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# Preferences on smartphone app features to monitor physical activity in asymptomatic brazilian adults according to cardiovascular risk

## *Preferências de funcionalidades de aplicativos de smartphone para monitorar a atividade física em adultos brasileiros assintomáticos de acordo com o risco cardiovascular*

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**Abstract –** Analyzing feature preferences of smartphone applications is imperative, especially among subjects with high cardiovascular risk (CVR) who primarily benefit from increasing regular physical activity. We aimed to identify feature preferences for smartphone applications to monitor physical activity in Brazilian asymptomatic adults stratified according to CVR. A cross-sectional study with 238 asymptomatic adults was conducted. Features preferences were assessed through a survey based on the following topics: Personal/individualized, Training, Performance, Social aspect, Feedback, Motivation, Suggestions, and Other. Participants were divided into two groups according to self-reported CVR (low CVR, ≤ 2, and moderate-to-high CVR, > 2 risk factors) and compared using the x2 test. The moderate-to-high CVR group considered "develop a training schedule/program" and "save and review training statistics" less critical than speech navigation and receiving encouragement and motivational messages. Although reported by both groups, "monitor own progression" is more important for low CVR. The "compete with friends" feature was less reported than "being part of a community/group" for both groups. Lastly, understanding the features preferences allows the improvement of smartphones applications to become more attractive to subjects with chronic conditions.

**Key words:** Physical activity; Mobile applications; Smartphone; m-health; Cardiovascular risk.

**Resumo –** *Analisar as preferências de funcionalidades dos aplicativos de smartphones é essencial, especialmente entre indivíduos com alto risco cardiovascular (RCV) que se beneficiam principalmente do aumento da atividade física regular. Nosso objetivo foi identificar preferências de funcionalidades de aplicativos de smartphones para monitorar atividade física em adultos brasileiros assintomáticos estratificados de acordo com o RCV. Foi realizado um estudo transversal com 238 adultos assintomáticos. Avaliaram-se as preferências de funcionalidades por meio de uma pesquisa com base nos seguintes temas: Pessoal/individualizado, Treinamento, Desempenho, Aspecto Social, Feedback, Motivação, Sugestões e Outros. Os participantes foram divididos em dois grupos de acordo com o RCV autorreferido (RCV baixo, ≤ 2, e RCV moderado a alto, > 2 fatores de risco) e comparados pelo teste x2. O grupo de CVR moderado a alto considerou "desenvolver um cronograma/programa de treinamento" e "salvar e revisar estatísticas de treinamento" menos críticos do que a navegação por áudio e o recebimento de mensagens de incentivo e motivacionais. Embora relatado por ambos os grupos, "monitorar a própria progressão" é mais importante para RCV baixo. A funcionalidade "competir com amigos" foi menos relatada do que "fazer parte de uma comunidade/grupo" para ambos os grupos. Por fim, compreender as preferências de funcionalidades permite aprimorar os aplicativos de smartphones para se tornarem mais atrativos para sujeitos com condições crônicas.*

**Palavras-chave:** *Atividade física; Aplicativos móveis; Smartphone; mSaúde; Fatores de risco de doenças cardiovasculares.*

# INTRODUCTION

Mobile health (m-health) has been increasing in the past years as a complementary resource for healthcare, with applications mainly focused on weight loss, disease control, and physical activity (PA), among others[1,2].

In the past decade, almost 50% of health applications available in the Apple Store were related to self-monitoring training and performance[3]. The features such as self-monitoring or periodic messages are facilitators for adherence to the use of applications. In contrast, operational problems (connectivity errors, unfriendly application), initial application configuration (application cost and font size), lack of knowledge about available applications, internet access, and self-perception of digital literacy are the main barriers[4]. The abandonment of applications is linked to the lack of desirable features and resources[5].

In high-income countries, the users are primarily young, well-educated, and wealthy[6]. In low, middle- and upper-middle-income countries (LMICs), such as Brazil, the profile of smartphone application users for PA remains unknown. Literature on feature preferences in smartphone applications according to cardiovascular risk (CVR) is also scarce.

Cardiovascular diseases (CVD) are the leading cause of mortality worldwide, responsible for 17.9 million deaths, of which ¾ occurred in LMICs[7]. In Brazil, there is a trend of the increasing prevalence of overweight, diabetes, hypertension, and CVD22. Since PA plays a central role in disease prevention and there is an association between aging and the increased prevalence of CVD, m-health strategies for monitoring and encouraging PA aimed at middle-aged adults and the elderly must be addressed.

Smartphone is a potential tool for monitoring PA. Additionally, application-based interventions lead to promising sedentary behavior and PA changes. However, few professionals recommend m-health to their patients due to lack of knowledge of its effectiveness and benefits, lack of interest, and patient's digital literacy[8]. Applications aimed at the elderly population are concentrated in high-income regions, focusing primarily on independent older adults[9].

Only a few patients with chronic conditions are application users, but they are interested in using it despite their low digital literacy[10]. In an upper-middle-income country, more than 50% of subjects with chronic conditions were willing to use PA applications, but the features did not meet their needs[11]. Given the growth of m-health, analyzing the preferences of the available features favors the comprehension of applications usage by subjects who would benefit from the increase in the PA level, particularly those at increased risk of CVD.

We aimed to identify the self-reported features preferences of smartphone applications to monitor PA in asymptomatic adults according to CVR, as well as setting the Brazilian profile of users of these applications.

# METHODS

A cross-sectional study was conducted with 238 participants eligible from Epidemiology and Human Movement (EPIMOV) Study and Playful data-driven Active Urban Living (PAUL) Study. Briefly, the EPIMOV Study is an ongoing prospective cohort study whose main purpose is to investigate the association between low PA level and low physical fitness and cardiorespiratory, metabolic and locomotor health outcomes over a short period of time the development of chronic conditions[12]. The PAUL Study is a multicentric research whose primary aim is to develop a smartphone application based on machine learning, behavior change techniques, personalized features, and gamification to promote PA[13]. All participants provided written informed consent before participation. The study was approved by the local Research Ethics Committee (#0676/2018). The study was carried out in Santos, São Paulo, Brazil. More information about recruitment, eligibility criteria and protocol assessment can be found in previous publications[12].

The feature preferences were investigated using a translated version of a previously proposed survey[14]. The feature preferences were assessed based on the following topics: Personal/individualized; Training; Performance; Social aspects; Feedback; Motivation; Suggestions; Other. The participant could choose more than one feature in each topic.

Participants who did not have a smartphone were excluded. Users were those that use at least one application available for download in the "health and fitness" category of the Apple Store or Play Store. The application must count the number of steps or allow the user to register PA.

Statistical analysis was performed using SPSS software, version 23 (SPSS Inc., USA). The data was descriptively analyzed according to the total sample and divided it into sex and smartphone application usage (i.e., non-users and users). The data were described as mean ± standard deviation for continuous variables and expressed as a percentage for categorical variables. Low CVR ≤ 2 risk factors and moderate-to-high CVR > 2 risk factors were considered. The features preferences were compared between low and moderate-to-high CVR groups using the x2 test. The significance level was set at $p < 0.05$.

## RESULTS

Although 560 volunteers were enrolled, only 238 participants were eligible (Figure 1). Our sample consisted mainly of middle-aged, white, overweight, and well-educated participants. The proportion of males and females was similar. Arterial hypertension, obesity, dyslipidemia, and physical inactivity were the most prevalent risk factors for CVD among participants. As expected, males presented lower mean age but higher body mass and height in comparison to females. Except for dyslipidemia, there were no significant differences between males and females (Table 1). Non-users were older with a higher Body Mass Index (BMI) and self-reported CVR when compared with users (Table 2).

Thus, 73.5% of participants were classified as low CVR, while 26.5% were moderate-to-high CVR. Although 36% of participants from the low CVR group reported using an application to monitor PA, the number of users in the moderate-to-high CVR group was even lower (14.3%). The low CVR group preferred "create a profile/personalize app" and "indicate what my physical status is" when compared to the moderate-to-high CVR group. The moderate-to-high CVR group considered less important an application "develop training schedule/program" and "save and review training statistics" than the low CVR group. Although "monitor own progress" was reported by both groups, this feature was more relevant for the low CVR group. Regarding social aspects features, both groups considered more interesting "being part of a community/group" than "competing with friends". When compared to the moderate-to-high CVR group, "receive feedback on performance", as well as "small assignments/tasks or challenges", was significantly preferred by the low CVR group. But the feature "receive motivational and encouraging messages and notifications" was more critical for the moderate-to-high CVR group. More than 80% of the participants reported the features related to suggestions from both groups, except receiving "suggestions for routes or places for PA". Regarding other features, the moderate-to-high CVR group preferred speech navigation instead of being able to "look back the route" as the low CVR group (Table 3).

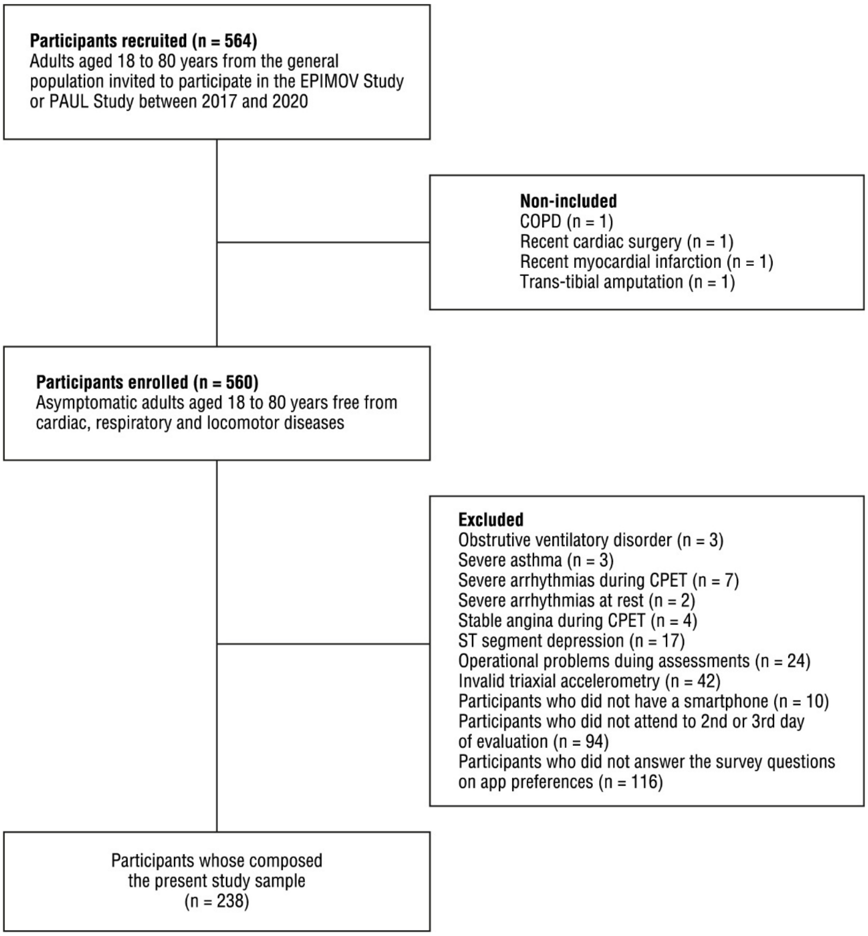


**Figure 1.** Flowchart of the study. EPIMOV: Epidemiological and Human Movement Study; PAUL: Playful data-driven Active Urban Living Study; COPD: chronic obstructive pulmonary disease; CPET: cardiopulmonary exercise testing.

**Table 1.** General characteristics of the total sample and according to sex (n = 238).

| Variables | Total | Female | Male |
|---|---|---|---|
| | (n = 238) | (n = 121) | (n = 117) |
| Age (years)* | 44 ± 13 | 46 ± 14 | 42 ± 11 |
| Body Mass (kg)* | 75.5 ± 18 | 69.1 ± 15.5 | 82.4 ± 18.1 |
| Height (m)* | 1.66 ± 0.09 | 1.60 ± 0.06 | 1.72 ± 0.07 |
| Body Mass Index (kg/m2) | 27.2 ± 5.4 | 27.0 ± 5.8 | 27.4 ± 5.1 |
| Educational level (%) | | | |
| Secondary complete or higher | 59.6 | 61.7 | 58.2 |
| Secondary incomplete | 40.4 | 38.3 | 41.8 |
| Race-ethnicity (%) | | | |
| White | 51.3 | 52.2 | 50.0 |

**Note.** Data were expressed as mean ± standard deviation or percentage. ¥ Assessed through self-report. € Classified according to Body Mass Index (> 30 kg/m2) after anthropometric evaluation. £ Assessed through triaxial accelerometry. *p < 0.05.

**Table 1.** Continued...

| Variables | Total (n = 238) | Female (n = 121) | Male (n = 117) |
|---|---|---|---|
| Black | 17.3 | 15.0 | 20.0 |
| Pardo/Mixed ethnicity | 27.4 | 28.3 | 26.4 |
| Indigenous | 1.8 | 1.8 | 1.8 |
| East Asian | 2.2 | 2.7 | 1.8 |
| Risk Factors for Cardiovascular Disease (%) | | | |
| Arterial hypertension¥ | 16.7 | 17.1 | 16.8 |
| Diabetes Mellitus¥ | 6.4 | 9.4 | 3.5 |
| Dyslipidemia¥* | 17.6 | 24.8 | 9.7 |
| Obesity€ | 23.7 | 27.4 | 19.6 |
| Current smoking¥ | 4.3 | 2.6 | 5.3 |
| Physical inactivity£ | 27.5 | 30.8 | 23.9 |

**Note.** Data were expressed as mean ± standard deviation or percentage. ¥ Assessed through self-report. € Classified according to Body Mass Index (> 30 kg/m2) after anthropometric evaluation. £ Assessed through triaxial accelerometry. *p < 0.05.

**Table 2.** General characteristics of the studied sample stratified according to users and non-users of smartphones applications to track physical activity (n = 238).

| Variables | Non-users (n = 166) | Users (n = 72) |
|---|---|---|
| Age (years)* | 46 ± 13 | 39 ± 10 |
| Body Mass (kg) | 76.7 ± 18.3 | 72.5 ± 16.7 |
| Height (m) | 1.66 ± 0.10 | 1.68 ± 0.08 |
| Body Mass Index (kg/m2)* | 27.8 ± 5.6 | 25.4 ± 4.5 |
| Sex (%) | | |
| Male | 48.2 | 51.5 |
| Female | 51.8 | 48.5 |
| Educational level (%)* | | |
| Secondary complete or higher | 54.0 | 51.5 |
| Secondary incomplete | 46.0 | 48.5 |
| Race-ethnicity (%) | | |
| White | 51.9 | 51.5 |
| Black | 14.8 | 23.4 |
| Pardo/Mixed ethnicity | 29.0 | 23.4 |
| Indigenous | 1.9 | 1.6 |
| East Asian | 2.5 | 1.6 |
| Risk Factors for Cardiovascular Disease (%) | | |
| Arterial hypertension* | 21.0 | 6.1 |
| Diabetes Mellitus[a] | 9.0 | 0.0 |
| Dyslipidemia* | 21 | 9.1 |
| Obesity* | 28.3 | 12.1 |
| Current smoking* | 4.8 | 3.0 |
| Physical inactivity | 31.1 | 18.2 |

**Note.** Data were expressed as mean ± standard deviation and percentage for continuous and categorical variables, respectively. *p < 0.05; [a] not tested for lack of data.

**Table 3.** Features preferences reported by sample stratified according to cardiovascular risk.

| Features | Low CVR group | Moderate-to-high CVR group |
|---|---|---|
| Personal/individualized, % | | |
| Create a profile/personalize app | 72.1 | 65.6 |
| Share my data for a tailored advice | 44.2 | 34.4 |
| Indicate how I feel about the course of the training session | 76.0 | 78.1 |
| Indicate what my physical status is | 80.8 | 62.5* |
| Training, % | | |

**Note.** CVR: cardiovascular risk. *p < 0.05.

**Table 3.** Continued...

| Features | Low CVR group | Moderate-to-high CVR group |
|---|---|---|
| Set personal goals | 81.7 | 78.1 |
| Develop training schedule/program | 79.8 | 59.4* |
| Monitor speed, time, distance, energy expenditure, heart rate and altimeters | 92.3 | 87.5 |
| Save and review training statistics | 88.5 | 71.9* |
| Performance (enhancements), % | | |
| Monitor personal records | 76.0 | 71.9 |
| Monitor own progress (e.g., in graphs and tables) | 93.3 | 87.5 |
| Social aspect, % | | |
| Competing with friends | 36.5 | 25 |
| Share activities with others via social media | 55.8 | 68.3 |
| Be able to view activities of others (and provide feedback) | 40.4 | 34.4 |
| Being part of a community/group | 67.3 | 62.5 |
| Feedback, % | | |
| Receive feedback on performance | 90.4 | 76.1* |
| Audio coaching (receive spoken messages during training) | 55.7 | 71.9 |
| Motivation, % | | |
| Small assignments/tasks or challenges | 78.8 | 62.5* |
| Encouragement to hold on | 71.4 | 84.4 |
| Encouragement to maintain or adjust speed during training | 76.0 | 75.0 |
| Receive rewards (e.g., winning badges of medals) | 54.8 | 53.1 |
| Receive motivational and encouraging messages and notifications | 62.5 | 84.4* |
| Suggestions for, % | | |
| Set-up of training | 80.8 | 84.4 |
| Variation in training | 80.8 | 84.4 |
| Routes or places for physical activity | 76.9 | 68.8 |
| Running or walking technique | 87.5 | 84.4 |
| Injury prevention | 89.4 | 87.5 |
| Other, % | | |
| Speech navigation | 57.3 | 75.0* |
| Looking back on route | 91.3 | 71.9* |
| Be able to listen to music during training | 72.1 | 65.6 |
| Weather prediction | 72.1 | 62.5 |

**Note.** CVR: cardiovascular risk. *$p < 0.05$.

The features preferences according to CVR groups (≥ 80%) were summarized in Table 4.

**Table 4.** Features preferences reported by more than 80% of participants stratified according to cardiovascular risk.

| Features | Low CVR group | Moderate-to-high CVR group |
|---|---|---|
| Personal/ individualized | Indicate what my physical status is* | |
| Training | Save and review training statistics*<br>Monitor speed, time, distance, energy, expenditure, heart rate and altimeters<br>Set personal goals | Monitor speed, time, distance, energy, expenditure, heart rate and altimeters |
| Performance (enhancements) | Monitor own progress (e.g., in graphs and tables) | Monitor own progress (e.g., in graphs and tables) |

**Note.** CVR: cardiovascular risk. * Higher proportion of feature preference reported when compared to moderate-to-high CVR group ($p < 0.05$). € Higher proportion of feature preferences reported when compared to low CVR group ($p < 0.05$).

**Table 4.** Continued...

| Features | Low CVR group | Moderate-to-high CVR group |
|---|---|---|
| Social aspect | | |
| Motivation | | Encouragement to hold on |
| | | Receive motivational and encouraging messages and notifications€ |
| Feedback | Receive feedback on performance* | |
| Suggestions for | Set-up of training | Set-up of training |
| | Variation in training | Variation in training |
| | Running or walking technique | Running or walking technique |
| | Injury prevention | Injury prevention |
| Other | Looking back on route* | |

**Note.** CVR: cardiovascular risk. * Higher proportion of feature preference reported when compared to moderate-to-high CVR group ($p < 0.05$). € Higher proportion of feature preferences reported when compared to low CVR group ($p < 0.05$).

# DISCUSSION

The present study investigated feature preferences of smartphone applications that monitor PA in Brazilian asymptomatic adults stratified according to CVR. To our knowledge, this is the first study to analyze the feature preferences particularly in subjects with moderate-to-high CVR. We were able to set a profile of smartphone application users in the Brazilian population.

Our sample was mainly white and overweight middle-aged individuals. Expectedly, the age range and being overweight are consistent with national data[15,16], except for the proportion of white subjects with substantially fewer black and pardo subjects[17]. We observed high scholarly differing from the Brazilian population[17]. These divergences can be explained by convenience sampling and the exclusion of subjects who did not have a smartphone. Since internet access, especially mobile broadband, is closely linked to age, sex, race-ethnicity, and educational level[17,18] considering these attributes are essential to comprehend our findings. Therefore, we detailed our sample characteristics, otherwise, the lack of discussion of social, economic, cultural, and geographical context would introduce a potential bias to our study.

In general, the prevalence of CVR was smaller when compared to the Brazilian population, except for obesity[16]. Physical inactivity was expressively lower in comparison to the national data[16], which can be attributed to the use of objective measures to obtain PA. Self-reported measurements tend to underestimate PA level and overestimate inactivity due to difficulty when recalling time spent sitting and lack of understanding about PA intensity during daily life[19]. This finding can also be related to local aspects that contribute to a more active lifestyle, such as geographical (a city located in a coastal plain zone), environmental (availability and access to leisure spaces and equipment for PA and extensive bike lane) and behavioral aspects (active transportation and leisure-time PA, including walking, jogging, swimming, practicing sports or recreational activities on the beach).

We found that the application users were younger with less prevalent CVR than non-users, which corroborates previous studies[6,20]. The absence of chronic conditions is a predictor of health application download, leading to almost 5x more engagement in PA[20]. These findings reinforce our primary purpose since stimulating behavior changes in a more vulnerable population can be challenging for health professionals and researchers. An application design must incorporate field experiment[11,18], which highlights our contributions to PAUL Study[13] by adding the feature preferences based on CVR. Health professionals must also be involved in application development to avoid already known safety issues such as poor and incorrect information, inappropriate response to users' needs, and failure in response to possible health dangers[21].

Adding personal data and physical status was preferred by the low CVR group. Similarly, most subjects desire to add body mass, height, motivational level, prior PA experience, and goals[22]. This feature allows the user to realize that their characteristics and needs will be considered during application use, which can positively affect both users' adherence and motivation. Monitoring your progress is a feature preferred for both groups, which allows setting short-term goals as motivation to sustain or change PA behavior[23]. However, self-monitoring could result in either positive or negative experiences, allowing more often analysis of own progress and whether personal goals were achieved[2]. Tables and graphs provided in real-time were useful to monitor the user's progress[24], raising awareness of current lifestyle and opportunities to improve it[25].

Receiving motivational messages and speech navigation were the main features reported by the moderate-to-high CVR group. Motivational messages were interesting and encouraging for lifestyle change[22,23]. However, tedious, similar, or repetitive messages can lead to undesirable findings, especially in inactive subjects[23]. Providing engagement and motivation can reduce or avoid the abandonment of the application[26]. Despite being effective in a short period, the literature still lacks evidence about sharing messages from long-term interventions[27]. Similarly, both active and inactive subjects reported preferences of receiving suggestions (how to achieve goals, how to make the activities more fun, how to exercise safely, and when is better for exercising)[22]. More than 80% of our participants were interested in receiving suggestions, regardless of the CVR group.

Regarding speech navigation, we attribute our finding to moderate-to-high CVR, which is often linked to socioeconomic status, race-ethnicity, low scholarly, advanced age[27] and more social vulnerability with possible low digital literacy in Brazil. It is imperative to investigate strategies for reducing barriers such as the need for training to use technology and overcoming decreased visual acuity[9]. The role of digital literacy must be addressed, mainly in LMICs. The lower the digital literacy, the lower the use of e-health, among other factors because the subjects do not feel confident about their skills to seek quality health information[28]. Although we did not directly evaluate digital literacy, the low proportion of black and pardo subjects, as well as less educated, could be related to digital exclusion either to the limited access to the internet or possession of personal devices. Only a few Brazilian elderly report using the internet and more than half do not know how to access it[17]. Although 80.2% of Brazilians use a mobile broadband connection, there are still subjects without a device for personal use[17]. Despite a simple interface design, visual information, animations, dictionaries, and links to other health resources, educational strategies must be part of applications[28].

Several studies investigated using feedback in applications. A systematic review pointed out that feedback, especially in real-time, contributes to users' motivation to achieve their goals and influences the effectiveness of behavior changes[29]. Most subjects would like to receive feedback after completing their activities, which accompanied by praise or motivational message favors the scheduling to exercise and to achieve their goals[22]. Receiving feedback motivates subjects to keep using the application[25], allows the subjects' comprehension of their PA level concerning the recommendations[24], raises awareness and encourages behavior change decision-making[23]. Furthermore, instant feedback, mainly by visual or audible stimulus, acts as an important source of information about current progress and health status change[28]. Therefore, our findings agree with previous studies.

Previously, competing led to promising results. But this feature was not a critical resource for our participants. Although competing contributes to sustained application use, some subjects preferred monitoring their progress instead of comparing them[22]. This feature must be used with caution since it can generate discomfort, internal conflicts and even discourage application use, particularly in subjects with increased CVR.

We found that being a part of a community was an important feature, regardless of CVR. Previously the sense of being in a community was also observed[22]. It may be related to the opportunity of meeting other subjects, knowing their performance while enhancing their own and the interactions with others with similar motivations. Being in a community with close friends and subjects with similar purposes led to a positive reaction due to sharing achievements and goals[22].

The present study has some limitations to be considered, especially the convenience sample and low proportion of moderate-to-high CVR participants. Both users and non-users answered the survey questions on applications which do not allow us to understand whether the feature preferences determine the download of an application or its usage. Unfortunately, we could not perform a secondary analysis about the feature preferences according to users and non-users from both CVR groups due to an insufficient number of participants that reported being users. However, we provided a detailed characterization of our sample, including race-ethnicity, educational level, anthropometrics, and the prevalence of risk factors for CVD, which can play an important role regarding health application use in LMICs. Another strength is our sample size which supports the data analysis proposed in our study.

Our findings have several practical implications. Future studies should investigate whether these preferences are related to download, usability, or usage of smartphone applications. Moreover, understanding the role of behavior change status can also contribute to enhancing the applications. Only 15% of the moderate-to-high CVR group were users. Thus, a qualitative analysis of the main barriers for application usage in non-users can favor comprehension about this scenario. A secondary analysis based on race-ethnicity and educational level, or even socioeconomic status, could also be interesting when comparing the profile of users and non-users, as well as the feature preferences. We reinforce the need to address and overcome commonly geographical and policy barriers in LMICs, including insufficient mobile network coverage, unstable internet services, lack of electricity and poor national m-health guidelines associated with a low level of knowledge and poor attitude and perception of users regarding applications[18].

# CONCLUSION

Speech navigation and receiving motivational messages are the most preferred features reported by white and high scholarly middle-aged Brazilian subjects with overweight and moderate-to-high CVR.

# Compliance with ethical standards

## Funding

The Sao Paulo Research Foundation financially supported this study (FAPESP), grant #2016/50249–3.

## Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

## Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee –UNIFESP and the protocol (no. 0676/2018) was written in accordance with the standards set by the Declaration of Helsinki.

## Conflict of interest statement

The authors have no conflict of interests to declare.

## Author Contributions

Conceived and designed the experiments: VZD, TLVDPO, and RCP. Performed the experiments: GFG. Analyzed the data: VZD. Contributed reagents/materials/analysis tools: VZD, TLVDPO, RCP, and GFG. Wrote the paper: VZD, TLVDPO, RCP, and GFG.

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