], affects over 40% of adults in desk jobs or with high screen time [14]. Dubbed "the new smoking" [20], it is linked to health risks such as obesity [7], cardiovascular disease [3], premature death [10], and other adverse outcomes [3, 6, 10]. Addressing sedentary behaviour can help prevent these illnesses while improving overall health, thereby contributing to the achievement of the Sustainable Development Goal (SDG) 3, which includes reducing premature mortality from non-communicable diseases, promoting healthy lifestyles, and achieving universal health coverage [13].

Sedentary behaviour occurs across various settings, including workplaces, schools, and homes - among these, the home environment accounts for a substantial proportion, a trend exacerbated by lifestyle changes during the COVID-19 pandemic [9, 16]. While its health risks are widely recognised, limited research has focused on sedentary behaviour within home settings, leaving a significant gap in understanding [15]. Thus, the present study aims to design innovative, home-specific approaches to reduce sedentary behaviour effectively. Our main research is: How to design interactive technologies to reduce adults' home sedentary behaviour? To investigate this overarching question, we focused on two subquestions as follows: 1) What are people's barriers to reducing current sedentary behaviour at home? 2) What are people's needs in addressing sedentary behaviour through technology at home?

To answer our research questions, we conducted a seven-day diary study focusing on 5 existing sedentary-improving Apps, the surveys with 56 responses and interviews with 5 participants to explore sedentary behaviour. Users showed low motivation to reduce sedentary behaviour and limited awareness of its long-term harms or reduction strategies. Our findings emphasised the need for non-invasive, emotionally-driven solutions that provide clear knowledge, engaging reminders with minimal disruption, and accurate data. To address these needs, we proposed and improved the design based on user testing, and finally developed SoleMate, a wearable slipper sensor paired with a desktop avatar app with non-invasive alerts, educational content, and data visualisation. SoleMate aims to unobtrusively detect prolonged sitting through

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pressure sensors and provides real-time feedback via an empathetic avatar, blending seamlessly into home life. Overall, this work contributes to Sustainable Human-Computer Interaction (SHCI) both empirically by addressing the research gap in home-based sedentary behaviour through mixed-method insights and practically through the design that integrates non-invasive tracking and empathy-driven engagement to promote behaviour change.

2 RELATED WORKS

Existing interventions focus on improving motivation and knowledge to reduce sedentary behaviour effectively. Techniques such as gamification [11], goal-setting [18], and social rewards [17] have proven effective in enhancing motivation, particularly in workplaces, by encouraging individuals to break prolonged sitting and adopt active habits. Similarly, knowledge gaps, which hinder individuals from translating awareness into action, can be addressed through educational interventions like data visualisation [22], educational campaigns [21], and gamified education [11, 23], empowering individuals to make informed behavioural changes.

While these interventions have effectively enhanced physical activity by improving users' motivation and knowledge in workplace settings, translating these approaches to home environments requires careful consideration. Specifically, the significant differences in motivation sources and behaviour patterns between home and workplace settings make it challenging to apply workplace interventions to home environments. This difficulty arises because behaviours at home tend to be more flexible and diverse, often driven by intrinsic motivation due to the personal and individualised nature of the setting. These unique characteristics not only require intervention designs to be more personalised and adaptable but also highlight a lack of existing solutions tailored for home contexts. Furthermore, users' attitudes and cognition regarding sedentary behaviour in home settings remain largely unexplored, underscoring a critical research gap. Therefore, this design seeks to bridge the gap by exploring users' sedentary behaviour patterns and attitudes and developing user-centric solutions to encourage healthier habits in home settings.

3 USER RESEARCH

3.1 Method

To gain an understanding of how existing applications and devices reduce sedentary behaviour and their effectiveness, a semi-structured seven-day diary study[1] of 5 participants (4 female, 1 male; aged 21-23) was conducted. We selected five commercially available apps that range from wearable to phone-based apps. Participants were instructed to log the scenario and experience using the app or device and reflect on the designs and functions in a digital notebook. Besides, to explore the frequency of sedentary behaviour, barriers and expected functions to reduce sedentary behaviour in a larger population, a mixed-method questionnaire with 56 responses (34 female, 21 male, 1 preferred not to say; 30 age 18-25, 11 age 26-35, 11 age 36-45, 4 age 46-55) was utilised. To further investigate the survey findings, we followed up with a semi-structured interview with 5 participants (3 females, 2 males; aged 21-30). Interview scripts were analysed using a top-down reflexive thematic analysis with the COM-B model [5, 12].

3.2 Findings

We identified three key issues from the diary study: failure to monitor real-time sedentary data, monotonous and rigid reminders, and difficult suggested exercises. As a result, users ignore reminders and feel disrupted. The survey showed that sedentary behaviour is common but often overlooked. Among people aged 18 to 45, 67.3% met the criteria for sedentary behaviour, with about half unaware of it. Sedentary behaviour is low among participants aged 46-55 (25%), so they are not included in our target group. During prolonged sitting, most engage with digital devices for work or study (89.3%), social media (62.5%), and gaming (48.2%). This suggested digital interventions could be useful. Key barriers include discomfort, lack of motivation, time constraints, and concerns about productivity. Users expect real-time monitoring, personalized reminders, and task-based exercise guidance. Interviews revealed that users break sedentary behaviour mainly due to physical discomfort rather than health awareness, indicating a lack of understanding and motivation to prevent long-term harm. Wearables were seen as intrusive and inconvenient, leading to low adherence and eventual abandonment. Overall, people underestimate their sedentary time and overlook its long-term effects. Existing solutions fail to meet their needs, and overly difficult exercise advice further reduces motivation.

3.3 User Needs

Based on the user research above, we identified four main user needs (UN) for an effective sedentary behaviour intervention: namely 1) learning about long-term harms; 2) stopping prolonged sitting without disrupting current activity; 3) receiving engaging reminders; and 4) being able to view accurate sedentary data. These needs are repetitively confirmed in the diary study, questionnaire and interviews.

4 DESIGN PROCESS

4.1 Ideation

Based on the Need-Driven Design Model, we then conducted the Solution Exploration phase. We brainstormed various features for each need and conducted a 2 x 2 analysis (Figure 1) to evaluate the effectiveness and engagement. The brainstormed ideas were either inspired by suggestions from participants in user research, transformed from users' needs to detailed practical designs or intervention design suggestions from previous behaviour change studies [1].

[1]The Apps tested in the diary study are:
1) Apple Fitness (watch): https://apps.apple.com/us/app/fitness/id1208224953;
2) Time Out (laptop): https://apps.apple.com/us/app/time-out-break-reminders/id402592703?mt=12;
3) Sitting Alarmy: https://apps.apple.com/us/app/sitting-alarmy-reminder-alarm/id1611670179;
4) NeckGo: https://apps.apple.com/us/app/neckgo-relief-for-your-neck/id1660505668;
5) Stand Up!: https://apps.apple.com/us/app/stand-up-the-work-break-timer/id828244687

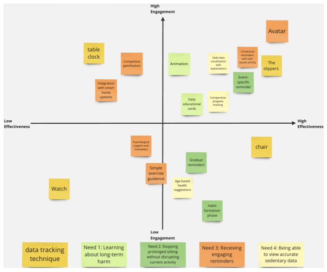

Figure 1: Results of the 2 x 2 matrix analysis on effectiveness and engagement (created in Miro.com)

4.2 First Prototype

We designed an application aimed at reducing sedentary behaviour, which features slippers equipped with sensors to detect real-time sitting activity (Figure 2).

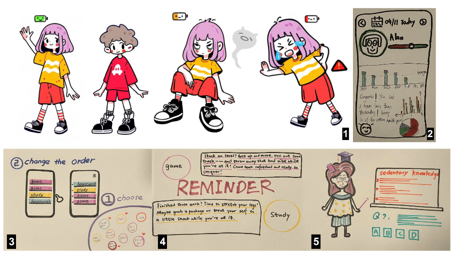

Figure 2: Sketches of the first prototype: (1) Avatars in different statuses. (2) Data visualisation page. (3) Self-set schedule page. (4) Contextual reminders. (5) Education with avatar page.

4.2.1 Slipper. Slippers are one of the most frequently used items in home life and closely align with user behaviour, enabling natural sedentary behaviour monitoring while avoiding the burden of wearing additional devices and ensuring continuous and accurate data collection. Our slippers contain Arduino pressure sensors to detect body postures. When people sit down, the pattern of pressure on the slipper is different from other postures, therefore we can calculate the sitting time using the slipper. It addresses users' needs to be able to view accurate sedentary data (UN4).

4.2.2 Contextual Reminders and Avatar. Based on our user research findings, we developed a context-aware reminder system with a customisable avatar that serves as an implicit reminder that was designed to be unobtrusive while still effective. This solution aimed to satisfy UN2 and UN3. Such a reminder aims to boost the user's confidence in successfully completing the task by offering clear and straightforward guidelines tied to existing activities. By making the reminder more acceptable and actionable, this approach reduces the challenge of improving sedentary behaviour, thereby increasing the likelihood of users taking action [2]. Meanwhile, the virtual avatar we designed will gradually display signs of pain, fatigue, or low energy as the user's sedentary time increases. Since the avatar remains visible on the screen, its state-based changes serve as subtle reminders without being perceived as intrusive. Empirical findings [23] and theoretical foundations [4] support the ability of customisable, interactive avatars to motivate positive action by enhancing bodily awareness and empathy. These feelings can prompt users to reflect on sedentary behaviour and health risks, strengthening their intention to act [8]. Additionally, when users stand and move, the avatar instantly returns to a healthy state, offering positive reinforcement and promoting long-term adherence to reminders.

4.2.3 Education. To enable users to learn about the long-term harm (UN1) of sedentary behaviour through interactions, we designed an interactive education section with a daily multiple-choice question. This section is here to ensure that users understand how prolonged sitting could be harmful and learn how to reduce the harm, thus raising their awareness of reducing sedentary behaviour. In this part, users answer one multiple-choice question every day. The avatar reacts happily or sadly to correct or wrong answers accordingly.

4.2.4 Data Visualisation. To help users maintain long-term engagement and fulfil UN4, we provide clear graphs and actionable feedback. This visualisation helps users become aware of their current behaviour patterns through real-time feedback, such as a comparison indicating "2 hours less sitting than yesterday," reinforcing their self-efficacy and motivation to reduce sedentary behaviour [2]. Additionally, it offers long-term trend analysis, fostering a sense of achievement and encouraging users to sustain healthier habits. Through clear and motivating visual feedback, this data visualization could enhance awareness and accomplishment, driving behaviour change and supporting sustained reductions in sedentary activity.

4.3 User Testing

Given the limited research on the effectiveness of using interactive avatars for education and situation-based reminders in home settings, we conducted a controlled experiment with a Wizard-of-Oz design of 11 participants (4 female, 6 male, 1 preferred not to say; 10 aged 18-25, 1 age 26-35) was conducted. A follow-up interview with 3 participants (2 female, 1 male; age 21-25) was conducted. Participants were recruited using convenience sampling. The majority of our participants reported moderate to severe sedentary behaviour at home.

Participants rated the avatar and interactive questions as somewhat effective and engaging and liked the presentation. However, some participants suggested providing more detailed information about the knowledge presented after answering questions and expressed a desire for greater interaction with the avatar. We also found that even when presented with task-related reminders, participants still focused on current tasks and were not motivated to stand up. Participants revealed that text-based reminders are not motivational, whereas reminding them of the harm of sedentary behaviour and visually salient and attractive changes are useful. The evaluation study and feedback guided the development of the high-fidelity prototype (Figure 3).

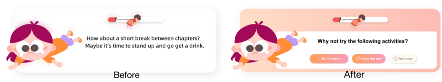

Figure 3: Iteration on the prototype of avatar reminders based on the first user testing (created in Figma)

4.4 Second Prototype

Based on feedback from the first usability test, we deleted situation-based reminders as participants found them ineffective and removed the schedule setting feature. Instead, we highlighted the harm of sedentary behaviour by using icons to raise users' motivation to reduce sedentary behaviour. Some short exercise suggestions would pop up when users' sedentary behaviour was detected. Moreover, we add information sources and practical strategies to reduce sedentary behaviour after daily interactive questions to enhance users' understanding of knowledge.

4.4.1 Heuristic Evaluation. A high-fidelity wireframe prototype was designed and evaluated using Nielsen's 10 usability heuristics. Our prototype has high user control freedom and consistency, but it lacks help and documentation. Therefore, we added introductory pages and a help centre to assist new users in using our app. We also redesigned some interface layouts to improve the clarity of user experience (Figure 4).

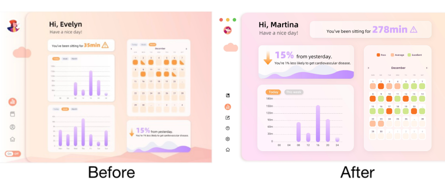

Figure 4: Iteration on the prototype of the data visualisation page (created in Figma)

4.5 Final Design

4.5.1 Slipper. Our slipper detects users' body positions using Arduino pressure sensors. Sensors are built inside the slipper so that users would not feel uncomfortable wearing our slipper. It can be paired with the device's IP address so that the application can distinguish the inactivity of the slipper between sleeping and leaving home.

4.5.2 App. The final prototype contains an onboarding page, customisation page, home page, helping centre, education or 'question for the day' page, data visualisation page and a desktop interactive avatar (Figure 5).

The onboarding pages introduce key features of our application. New users are then led to the customisation page, which allows them to customise the avatar's appearance and name. Users can update the avatar at any time. The created avatar will appear as the profile picture and floating desktop decoration when users minimise the app. On the home page, users are presented with the avatar, the total amount, a bar graph of today's sitting time, and a comparison between today's and yesterday's sitting time. On the helping page, a simple explanation and guidance for each page are listed to facilitate users' interaction with SoleMate.

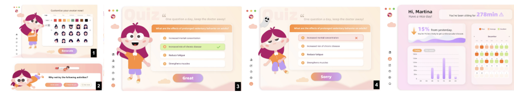

Figure 5: Interfaces of SoleMate. (1) Avatar customisation page. (2) Avatar desktop reminder. (3) Education page when answered correctly. (4) Education page when answered incorrectly. (5) Data visualisation page (created in Figma)

On the education page, a daily quiz question and the avatar are presented in the form of multiple-choice. After answering the response, the correct answer, detailed information about the answer and information source pop up. The avatar also shows corresponding facial expressions according to whether users answered correctly to deepen their memories. The daily questions are about the long-term harm of sedentary behaviour and everyday examples of how to reduce sedentary behaviour. The notebook collects previous questions and explanations for users to review.

The data visualisation page displays graphs of sitting time for the day, week, and month. The bar chart shows how many minutes users sit every 4 hours in a day. The aggregated sedentary time is also summarised. Weekly sitting hours and a comparison between today's and yesterday's sitting times are displayed." There is also a coloured calendar highlighting sedentary behaviour. Each day is either green (0-4 hours), yellow (4-8 hours) or red (more than 8 hours) based on the sitting time of that day. When users select a specific day on the calendar, a bar chart of that day and the total time spent sitting will appear.

Finally, there is a desktop avatar with an energy bar to remind users to stand up. The avatar becomes less energetic when users remain sitting, and the energy bar changes from green (0-15 minutes) to yellow (15-30 minutes) to red (more than 30 minutes). When the sitting time reaches the sedentary criteria, an icon highlighting the painful body parts pops up to remind people of the harm of prolonged sitting. Two simple guidance also pops up to suggest users move. When users stop sitting after seeing reminders, the avatar becomes energetic again as a reward.

5 DISCUSSION

Few existing research and products for reducing sedentary behaviour effectively target sedentary behaviour at home. Therefore, our work designed a prototype SoleMate, which intends to reduce sedentary behaviour at home by communicating knowledge, reflecting on the history of sitting time, and highlighting the harms of sedentary behaviour through avatars. These features aim to allow users to not only reduce current prolonged sitting but also enhance the motivation to keep a healthier lifestyle at home.

The limitations of this study include the small sample size in the usability tests. Since reasons and scenarios for prolonged sitting at home can be different among users, a larger sample with users in different employment statuses or age groups will be helpful in evaluating our design. This study focused on testing specific functions in isolation rather than evaluating the overall user experience of the comprehensive application. It is also conducted in a controlled setting, and participants' performance may deviate from their daily performance. Future studies can assess the effectiveness of daily use using a diary study with participants from different daily routines. Specifically, future studies can focus on whether reminders are disruptive and whether users follow reminders to break their sedentary behaviour.

Our design aims to reduce sedentary behaviour at home among people aged 18 to 45, as the sedentary lifestyle is physically and emotionally harmful yet widespread. SoleMate uses a non-invasive slipper to monitor sedentary behaviour and fits in home settings. It also communicates knowledge and reminds users through an empathy-eliciting avatar, which can lead to not only behavioural change but also an increase in motivation. By using SoleMate continuously, users can gradually form a non-sedentary lifestyle and exercise habits, aligning with promoting a healthy lifestyle in SDG3. Combining non-invasive design and emotionally resonant feedback offers a unique contribution to HCI. By balancing usability, emotional engagement, and unobtrusiveness, SoleMate bridges the gap in interventions to reduce sedentary behaviour at home. It demonstrates how emotional cues can effectively drive behaviour and motivation change, inspiring new directions for empathy-driven design in promoting healthier lifestyles, as suggested in SDG3. In future work, we aim to enhance the project's credibility and validity by incorporating broader stakeholder involvement, including input from health professionals and behaviour change experts.

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