Original Article

RBAFS Revista Brasileira de Atividade Física & Saúde
SOCIEDADE BRASILEIRA DE ATIVIDADE FÍSICA & SAÚDE

rbafs.org.br

Preferred functionalities on smartphone applications for physical activity in adults with low cardiorespiratory fitness

Preferências de funcionalidades de aplicativos de smartphone para a atividade física em adultos brasileiros com baixa aptidão cardiorrespiratória

AUTHORS

Thatiane Lopes Valentim Di Paschoale Ostolin[1]
Victor Zuniga Dourado[1]

1 Universidade Federal de São Paulo, Campus Baixada Santista, Departamento de Ciências do Movimento Humano, Santos, São Paulo, Brazil.

CORRESPONDING

Victor Zuniga Dourado
victor.dourado@unifesp.br
Rua Silva Jardim, nº 136, Santos, São Paulo, Brazil.
Zip-code: 11015-020

DOI

10.12820/rbafs.30e0401

ABSTRACT

Objectives: To identify smartphone applications' preferred functionalities for physical activity in adults with low cardiorespiratory fitness (CRF). Methods: We assessed preferences through a survey of 238 participants based on 36 functionalities divided into the following topics: Personal/individualized, Training, Performance, Social aspect, Feedback, Motivation, Suggestions, and Other. Participants performed a cardiopulmonary exercise test and spirometry to assess maximum oxygen uptake (VO_2 máx), forced vital capacity, and forced expiratory volume in 1s. We compared participants with low CRF (tertile 1) with those with median/good CRF (tertiles 2 and 3). Results: Only 17% of adults with low CRF referred to using an application. "Track speed, time, distance, energy expenditure, heart rate, and altitude"; "Monitor your progress with graphs and tables"; "Get feedback on my performance"; "Receive suggestions for activity technique"; "Receive suggestions for injury prevention"; and "Get access to the weather forecast" were the most popular in the low CRF group (81-93%). However, functionalities such as "Share my data with another profile or custom device"; "Compete with friends"; "Share activities through social networks"; "Being able to view others' activities and give feedback"; "Be part of a community/group"; and "Monitor the route" were significantly less prevalent among low CRF participants (31, 17, 34, 22, 50, and 78%, respectively), i.e., reported by less than 80% of participants. Conclusions: As expected, less than a fifth of the adults with low CRF are applications' users. Among the features commonly included in smartphone applications, monitoring training and performance, receiving feedback, and suggestions were the most popular among the low CRF group.

Keywords: Physical activity; Mobile applications; Smartphone; m-health; Cardiorespiratory fitness; Chronic condition.

RESUMO

Objetivo: Identificar as preferências de funcionalidades de aplicativos de smartphones para atividade física em adultos com baixa aptidão cardiorrespiratória (ACR). Método: Avaliamos as preferências por meio de um questionário dividido nos seguintes tópicos: Pessoal/individualizado, Treinamento, Desempenho, Aspecto Social, Feedback, Motivação, Sugestões e Outros. Os participantes foram submetidos a um teste de exercício cardiopulmonar e espirometria para obtenção do consumo máximo de oxigênio (VO_2 máx), capacidade vital forçada e volume expiratório forçado no 1s. As preferências foram comparadas entre participantes com baixa ACR (primeiro tercil) e regular/boa ACR (segundo e terceiro tercis). Resultados: Somente 17% dos adultos com baixa ACR referiram uso de aplicativos. "Monitorar a velocidade, tempo, distância, gasto de energia, frequência cardíaca e altitude", "Monitorar o próprio progresso com gráficos e tabelas", "Receber feedback sobre meu desempenho", "Receber sugestões para execução da atividade", "Receber sugestões para prevenção de lesões" e "Ter acesso à previsão do tempo" foram as funcionalidades mais populares entre o grupo com baixa ACR (81-93%). Contudo, funcionalidades a exemplo de "Compartilhar meus dados com outro perfil ou dispositivo personalizado", "Competir com amigos", "Compartilhar atividades por meio de redes sociais", "Ser capaz de visualizar atividades dos outros e fornecer feedback", "Ser parte de uma comunidade" e "Monitorar o percurso percorrido" foram menos prevalentes entre os adultos com baixa ACR (31, 17, 34, 22, 50 e 78%, respectivamente), i.e., reportado por menos do que 80% dos participantes. Conclusão: Conforme esperado, menos de um quinto dos adultos com baixa ACR são usuários de aplicativos. Dentre as funcionalidades comumente presentes em aplicativos, as mais populares entre o grupo de baixa ACR foram o monitoramento tanto do treinamento quanto do desempenho e o recebimento de feedback e sugestões.

Palavras-chave: *Atividade física; Aplicativos móveis; Smartphone; Telessaúde; Aptidão cardiorrespiratória; Doença crônica.*

Introduction

Currently, mobile health (m-health) has been seen as a complementary resource for delivering healthcare characterized by several types of mobile applications (apps), including those focused on physical activity[1]. The use of multiple sensors helps the user capture video and photos, record voice, track location, share data, and communicate with other users, which allows to explain that almost half of the available health applications were related to self-monitoring training and performance[2] already a decade ago. These types of health apps tend to increase even more with the use of wearable devices such as smartwatches nowadays. It is worth nothing that these functionalities favor adherence to using apps, while lacking desirable resources are linked to their abandonment[3]. Accordingly, including the target population as collaborators in the development of apps potentially increases the chance of having more users, concurrently leading to more engagement and effectiveness[4].

As widely addressed, physical activity plays a central role in disease prevention and treatment. As it is linked to cardiorespiratory fitness (CRF), physical activity requires being monitored as a vital sign and promoted by setting specific goals for its improvement[5], regardless of age, scholarly, **gender**, and health condition. Self-report and wearable technology proved to be appropriate to monitor physical activity for different age ranges and health status[6], including older adults with chronic conditions[7]. Despite data variability[8,9], mobile technology allows a long-term individualized self-monitoring of physical activity. Additionally, application-based interventions and wearable devices already showed to be effective for sedentary behavior and physical activity-related changes[10-12].

Although more prominent in patients who suffered from the disease, the ongoing COVID-19 pandemic affected the health status from overall population due to lifestyle changes, discontinuation of rehabilitation, lockdown, among others. A systematic review showed alarming changes in physical activity level of elderly people with persistent impact even after the end of lockdown and social isolation[13]. However, the use of wearable technology increased and proved to enhance physical activity level[14]. Moreover, mobile technology contributed to maintenance of connection between families and friends and encouragement to improve lifestyle in older adults, which attenuated pandemic impact in physical activity level[15]. Lastly, users of digital platforms were more likely to meet guidelines for physical activity and muscle-strengthening exercise during social isolation than non-users[16].

Given the association between aging and decreased CRF[17], m-health strategies for monitoring and encouraging physical activity aimed at middle-aged and older adults must be investigated. In addition, when higher the CRF, lower the risk of all-cause mortality[18]. An overview of meta-analyses found a decrease in all-cause mortality between 11 and 17% for each 1 metabolic equivalent of task (MET)[19]. It is important to point out that Singh et al.[20] showed a similar dose-response for all-cause mortality when comparing objectively measured or estimated CRF.

However, apps users from high-income countries are often young, well-educated, and wealthy individuals[21]. Regarding low, middle and upper-middle-income countries, the profile of smartphone app users for both monitoring and promoting physical activity is still insufficient. Although interested, just a few patients with chronic diseases are self-reported users[22]. Functionalities disconnected from the desires and needs of the users are a barrier, particularly for subjects with chronic conditions willing to use physical activity apps[23]. Furthermore, literature lacks publications about smartphone apps' preferred functionalities for physical activity in adults with decreased CRF who can largely benefit from monitoring and improving physical activity level.

Since monitoring physical activity in large groups and promoting behavior-related changes are challenges worldwide, investigating smartphone apps' preferred functionalities will contribute to a better understanding about the most attractive features for health apps. Particularly for those adults with low CRF that a smaller number of users is expected, the preference of functionalities for both users and non-users can be a key factor not only for developing more appropriate apps but also for ensuring short and long-term engagement and providing friendly m-health actions for these individuals. Therefore, we aimed to identify smartphone apps' preferred functionalities for physical activity in adults with low CRF. Secondarily, we compare these preferences between adults with low CRF and medium/good CRF.

Methods

Study design and participants

We carried out a cross-sectional study with participants eligible (i.e., subjects who have a smartphone and answered the survey questions on application preferences) from Epidemiology and Human Movement (EPIMOV) study[24] and Playful data-driven Active Urban Living (PAUL) study[25] according to the guidelines of the Declaration of Helsinki and approved by the Research Ethics Committee of the Federal University of São Paulo (#0499/2018). Participants were informed about the possible risks and discomforts of the evaluations and signed an Informed Consent Term. The Human Research Ethics Committee of the Federal University of São Paulo (number 186,796) approved the present study[24,25].

We recruited asymptomatic or with treated/controlled chronic conditions subjects aged 18-80 years from both genders and able to safely perform physical effort to participate in the EPIMOV study through advertisements in social media, local universities, and newspapers. Previously diagnosed pulmonary, cardiovascular, musculoskeletal, or neuromuscular diseases, ventilatory disorders, chest pain or abnormalities in the electrocardiographic tracing during effort, opera-tional problems and lacking one or more evaluations from the EPIMOV study protocol were exclusion criteria.

Clinical health screening

The clinical health screening included sociodemographic data (e.g., age, **gender**, race-ethnicity, and educational level), history of health problems, regular use of medication and self-reported cardiovascular risk (i.e., current smoking, hypertension, dyslipidemia or hypercholesterolemia, diabetes mellitus or hyperglycemia, and physical inactivity). Then, we measured body mass (kg) and height (m) using a digital scale with a stadiometer as recommended and calculated body mass index (kg/m^2). Lastly, pulmonary function was obtained using a portable spirometer (Quark PFT, COSMED, Pavona di Albano, Italy) according to the standard recommendations and previously described[26]. Forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and the FEV_1/FVC ratio were registered.

Cardiopulmonary exercise test

Participants underwent a symptom-limited and individualized cardiopulmonary exercise testing in a motorized treadmill (ATL, Inbramed, Porto Alegre, Brazil) following a ramp protocol[27]. We monitored metabolic, cardiovascular, and ventilatory breath-to-breath responses filtered at 15s intervals using a gas analyzer (Quark PFT, COSMED, Pavona Albano, Italy) and a 12-lead electrocardiogram (C12X, COSMED, Italy). At every two minutes, blood pressure perceived exertion regarding dyspnea and lower limb fatigue were measured using a sphygmomanometer and the modified Borg scale respectively. The tests were evaluated by a cardiologist.

Cardiopulmonary exercise testing was symptom-limited, except when observed signals of suggestive myocardial ischemia (ST-segment depression), chest pain, sudden drop in systolic blood pressure ≥20 mmHg, systolic blood pressure ≥250 mmHg, signs of respiratory failure, loss of coordination or mental confusion. VO_2 peak was considered as the equivalent value of VO_2 achieved when reached the peak of effort, e.g. the average value obtained during the last 15s.

Survey Questions on Application Preferences

We investigated smartphone apps' preferred functionalities for physical activity using a translated version of the survey proposed by Dalling et al.[28] based on the following topics: Personal/individualized; Training; Performance; Social aspects; Feedback; Motivation; Suggestions; Other. For each topic, the participant was allowed to choose more than one feature when applied. We classified participants as users (i.e., participants who use, at least, one application available for download in the "health and fitness" category of the Apple or Play Store that count the number of steps or allows recording physical activity) and non-users.

Triaxial accelerometry

We obtained triaxial accelerometer-based physical activity level (Actigraph GT3x +, MTI, Pensacola, FL, USA) as described[29]. Participants wore the device at the waist above the dominant hip for at least ten waking hours a day (i.e., until bedtime, except in the shower and water-related activities, nighttime sleep, and contact sports) for at least four consecutive days. Wearing time was considered 24h minus non-wearing time (i.e., interval of zero counts for ≥ 60 minutes). The thresholds for activity intensity in counts per minute (cpm) were very light (100-759 cpm), light (760-1951), moderate (1952-5724), vigorous (5725-9498), very vigorous (≥ 9499) and sedentary time (< 100 cpm or < 1.5 MET). We considered as physically inactive those participants with < 150min/week of moderate-to-vigorous physical activity.

Statistical analysis

Statistical analysis was performed using SPSS software, version 23 (SPSS Inc., USA). We analyzed the data descriptively according to the total sample, **gender**, 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. Our sample was divided according to tertiles of CRF (1^{st} (low) vs. 2^{nd} and 3^{rd} (median/good)). Lastly, we compared the features preferences between CRF groups using the x^2 test. We set the significance level at $p < 0.05$.

Results

Overall, 238 subjects were included (Figure 1), mostly middle-aged, white, overweight, and well-educated. Although **gender**-related anthropometrics and demographic differences were expectedly, cardiovascular risk was similar between males and females, except for dyslipidemia. Non-users were older and well-educated with a higher body mass index and self-reported cardiovascular risk compared to users. Similarly, the low CRF group were older than the median/good CRF group, as well as presenting a significant higher prevalence of all cardiovascular risk factors when compared to those with better CRF, except for smoking (Table 1).

Based on tertiles of CRF, 34% (n = 81) of participants were classified as low CRF and 66% (n = 157) as median/good CRF. Only 17% (n = 14) of participants from low CRF were app users, while 40% from median/good were considered users (17% vs. 40%; p < 0.001).

"Share my data with another profile or custom device"; "Compete with friends"; "Share activities through social networks"; "Being able to view others' activities and give feedback"; "Be part of a community/group"; and "Monitor the route" were significantly less prevalent among low CRF participants (31, 17, 34, 22, 50, and 78%, respectively). Conversely, "Track speed, time, distance, energy expenditure, heart rate, and altitude"; "Monitor your progress with graphs and tables"; "Get feedback on my performance"; "Receive suggestions for activity technique"; "Receive suggestions for injury prevention"; and "Get access to the weather forecast" were the most popular in the low CRF group (81-93%) (Table 2).

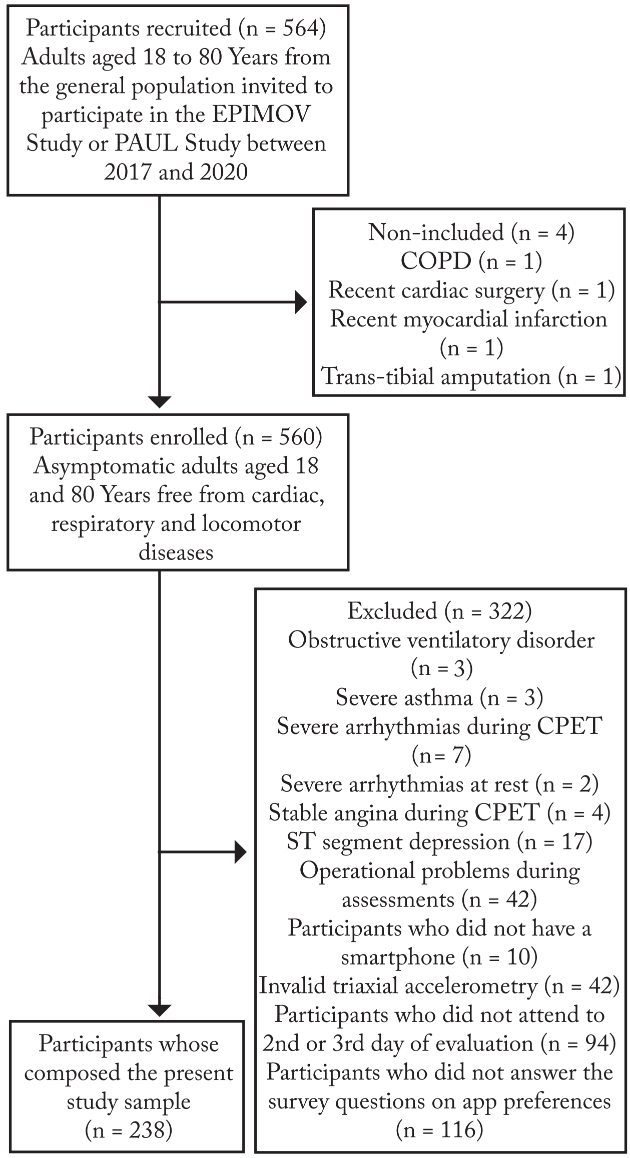

Figure 1 – Flowchart of the study. EPIMOV: Epidemiological and Human Movement Study; PAUL: Playful data-driven Active Urban Living Study; COPD: chronic obstructive pulmonary disease; CPET: cardiopulmonary exercise testing.

Discussion

The present study investigated smartphone apps' preferred functionalities in the Brazilian asymptomatic adults with low CRF. The novelty of our study is setting the self-reported functionalities preferences particularly in these subjects. We are unaware of previous studies that analyzed this topic. Functionalities related to training, performance, feedback, and suggestions were the most popular among the low CRF group.

Our sample was similar to the Brazilian population[29], except for race-ethnicity and scholarly. Participants were mostly white and well-educated, possibly due to convenience sampling and eligibility criteria (i.e., exclusion of subjects who did not have a smartphone). Our findings must be critically analyzed since we are aware of digital divide in Brazil.

Overall cardiovascular risk was smaller than expect-

Table 1 – General characteristics of the total sample and according to **gender**, use of smartphone applications and cardiorespiratory fitness (n = 238).

Variables	Total (n = 238)	Female (n = 121)	Male (n = 117)	Non-users (n = 166)	Users (n = 72)	Low cardiorespiratory fitness group (n = 81)	Median/good cardiorespiratory fitness group (n = 157)
Age (years)	44 ± 13	46 ± 14*	42 ± 11	46 ± 13β	39 ± 10	43 ± 14#	42 ± 11
Body mass (kg)	75.5 ± 18	69.1 ± 15.5*	82.4 ± 18.1	76.7 ± 18.3	72.5 ± 16.7	76.7 ± 19.8#	74.0 ± 14.2
Height (m)	1.66 ± 0.09	1.60 ± 0.06*	1.72 ± 0.07	1.66 ± 0.10	1.68 ± 0.08	1.65 ± 0.10	1.67 ± 0.09
Body mass index (kg/m^2)	27.2 ± 5.4	27.0 ± 5.8	27.4 ± 5.1	27.8 ± 5.6β	25.4 ± 4.5	27.8 ± 6.6#	26.3 ± 4.0
Educational level (%)							
Secondary complete or higher	59.6	61.7	58.2	54.0β	51.5	65.6	54.7
Secondary incomplete	40.4	38.3	41.8	46.0β	48.5	34.4	45.3
Race-ethnicity (%)							
White	51.3	52.2	50.0	51.9	51.5	53.9	49.1
Black	17.3	15.0	20.0	14.8	23.4	10.1	17.8
Pardo/Mixed ethnicity	27.4	28.3	26.4	29.0	23.4	30.3	29.6
Indigenous	1.8	1.8	1.8	1.9	1.6	2.2	1.8
East Asian	2.2	2.7	1.8	2.5	1.6	3.4	1.2
Risk factors for cardiovascular disease (%)							
Arterial hypertension	16.7	17.1	16.8	21.0β	6.1	21.1#	8.0
Diabetes mellitus	6.4	9.4	3.5	9.0	0.0	12.2#	1.1
Dyslipidemia	17.6	24.8*	9.7	21.0β	9.1	22.2#	11.4
Obesity	23.7	27.4	19.6	28.3β	12.1	31.1#	15.4
Current smoking	4.3	2.6	5.3	4.8β	3.0	7.8	4.6
Physical inactivity	27.5	30.8	23.9	31.1	18.2	46.7#	14.9

Data were expressed as mean ± standard deviation or percentage. Level of significance $p < 0.05$.
*: vs. males; β: vs. users; #: vs. Median/good cardiorespiratory fitness; a: not tested for lack of data when comparing users and non-users.

ed[30], regardless **gender**. Inactivity was expectedly lower compared to the national data, which can be attributed to divergence in adopted criteria and methodological differences[30]. Self-reported physical activity tends to overestimate inactivity, mostly due to difficulty when recalling time spent sitting and lack of understanding about activity intensity during daily life activities. However, almost half of the Brazilian population did not achieve the amount of moderate-to-vigorous physical activity recommended[30], which are compatible to our data. Similar to previous studies[21,31,32], the profile of users was younger with great CRF and less prevalent cardiovascular risk than non-users. Being asymptomatic or apparently healthy predicts the download of health applications while increasing engagement in physical activity[32], which can also allow us to understand the profile of users.

When considering the low number of users among those with low CRF in addition to the fact that non-users presented higher cardiovascular risk, investigating the apps' preferences, regardless of being users, can broaden the perspective on this topic. Similarly, comparing these preferences with subjects with higher CRF allows us a better comprehension about a potential link between the CRF profile and the type of functionality.

"Track speed, time, distance, energy expenditure, heart rate, and altitude" and "Get access to the weather forecast" are features associated to geographical (i.e., the city where the study was conducted is located in a coastal plain zone), environmental (i.e., availability of outdoor leisure spaces and equipment for physical activity and extensive bike lane) and behavioral-related factors (i.e., active transportation and leisure-time physical activity, including walking, jogging, swimming, practicing sports or recreational activities on the beach). Our findings agree with previous studies[33], i.e. Latin-Americans, mostly men, present more active transportation and friendly environments contribute to engagement in different types of activities, especially outdoor.

"Monitor your progress with graphs and tables" was popular among the low CRF group. Since tables and graphs are useful to monitor the user's progress in real-time, using them contributes to raising lifestyle awareness and performance improvement[34]. Therefore, graphs and tables can be helpful to self-monitoring short-term personal goals since visual cues play an im-

Table 2 – Smartphone apps' preferred functionalities reported by sample stratified according to cardiopulmonary fitness.

Functionalities	Low cardiorespiratory fitness group (n = 81)	Median/good cardiorespiratory fitness group (n = 157)	p-value
	%	%	
Personal/individualized			
Create a profile/personalize app	75.4	61.4	0.090
Share my data for tailored advice	31.7	50.0*	0.040
Indicate how I feel about the course of the training session	69.0	73.8	0.544
Indicate what my physical status is	73.8	73.8	0.996
Training			
Set personal goals	69.0	76.2	0.359
Develop training schedule/program	66.7	75.4	0.267
Monitor speed, time, distance, energy expenditure, heart rate and altimeters	92.9	93.1	0.961
Save and review training statistics	76.2	83.1	0.319
Performance (enhancements)			
Monitor personal records	66.7	78.5	0.122
Monitor own progress (e.g., in graphs and tables)	90.5	90.8	0.955
Social aspect			
Competing with friends	17.5	45.4*	0.001
Share activities with others via social media	34.1	64.6*	0.001
Be able to view activities of others (and provide feedback)	22.0	48.5*	0.003
Being part of a community/group	50.0	69.2*	0.024
Feedback			
Receive feedback on performance	81.0	90.8	0.084
Audio coaching (receive spoken messages during training)	36.6	46.2	0.282
Motivation			
Small assignments/tasks or challenges	66.7	77.4	0.328
Encouragement to hold on	69.0	70.0	0.907
Encouragement to maintain or adjust speed during training	66.7	73.1	0.424
Receive rewards (e.g., winning badges of medals)	51.2	56.9	0.522
Receive motivational and encouraging messages and notifications	69.0	63.1	0.482
Suggestions for			
Set-up of training	73.8	74.6	0.917
Variation in training	76.2	78.5	0.758
Routes or places for physical activity	73.8	73.8	0.996
Running or walking technique	81.0	83.1	0.752
Injury prevention	92.9	86.6	0.297
Other			
Speech navigation	56.1	56.2	0.995
Looking back on route	78.0	90.0*	0.046
Be able to listen to music during training	61.9	61.5	0.966
Weather prediction	70.7	66.2	0.586

*$p < 0.05$.

portant role as a source of information about current progress and health status change[35,36], which can explain our findings. Feedback is also associated with motivational aspects, helping the users to achieve their goals[37]. Receiving feedback favors the scheduling to exercise, motivates the sustained application use, allows the subjects' comprehension and comparison of their physical activity level concerning the recommendations, and encourages behavior change decision-making[34,35,38,39].

Receiving suggestions were popularly reported among the low CRF group, which can be attributed to our sample characteristics (i.e., middled-aged adults, white and well-educated individuals with controlled chronic conditions). Seeking suggestions for injury prevention and activity techniques can be understood as a safety concern about performing physical activity. Thus, our data reinforces previous findings about preference for tips on how to safely exercise[38] and targeting on active transportation and household activities for behavior-related changes[40]. Additionally, an overview found that using messages is effective in the self-management of health outcomes goals and chronic conditions[41].

Conversely, social-related features were less popular, which can be explained by our sample characteristics that do not have interest in engaging in competition and expect to enhance clinical and self-care through apps instead of focusing on performance[39,42,43]. Despite the potential of fitness applications in promoting lifestyle behavioral changes, health professionals must recommend them to their patients. According to Simmich et al.[39], elderly with chronic conditions would like to share data from m-health with their clinicians. Moreover, it is also reasonable that health professionals have to be involved in application development which can help to improve the response to users' needs[44].

Limitations and practical implications

The convenience sample and the low proportion of participants classified as low CRF were our main limitations. Unfortunately, we were unable to compare preferences according to users and non-users due to the small sample of users in the low CRF group. Besides our protocol, that includes standard measures for pulmonary function, CRF, and physical activity level, we included a detailed characterization of our sample, including sociodemographic variables that play an important role as barriers or facilitators in m-health, particularly in low, middle and upper-middle-income countries. Even during the pandemic, literature mostly originated from high-income countries of Europe and North America with a substantial gap in more vulnerable areas[45]. We are unaware of previous studies that carried out this analysis. Moreover, an important strength of the present study is the multidisciplinary and interprofessional composition of our research team that helps us to broaden the scope of this topic.

Our findings have several practical implications, especially for upper-middle-income countries. Mapping smartphone apps' preferred functionalities has the potential of overcoming the challenges for physical activity promotion and application usage in subjects with less physical fitness and one or more chronic conditions. Future studies need to investigate whether these preferences are related to download, usability, or usage of smartphone applications. Given the increased implementation of technology-based behavior changes techniques over the past few years, it is interesting to investigate whether the status of behavior change determines the features preferences or vice versa. Lastly, analyzing the main barriers and facilitators for application usage in non-users can favor understanding the implication of m-health for subjects with less physical fitness and chronic conditions.

Conclusion

Only 17% of asymptomatic adults with low CRF were considered users of physical activity smartphone applications. Regardless of being users or non-users, understanding preferred functionalities has the potential to allow smartphone apps to become more friendly and attractive to these subjects. Competing functionalities and viewing others' activities were interesting for less than a third of adults with low CRF. Data sharing and being a part of a community did not reach fifty percent of preference among adults with low CRF. Notwithstanding, self-monitoring both training and performance and receiving feedback and suggestions about how to be more active were the most popular functionalities commonly included in smartphone apps among the low CRF group.

Conflict of interest

The authors declare no conflict of interest.

Funding

This research was funded by São Paulo Research Foundation (*Fundação de Amparo à Pesquisa do Estado de São Paulo* - FAPESP), grant number #2016/50249-3.

Author's contributions

Ostolin TLVDP: Methodology; Formal analysis; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Dourado VZ: Conceptualization; Methodology; Software; Validation; Formal analysis; Data curation; Supervision; Project administration; Funding acquisition; Writing – original draft; Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools for preparation of the manuscript.

Availability of research data and other materials

The contents underlying the research text are contained in the manuscript.

Acknowledgments

We are thankful for the support of the EPIMOV Study team.

References

1. Carter DD, Robinson K, Forbes J, Hayes S. Experiences of mobile health in promoting physical activity: A qualitative systematic review and meta-ethnography. PLoS One. 2018; 13(12):e0208759. doi: https://doi.org/10.1371/journal.pone.0208759
2. Sama PR, Eapen ZJ, Weinfurt KP, Shah BR, Schulman KA. An Evaluation of Mobile Health Application Tools. JMIR Mhealth Uhealth. 2014;2(2):e19. doi: https://doi.org/10.2196/mhealth.3088
3. Murnane EL, Huffaker D, Kossinets G. Mobile health apps: Adoption, adherence, and abandonment. UbiComp ISWC 2015 - Proc. 2015 ACM Int. Jt. Conf. Pervasive Ubiquitous Comput. Proc. 2015 ACM Int Symp Wearable Comput. 2015;261–64.doi: https://doi.org/10.1145/2800835.2800943
4. Sun RT, Han W, Chang HL, Shaw MJ. Motivating Adherence to Exercise Plans Through a Personalized Mobile Health App: Enhanced Action Design Research Approach. JMIR Mhealth Uhealth. 2021;9(6):e19941.doi: https://doi.org/10.2196/19941
5. Ross R, Blair SN, Arena R, Church TS, Després JP, Franklin BA, et al. Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign: A Scientific Statement From the American Heart Association. Circulation. 2016;134(24):e653–e699. doi: https://doi.org/10.1161/CIR.0000000000000461
6. Evenson KR, Goto MM, Furberg, RD. Systematic review of the validity and reliability of consumer-wearable activity trackers. Int J Behav Nutr Phys Act. 2015;18:12:159. doi: https://doi.org/10.1186/s12966-015-0314-1
7. Mercer K, Giangregorio L, Schneider E, Chilana P, Li M, Grindrod K. Acceptance of Commercially Available Wearable Activity Trackers Among Adults Aged Over 50 and With Chronic Illness: A Mixed-Methods Evaluation. JMIR Mhealth Uhealth. 2016;4(1)e7. doi: https://doi.org/10.2196/mhealth.4225
8. Silva AG, Simões P, Queirós A, Rodrigues M, Rocha NP. Mobile Apps to Quantify Aspects of Physical Activity: a Systematic Review on its Reliability and Validity. J. Med. Syst. 2020;44(2):51. doi: https://doi.org/10.1007/s10916-019-1506-z
9. Ummels D, Beekman E, Theunissen K, Braun S, Beurskens AJ. Counting Steps in Activities of Daily Living in People With a Chronic Disease Using Nine Commercially Available Fitness Trackers: Cross-Sectional Validity Study. JMIR Mhealth Uhealth. 2018;6(4):e70. doi: https://doi.org/10.2196/mhealth.8524
10. Yerrakalva D, Yerrakalva D, Hajna S, Griffin S. Effects of Mobile Health App Interventions on Sedentary Time, Physical Activity, and Fitness in Older Adults: Systematic Review and Meta-Analysis. J Med Internet Res. 2019;21(11):e14343. doi: https://doi.org/10.2196/14343
11. Hodkinson A, Kontopantelis E, Adeniji C, van Marwijk H, McMillian B, Bower P, et al. Interventions Using Wearable Physical Activity Trackers Among Adults With Cardiometabolic Conditions: A Systematic Review and Meta-analysis. JAMA Netw Open. 2021;4(7):e2116382. doi: https://doi.org/10.1001/jamanetworkopen.2021.16382
12. Zhang M, Wang W, Li M, Sheng H, Zhai Y. Efficacy of Mobile Health Applications to Improve Physical Activity and Sedentary Behavior: A Systematic Review and Meta-Analysis for Physically Inactive Individuals. Int J Environ Res Public Health. 2022;19(8):4905. doi: https://doi.org/10.3390/ijerph19084905
13. Oliveira MR, Sudati IP, Konzen VM, de Campos AC, Wibelinger LM, Correa C, et al. Covid-19 and the impact on the physical activity level of elderly people: A systematic review. Exp Gerontol. 2022;159:111675. doi: https://doi.org/10.1016/j.exger.2021.111675
14. Panicker RM, Chandrasekaran B. “Wearables on vogue”: a scoping review on wearables on physical activity and sedentary behavior during COVID-19 pandemic. Sport Sci Health. 2022;18(3):641-57. doi: https://doi.org/10.1007/s11332-021-00885-x
15. Yang Y, Koenigstorfer J. Determinants of physical activity maintenance during the Covid-19 pandemic: a focus on fitness apps. Transl Behav Med. 2020;10(4):835-42. doi: https://doi.org/10.1093/tbm/ibaa086
16. Parker K, Uddin R, Ridgers ND, Brown H, Veitch J, Salmon J, et al. The Use of Digital Platforms for Adults’ and Adolescents’ Physical Activity During the COVID-19 Pandemic (Our Life at Home): Survey Study. J Med Internet Res. 2021;23(2):e23389. doi: https://doi.org/10.2196/23389
17. Jackson AS, Sui X, Hébert JR, Church TS, Blair SN. Role of Lifestyle and Aging on the Longitudinal Change in Cardiorespiratory Fitness. Arch Intern Med. 2009;169(19):1781-7. doi: https://doi.org/10.1001/archinternmed.2009.312
18. Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. JAMA. 2009;301(19):2024-35. doi: https://doi.org/10.1001/jama.2009.681
19. Lang JJ, Prince SA, Merucci K, Cadenas-Sanchez C, Chaput JP, Fraser BJ, et al. Cardiorespiratory fitness is a strong and consistent predictor of morbidity and mortality among adults: an overview of meta-analyses representing over 20.9 million observations from 199 unique cohort studies. Br J Sports Med. 2024;58(10):556-566. doi: https://doi.org/10.1136/bjsports-2023-107849
20. Singh B, Cadenas-Sanchez C, Costa BGG, Castro-Piñero J, Chaput JP, Cuenca-García M, et al. Comparison of objectively measured and estimated cardiorespiratory fitness to predict all-cause and cardiovascular disease mortality in adults: A systematic review and meta-analysis of 42 studies representing 35 cohorts and 3.8 million observations. J Sport Health Sci. 2024;14:100986. doi: https://doi.org/10.1016/j.jshs.2024.100986
21. Carroll JK, et al. Who Uses Mobile Phone Health Apps and Does Use Matter? A Secondary Data Analytics Approach. J Med Internet Res. 2017;19(4):e125. doi: https://doi.org/10.2196/jmir.5604
22. Knitza J, Simon D, Lambrecht A, Raab C, Tascilar K, Hagen M, et al. Mobile Health Usage, Preferences, Barriers, and eHealth Literacy in Rheumatology: Patient Survey Study. JMIR Mhealth Uhealth. 2020;8(8):e19661. doi: https://doi.org/10.2196/19661
23. Sun L, Wang Y, Greene B, Xiao Q, Jiao C, Ji M, et al. Facilitators and barriers to using physical activity smartphone apps among Chinese patients with chronic diseases. BMC Med Inform Decis Mak. 2017;17(1):44. doi: https://doi.org/10.1186/s12911-017-0446-0
24. de Sousa TLW, Ostoli TLVDP, Sperandio EF, Arantes RL, Gagliardi ART, Romiti M, et al. Dose-response relationship between very vigorous physical activity and cardiovascular health assessed by heart rate variability in adults: Cross-sectional results from the EPIMOV study. PLoS One. 2019;14(1):e0210216. doi:10.1371/journal.pone.0210216

25. Gonze BB, Padovani RDC, Simoes MDS, Lauria V, Proença NL, Sperandio EF, et al. Use of a Smartphone App to Increase Physical Activity Levels in Insufficiently Active Adults: Feasibility Sequential Multiple Assignment Randomized Trial (SMART). JMIR Res Protoc. 2020;9(10):e14322. doi: https://doi.org/10.2196/14322

26. Miller MR, Hankinson JATS, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J. 2005;26(2):319-38. doi: https://doi.org/10.1183/09031936.05.00034805

27. Wasserman K, Hansen JE, Sue DY, Stringer WW, Sietsema KE, Sun XG, Whipp BJ. Principles of Exercise Testing and Interpretation: Including Pathophysiology and Clinical Applications. 5th ed. Wolters Kluwer/Lippincott Williams & Wilkins; Philadelphia, PA, USA: 2011.

28. Dallinga JM, Mennes M, Alpay L, Bijwaard H, Baart De La Faille-Deutekom M. App use, physical activity and healthy lifestyle: A cross sectional study. BMC Public Health. 2015;15:833. doi: https://doi.org/10.1186/s12889-015-2165-8

29. Instituto Brasileiro de Geografia e Estatistica - IBGE. Pesquisa Nacional de Sáude - atenção primária. (2020).

30. Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde e Ambiente. Departamento de Análise Epidemiológica e Vigilância de Doenças Não Transmissíveis. Vigitel Brasil 2023: vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico: estimativas sobre frequência e distribuição sociodemográfica de fatores de risco e proteção para doenças crônicas nas capitais dos 26 estados brasileiros e no Distrito Federal em 2023 [recurso eletrônico] / Ministério da Saúde, Secretaria de Vigilância em Saúde e Ambiente, Departamento de Análise Epidemiológica e Vigilância de Doenças Não Transmissíveis. – Brasília : Ministério da Saúde, 2023.

31. Chae J. A Comprehensive Profile of Those Who Have Health-Related Apps. Health Educ Behav. 2018;45(4):591-8. doi: https://doi.org/10.1177/1090198117752784

32. Robbins R, Krebs P, Jagannathan R, Jean-Louis G, Duncan DT. Health App Use Among US Mobile Phone Users: Analysis of Trends by Chronic Disease Status. JMIR Mhealth Uhealth. 2017;5(12):e197. doi: https://doi.org/10.2196/mhealth.7832

33. Prevalence of active transportation among adults in Latin America and the Caribbean: a systematic review of population-based studies. https://iris.paho.org/handle/10665.2/33966.

34. Fukuoka Y, Lindgren T, Jong S. Qualitative exploration of the acceptability of a mobile phone and pedometer-based physical activity program in a diverse sample of sedentary women. Public Health Nurs. 2012;29(3):232-40. doi: https://doi.org/10.1111/j.1525-1446.2011.00997.x

35. Lindqvist AK, Rutberg S, Söderström E, Ek A, Alexandrou C, Maddison R, et al. User Perception of a Smartphone App to Promote Physical Activity Through Active Transportation: Inductive Qualitative Content Analysis Within the Smart City Active Mobile Phone Intervention (SCAMPI) Study. JMIR Mhealth Uhealth. 2020;8(8):e19380. doi: https://doi.org/10.2196/19380

36. Kim H, Xie B. Health Literacy and Internet- and Mobile App-based Health Services: A Systematic Review of the Literature. Proc Assoc Inf Sci Technol. 2015;52:1-4. doi:10.1002/pra2.2015.145052010075

37. Sardi L, Idri A, Fernández-Alemán JL. A systematic review of gamification in e-Health. J Biomed Inform. 2017;71:31-48. doi: https://doi.org/10.1016/j.jbi.2017.05.011

38. Middelweerd A, van der Laan DM, van Stralen MM, Mollee JS, Stuij M, te Velde SJ, et al. What features do Dutch university students prefer in a smartphone application for promotion of physical activity? A qualitative approach. Int J Behav Nutr Phys Act. 2015;12:31. doi: https://doi.org/10.1186/s12966-015-0189-1

39. Simmich J, Mandrusiak A, Russell T, Smith S, Hartley N. Perspectives of older adults with chronic disease on the use of wearable technology and video games for physical activity. Digit Health. 2021;7:20552076211019900. doi: https://doi.org/10.1177/20552076211019900

40. Huang X, Zhu W, Gao X, Yu D, Jin H, Huang J, et al. Relationship Between Old-Aged Preferences Regarding Various Types of Physical Activity and Chronic Disease Status: A Cross-Sectional Study in Shanghai, China. Front Public Health. 2022;10:865328. doi: https://doi.org/10.3389/fpubh.2022.865328

41. Hall AK, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: a systematic review of reviews. Annu Rev Public Health. 2015;36:393-415. doi: https://doi.org/10.1146/annurev-publhealth-031914-122855

42. Kanstrup AM, Bertelsen P, Jensen MB. Contradictions in digital health engagement: An activity tracker's ambiguous influence on vulnerable young adults' engagement in own health. Digit Health. 2018;4:2055207618775192. doi: https://doi.org/10.1177/2055207618775192

43. Li L, Peng W, Kononova A, Bowen M, Cotten SR. Factors Associated with Older Adults' Long-Term Use of Wearable Activity Trackers. Telemed J E Health. 2020;26(6):769-75. doi: https://doi.org/10.1089/tmj.2019.0052

44. Akbar S, Coiera E, Magrabi F. Safety concerns with consumer-facing mobile health applications and their consequences: a scoping review. J Am Med Informatics Assoc. 2020;27(2):330-40. doi: https://doi.org/10.1093/jamia/ocz175

45. Wattanapisit A, Kotepui M, Wattanapisit S, Crampton N. Bibliometric Analysis of Literature on Physical Activity and COVID-19. Int J Environ Res Public Health. 2022;19(12):7116. doi: https://doi.org/10.3390/ijerph19127116

Received: 12/02/2024
Reviewed: 02/18/2025
Approved: 06/14/2025

Cite this article as:
Ostolin TLVDP, Dourado VZ. Preferred functionalities on smartphone applications for physical activity in adults with low cardiorespiratory fitness. Rev. Bras. Ativ. Fis. Saúde. 2025;30:e0401. doi: 10.12820/rbafs.30e0401

Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Glauber Carvalho Nobre
Instituto Federal de Educação, Ciências e Tecnologia do Ceará, Ceará, Brazil.

Dear authors,

I hope this email finds you well. I would like to congratulate you on developing the paper titled "Preferred Functionalities on Smartphone Applications for Physical Activity in Adults with Low Cardiorespiratory Function". Although the authors put significant effort into conducting this study, there are major concerns regarding abstract, rationale, methods (e.g., participant characterization, statistical analysis, inclusion criteria), results, and conclusions that need to be addressed. My intention in reviewing your paper is simply to contribute to strengthening and improving it.

I have outlined these concerns below:

Abstract

- There are several points in the abstract that need to be revised and rewritten. For example, line 10 "Results: The proportion of App users was significantly lower in the low CRF group (17% vs. 40%; p<0.001)." In this case, what does the 40% refer to? Further, the conclusion should consider the main evidence presented earlier, including the results of the comparison between the low and medium/good CRF groups.

Rationalization

- The text helps us understand the importance of mobile health (m-health) for monitoring and improving physical activity levels, particularly among individuals with chronic health conditions. However, it falls short in justifying the importance of investigating app user preferences compared to non-users in the low and medium/good CRF groups. Please consider making significant revisions to address this concern.
- The authors announced the objective by different ways among the paper sections (see list below). It is more reasonable to choose only one for reporting in all the paper sections. Further, considering the rationality and results presented in study, I suggest the following objective: "to investigate smartphone apps' preferred functionalities in adults according to low and median/good cardiopulmonary function".
- Introduction: page 3, line 22-23 – "Therefore, we aimed to identify smartphone apps' preferred functionalities for physical activity in adults with low CRF".
- Abstract: page 1, lines 3-4: "To identify smartphone apps' preferred functionalities for physical activity in adults with low cardiorespiratory function (CRF)".
- Discussion: page 8, lines 2-3: "The present study investigated smartphone apps' preferred functionalities in asymptomatic adults from Brazil stratified according to CRF".
- Further, in accordance with objective, the title must be rewritten: "smartphone apps' preferred functionalities in adults according to low and median/good cardiopulmonary function".

Methods

- Participants:
  Information concerning the number of participants according to cardiopulmonary function categories (Low CRF and Median/good CRF group) weren't presented in the "participant section". It is very important to report the "n" in each group once the core study problem is based on these categories.
  I have significant questions regarding the participant categories: Why should non-users be included in this study? Does it make sense, given that non-users do not interact with mobile health apps? Could non-users be a target population for studies aiming to investigate the preferred functionalities of smartphone apps? If so, could the authors address this question more thoroughly? If not, the authors might consider using this as an inclusion or exclusion criteria.
- Statistical analysis:
  Why did the authors report the categorical variables only percentage results? Absolute frequency provides the number of individuals in each condition or category; consequently, it helps us to better understand the chi square results. Thus, absolute frequency should be considered.

Results

Why did the authors organize the General Characteristics results (see Table 1) by gender and user/non-user groups when the primary comparison is between the low and medium/good CRF groups? Wouldn't it be more appropriate to present the results based on the low and medium/good CRF groups? Furthermore, should this information be included solely in the Methods section (e.g., participant characteristics), given that the objective is "to investigate smartphone apps' preferred functionalities in adults according to low and median/good cardiopulmonary function"

Limitations and practical implication

- Page 10, lines 7-9: "The convenience sample and the low proportion of participants classified as low CRF were our main limitations. Unfortunately, we were unable to compare preferences according to users and non-users due to the small sample of users in the low CRF group."
- Could the small sample of users in the low CRF group hinder the group comparison? What is the number of users and non-users in the low CRF group?

Final decision:

- Substantial revisions required

Reviewer B

Anonymous

Format

- Does the article comply with the manuscript preparation guidelines for submission to the Revista Brasileira de Atividade Física & Saúde?
  Yes
- Is the language appropriate, and is the text clear, precise, and objective?
  Yes
- Was there any indication of plagiarism in the manuscript?
  No
  Suggestions/Comments:
- The article fully complies with the manuscript preparation guidelines. The text is well-structured, follows a logical and coherent organization, and clearly outlines the objectives, methodology, results, and conclusions.

Abstract

- Are the abstract and summary adequate (including objective, information about the study participants, variables investigated, main findings, and a conclusion) and reflective of the article's content?
  Yes
  Suggestions/Comments:
- The abstract meets the requirements clearly.

Introduction

- Is the research problem clearly defined and delimited?
  Yes
- Is the research problem adequately contextualized in relation to existing knowledge, moving from general to specific?
  Yes
- Are the reasons that justify the study (including the authors' assumptions about the problem) well-established in the writing?
  Partially
- Are the references supporting the presentation of the research problem current and relevant to the topic?
  Yes
- Is the objective clearly stated?
  Yes
  Suggestions/Comments:
- I suggest better contextualizing the problem in relation to the objective of the research.

Methods

- Are the methodological procedures generally appropriate for the research problem?
  Yes
- Are the methodological procedures adopted for the study sufficiently detailed?
  Yes
- Is the procedure adopted for selecting or recruiting participants appropriate for the problem studied and sufficiently clear and objective?
  Yes
- Have information about the instruments used in data collection been provided, including their psychometric properties (e.g., reproducibility, internal consistency, and validity) and, where applicable, the operational definition of variables?
- Partially
- Is the data analysis plan appropriate and adequately

described?
Yes

- Have the inclusion and/or exclusion criteria for the participants been described and are they adequate for the study?
Yes
- Have the authors provided clarification on the ethical procedures adopted for conducting the research?
Yes

Suggestions/Comments:

- The methodology is clear and meets the proposed criteria.

Results

- Is the use of tables and figures appropriate and do they facilitate the adequate presentation of the study's results?
Yes
- Is the number of illustrations in the article consistent with the journal's submission guidelines?
Not applicable
- Is the number of participants at each stage of the study, as well as the number and reasons for losses and refusals, presented in the manuscript?
Not applicable
- Are the participant characteristics presented adequately?
Yes
- Are the results presented appropriately, highlighting the main findings and avoiding unnecessary repetition?
Yes

Suggestions/Comments:

- No suggestions.

Discussion

- Are the study's main findings presented?
Yes
- Are the limitations and strengths of the study presented and discussed?
Yes
- Are the results discussed in light of the study's limitations and existing knowledge on the topic?
Yes
- Do the authors discuss the potential contributions of the main findings to scientific development, innovation, or practical interventions?
Yes

Suggestions/Comments:

- No comments.

Conclusion

- Is the conclusion adequately presented and consistent with the study objective?
Yes
- Is the conclusion original?
Yes

Suggestions/Comments:

- I suggest slightly extending the conclusion to more directly address the article's research problem.

References

- Are the references up-to-date and sufficient?
Yes
- Is the majority comprised of original research articles?
Yes
- Do the references conform to the journal's guidelines (number and format)?
Yes
- Is the in-text citation appropriate, i.e., are the claims in the text substantiated by cited references?
Yes

Suggestions/Comments:

- The references are sufficient and up-to-date as appropriate.

Final decision

- Minor revisions required.