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Exploring the Feasibility of Accelerometer-Based Mobile Health Apps to Enhance Physical Activity in Western Rajasthan

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Abstract

Background: Physical inactivity is a prominent global health issue that accounts for many non-communicable diseases and premature mortality. mHealth technologies can be effective in increasing physical activity by offering personalized guidance, reminders, feedback, in addressing barriers like accessibility and motivation. **Objective:** This study aims to develop and evaluate the feasibility of an open source accelerometer-based m-health application for testing an intervention protocol designed to enhance physical activity in Western Rajasthan. **Methods:** This study aimed to evaluate the feasibility of two mHealth tools developed using open-source applications, designed to promote increased physical activity among patients with sedentary lifestyles. The applications were tested with 10 participants between the age group of 30 to 45 years visiting clinicians for treatment of non-communicable diseases in the western part of Rajasthan. The mixed method research was used to analyze the issues encountered while collecting the data, the effect of the mHealth application interventions, and suggested changes. **Findings:** A total number of 10 participants walking less than 1000 steps with an average of less than 15 minutes of Moderate to Vigorous Physical Activity (MVPA) per day were enrolled for the study using pre-tested Sedentary Lifestyle Assessment Tool. At the end of the observation period, an increase of up to 4500 steps and 45 minutes of MVPA was observed. The mean duration of the registration process was around 316 seconds, and the physical activity tool was around 2700 seconds. During the testing of the intervention, a few of the participants had difficulties in entering the app credentials, writing phone numbers, installing the applications, and using the app to capture physical activity-related data.

Novelty: The study found positive participant experiences with the accelerometer-based mHealth app, emphasizing ease of use and motivation. However, installation and data capture issues were noted, requiring improvement for future implementation and adoption.

Keywords: mHealth; Physical Activity; Technology Interventions; Remote monitoring; Sensor data

1 Introduction

Worldwide, physical inactivity is a major public health concern since it contributes to the high incidence of numerous non-communicable diseases and early mortality(1). According to the World Health Organization, physical inactivity is the fourth highest risk factor for mortality, accounting for an estimated 3.2 million deaths annually worldwide(2). Regular exercise can lower the risk of heart disease, stroke, Type 2 Diabetes, and cancer(3). Despite this well-established association between physical activity and disease risk, sedentary behavior is common among the population. The gap lies in between identifying the need of changes and find a way to effectively addressing them that prevent individuals from adopting active lifestyles. Therefore, there is a need to develop interventions that encourage physical activity and address sedentary lifestyles(4),(5). The potential for m-health technology to improve health outcomes and increase physical activity is significant(6). The widespread availability of smart-phones and wearable devices can provide tailored guidance and immediate feedback to individuals and help them overcome challenges with traditional exercise schemes such as lack of accessibility and motivation(7).

However, while m-health applications are becoming more common, their feasibility and effectiveness must be explored within specific sociocultural and environmental contexts. The development of these applications is important for increasing physical activity and people's general well-being in semi-arid areas like western Rajasthan, where there are many different kinds of problems, including the lack of access to healthcare facilities, socioeconomic factors, lifestyle choices, and cultural beliefs(8). These barriers may be responsible for the increase in sedentary behavior among the population of the state, highlighting the need for targeted interventions(9).

Research demonstrates that accelerometer-based mobile health apps are successful in raising levels of physical activity and encouraging behavioral changes(10). Studies have shown that these apps measure activity levels accurately, offer personalized feedback, and maintain long-term improvements in physical activity(11). By integrating these m-health apps in comprehensive health strategies in Rajasthan, physical activity is not only encouraged but also embraced physical exercise as an essential component of everyday life. Addressing this gap is essential for understanding the practical feasibility and impact of m-health solutions in this region.

This study aimed to develop and assess the feasibility of accelerometer-based m-health application to enhance the physical activity in Western Rajasthan. By contextualizing the intervention to the unique challenges of this region, the study seeks to contribute to the growing evidence base for innovative m-health strategies in diverse cultural and environmental settings.

2 Methodology

To create and investigate the viability of accelerometer-based mobile health applications in promoting physical activity among the population of Western Rajasthan, a mixed-methods approach was employed. In phase 1 (development), a mobile application based on a cultural and linguistic accelerometer was created to promote physical activity. Following a thorough assessment of the literature and stakeholder consultations, the m-health application was examined, and a few small changes were made. In phase 2, pilot research was conducted with a sample size of 10% of the total targeted participants. These ten individuals utilized the m-health app under a clinician's supervision for six weeks. Later, the collected data was analyzed and participants provided feedback on the challenges encountered in implementing the application.

3 Results & Discussion

We performed a thorough literature analysis and stakeholder consultations in order to create an accelerometer-based m-health application that aims to increase physical activity. Clinicians, public health specialists, and IT specialists were among these stakeholders. A cultural and linguistic accelerometer-based mobile health application was developed to promote physical activity on the Android platform following a thorough literature analysis and consultation activities. We created a thorough questionnaire using open-source data gathering software in order to gather daily activity data. This software records physical activity data using an integrated GPS field.

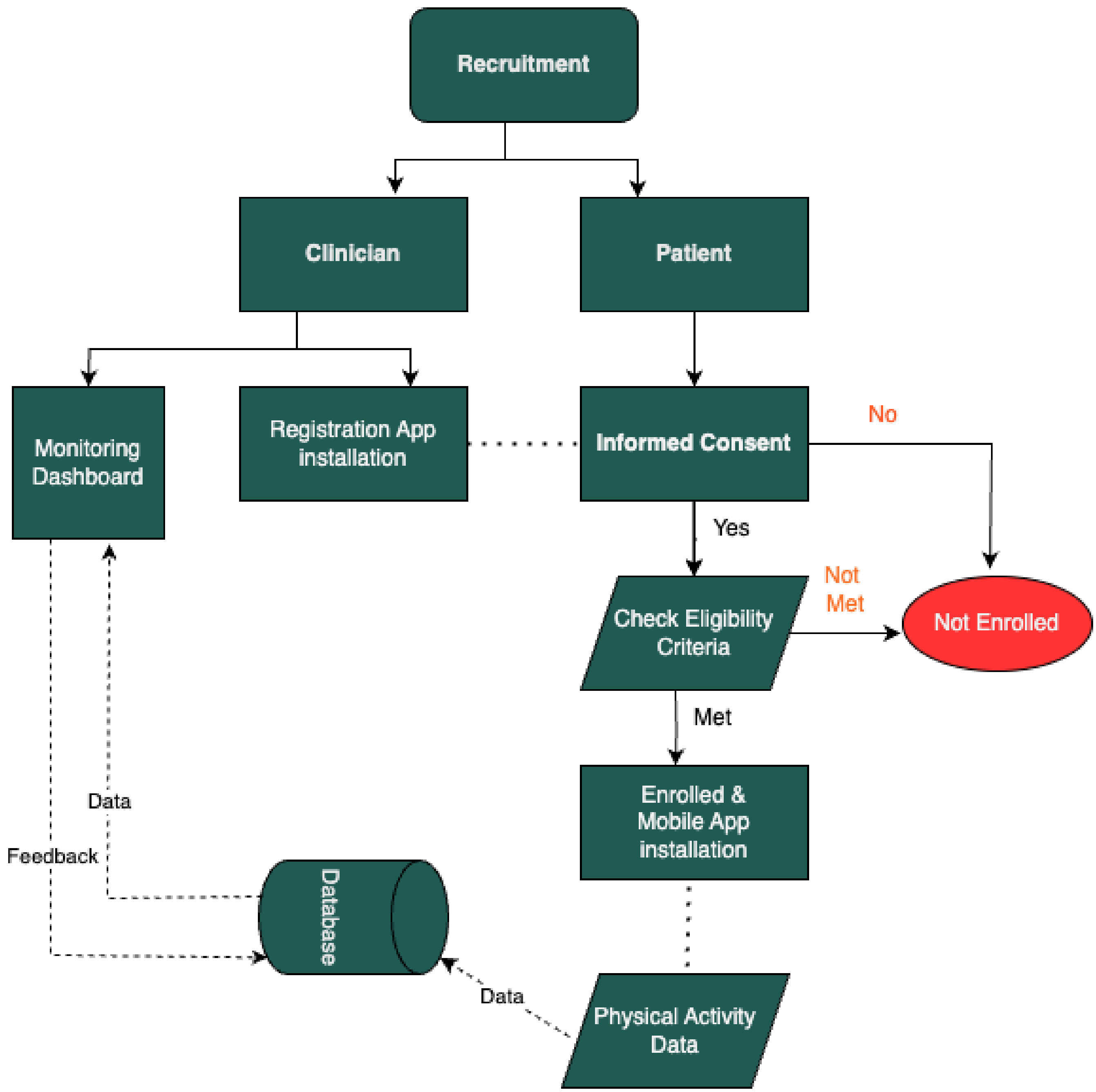

Fig 1. Workflow diagram

The data was collected using quantitative and qualitative both approaches. To evaluate the improvement in physical activity of the 10 participants, several indicators were used, including the number of steps taken per day, the duration of Moderate to Vigorous Physical Activity (MVPA), and the distance walked per week. The mean age of the participants was 41.1 years, and their mean BMI was 26.16 kg/m^2. At baseline, participants averaged less than 1,000 steps per day, engaged in 5-15 minutes of MVPA per day, and walked less than 1 KM per day. The mean sedentary duration was measured at 14.7 hours on weekdays and approximately 18.1 hours on weekends. Following a 4-week intervention using the m-health application, the average number of steps taken per day increased to 3,500 steps, the average duration of MVPA rose to 45 minutes per day, and the average distance walked per week grew to 3 kilometers. Additionally, the frequency of physical activity sessions increased from three to five times per week, and self-reported physical activity enjoyment scores improved from an average of 3 to 8 on a scale of 1 to 10. Clinicians provided regular reminders and motivational messages to participants through WhatsApp, which helped maintain their engagement and adherence to the physical activity regimen. Data on physical activity were collected, revealing a statistically significant improvement, with a total of 212 events documented among the anticipated 280 physical activity events. The mean duration for completing the Registration tool was around 316.5 seconds, and the mean duration for completing the Physical Activity tool was 2700 seconds. These results indicate significant improvements in physical activity levels among the participants, demonstrating the feasibility and potential effectiveness of the m-health application in promoting a more active lifestyle. Participants reported increased frequency and duration of physical activity through self-reported surveys, supporting the overall positive impact of the intervention. Later, received data were scrutinized in context to the feedback provided by the participants and clinician. The participants have faced difficulty in changing language as per their choice for better understanding of the questions. Out of 10 registrations, 6 interviews had minor mistakes in entering the text. Some of them mentioned their names in local language which might cause issues, highlighting the need of uniformity of languages. Almost all the participants reported difficulty in typing phone numbers due to small keyboard keys. Approximately 71% of the total survey time spent in entering the hours and minutes questions related to the sedentary lifestyle score. Table 1 highlights the significant improvements in physical activity levels among the participants, demonstrating the feasibility and effectiveness of the m-health application.

Table 1. Changes observed in key indicators

Indicator	Baseline	Post-Intervention	Change
Mean Age (years)	41.1	-	-
Mean BMI (kg/m^2)	26.16	-	-
Mean Steps per Day	<1000	4,500	+3,500 steps
Mean MVPA per Day (minutes)	<15	>45	+30 minutes
Mean Distance Walked per Day (km)	<1	3	+2 km
Frequency of Physical Activity Sessions	1 time per week	5 times per week	+4 sessions per week
Physical Activity Enjoyment (scale 1-10)	3	8	+5 points
Mean Sedentary Duration (weekdays)	14.7 hours	-	-
Mean Sedentary Duration (weekends)	18.1 hours	-	-
Documented Physical Activity Events	-	212 (out of 280 expected)	-
Mean Duration (Registration tool)	316 seconds	-	-
Mean Duration (Physical Activity tool)	-	2700 Seconds	-
Self-Reported Increase in Activity	-	Yes	-

According to qualitative analysis, participant feedback suggested that they had a good experience using the application. The application's motivational elements and ease of use were praised by participants as helping them reach their physical activity objectives. Notwithstanding its advantages, there were certain difficulties, such as technical problems and the requirement for participants to be continuously motivated. Qualitative data was used to investigate the obstacles and enablers to the uptake and use of mobile health applications. Installing the data collection application, setting up login credentials, using GPS to record and save physical activity data, and not having Internet access were among the technological obstacles. Family members' assistance served as the facilitators, and their involvement was crucial in encouraging the use of the application.

Recent studies have emphasized the effectiveness of m-Health interventions in improving behavior changes interventions like improving physical activity in diverse population. For example, Novak et al (2024) underlined the importance of participatory approach from general physician in implementing m-Health interventions whereas, Eklund et al. (2019) linked physical activities to improved mortality outcomes [(12)], [(13)]. Similarly, Fabbrizio et al. (2023) reviewed interventions related to IoT and AI but there are very few studies that have rigorously examined the accelerometer-based application in context to the environmental and culture like Arvidsson et al. (2019) did[14],[15].

This study aimed to fill this gape by developing and evaluating the feasibility of culturally sensitive accelerometer based mobile health application to enhance physical activity levels among the population of western Rajasthan. The study focused on development of culturally tailored m-health application by engaging stakeholders and public health professionals in initial phase. The application was made through collaborative approach and the continuous stakeholder engagement was ensured while developing the application increases its usability. Similarly, the studies mentioned that stakeholder engagement in research enhances the feasibility and acceptability of study[15].

The tools for collecting registration and physical activity data were developed on open-source data collection software that can capture the data offline without the internet connection. By leveraging open-source software, we are able to significantly reduce the overall cost associated with the mHealth intervention, as it eliminates the need for expensive proprietary solutions and extensive resources that would be required to develop a custom application from scratch[16]. Additionally, this approach offered considerable time savings and easy to scale up. Developing a new application from the ground up is a time-consuming process that involves extensive coding, testing, and debugging. By using an existing open-source solution, we bypass these stages and can quickly deploy a functional tool for data collection[17].

Moreover, the use of open-source data collection software democratizes the creation of mHealth interventions. Even individuals without a background in technology or programming can easily learn to use these tools. Once they understand the basics, they can create their own mHealth interventions tailored to their specific needs and objectives[17]. This accessibility empowers a broader range of users to engage in health data collection and intervention, fostering innovation and personalized healthcare solutions.

The study used both quantitative and qualitative data to provide a more comprehensive picture of findings, offering important insights into their physical activity and sedentary behaviors. The quantitative analysis indicated high sedentary behaviors in population of mean age group of 41.1 years. The high sedentary duration (14.7 hours on weekdays; 18.1 hours on weekends) highlights the issue of sedentary lifestyles in this era. This aligns with the study by Kamalesh C. Dey that reported prolonged sedentary behaviors in adult population[18]. The m-health intervention showed a statistically significant improvement in physical activity levels. Quantitatively, the study results showed improvements in daily average steps, duration of Moderate to Vigorous Physical Activity (MVPA) and average distance walked per day. This aligns with findings from previous research indicated that these interventions could lead to increase in activity levels[19]. Further, the increase in average daily steps and minutes of physical activity post intervention shows effectiveness of this m-health application. Additionally, the regular reminders and motivational messages through clinician helped in enhancing participant engagement and adherence to physical activity regimen.

The feedback from participants and clinician related to data collection process shed light on some challenges and areas of improvement in the process. The participants faced difficulties in the registration process due to language preferences as the form was loading in English by default. The study highlighted the importance of linguistic accessibility in such mobile applications. Our findings align with the study by V Vien Lee that emphasizing the significance of language localization in promoting user engagement and adoption of m-health interventions[20]. Therefore, the instructions for changing the language were added and it was made sure that the form by default was loading in 'Hindi language'. Similarly, the study highlights the need of continuous modification of tool as per user feedback[21]. The users may enter special characters and numbers in text fields which improved inclusivity. The recommendations were made on a larger, more prominently displayed numerical keypad interface for entering phone numbers to enhance the user experience. These findings are in line with previous studies that mentioned the significance of user-centered design in mobile health interventions[21],[22]. More survey time was spending on sedentary lifestyle questions indicated a need of simplified input methods. Additionally, limitation on accepting the username with capital letters was observed. This led to the decision to enter the username in lowercase. These challenges highlight the need of more user-friendly approach to enhance the data accuracy.

Through qualitative analysis, the study showed positive experiences for accelerometer-based m-health application among the target population. Participants found this application easy to use and appreciating its motivational features. The researchers mentioned the need of qualitative research for capturing users' experiences and informing the further app development[23].

As this study was conducted as a pilot, covering only 10% of the total targeted participants, we plan for a full-scale study to validate our findings on a larger population. Based on the insights gained from this preliminary research, we plan to design and implement a comprehensive study to further assess the effectiveness and scalability of this intervention protocol. This expanded study will allow for a more in-depth evaluation of its impact on increasing physical activity levels and addressing sedentary behavior in a broader demographic.

However, the challenges like technical issues mentioned by study participants. They faced difficulties with installing the application, configuring credentials, and capturing and saving physical activity data via GPS. The study by Zakerabasali mentioned the factors and barriers at technical, individual and healthcare system levels affecting the m-health adoption. It is important to understand the barriers encountered in application for improving the implementation of such application[24].

4 Conclusion

This study underscores the feasibility and potential of an accelerometer-based mHealth application to enhance physical activity in the culturally and environmentally unique context of Western Rajasthan. Physical inactivity, a critical global health issue, is becoming prominent issue in this region as well due to technological advancement related lifestyle changes, limited awareness, and cultural beliefs. Sedentary behavior in such settings contributes significantly to the prevalence of life-style related non-communicable diseases, emphasizing the urgent need for tailored interventions.

While previous studies have extensively explored mHealth solutions in urban or generalized populations, this study bridges a critical gap by focusing on a rural and resource-constrained setting. The findings reinforce the viability of such interventions in improving public health outcomes, particularly in regions where traditional healthcare delivery models face significant barriers.

Accelerometer-based mHealth applications present a promising solution by providing real-time feedback and personalized activity guidance, leveraging widely available technologies such as smartphones and wearable devices. These applications address barriers to physical activity like, lack of motivation, accessibility challenges, and the need for continuous monitoring. Studies, including this one, have demonstrated the effectiveness of accelerometer apps in increasing physical activity levels, promoting behavior change, and supporting long-term adherence to healthier lifestyles. This study also aligns with prior evidence showing that feedback-driven interventions lead to sustained improvements in physical activity and helps reducing the sedentary behavior.

This study acknowledges the limitation of relatively short duration of the feasibility assessment. It also recommends the need for a larger, more diverse sample size to generalize the findings. Future research should aim to expand the scope of such interventions by incorporating advanced features like AI-driven personalization and community engagement tools. This can help in enhancing the scalability and impact of such interventions.

To conclude, this study demonstrates the feasibility and potential impact of accelerometer-based mHealth interventions in enhancing physical activity levels and addressing sedentary behavior in Western Rajasthan. By addressing unique regional challenges, such interventions can contribute significantly in reducing the burden of non-communicable diseases and improving overall health outcomes. Scaling these efforts through comprehensive public health strategies can pave the way for a healthier, more active population, not only in Rajasthan but also in similar rural and resource-limited settings worldwide.

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