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Effects of healthy-habit-oriented mobile apps on depressive symptomatology, anxiety and stress: A systematic review

Ricardo Manuel Santos-Labrador[1], Alejandra Rebeca Melero Ventola[1], António Moreira[2], Rui Neves[2], Armando González Sánchez[3], & Marina Wobbeking Sánchez[1]
[1]Universidad de Salamanca (España)
[2]Universidade de Aveiro (Portugal)
[3]Instituto de Biomedicina de Salamanca (España)

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Abstract. *Introduction. Emotional problems such as anxiety, depression and stress are a public health problem. Meanwhile, scientific evidence alerts us to the importance of maintaining healthy lifestyle habits to prevent and intervene to address anxious and depressive symptoms and stress. In recent years, the use of technology has been considered for this purpose, with the most widely used technological tools being mobile applications known as mHealth. Objective: To analyze the potential of the use of mobile apps based on healthy habits (exercise, diet and sleep habits) as effective tools to reduce symptoms of anxiety, depression and self-perceived stress in the adult population. Method. A systematic review was carried out following PRISMA guidelines. The review included the randomized clinical trials found in PubMed, Medli-ne and PsycINFO, with a final total of 10 studies. Inclusion criteria called for randomized controlled trials (RCTs) written in English, with an adult population, using mobile apps related to healthy habits and analyzing their effects on anxious, depressive and stress symptoms. Results and conclusions. The results suggest that the use of apps that influence adherence to healthy habits seems to reduce the anxiety, depression, and perceived stress scores. However, more research is needed to identify the specific habits that improve the indicated psychological factors through mHealth.*

Keywords: *Apps; emotional problems; lifestyle habits; review.*

Efectos de las aplicaciones móviles, basadas en hábitos saludables, sobre la sintomatología depresiva, la ansiedad y el estrés: Una revisión sistemática

Resumen. *Introducción. Los problemas emocionales como la ansiedad, la depresión y el estrés constituyen un problema de salud pública. Mientras tanto, la evidencia científica nos alerta de la importancia de mantener hábitos de vida saludables para prevenir e intervenir frente a los síntomas ansiosos, depresivos y el estrés. En los últimos años se ha planteado el uso de la tecnología para este fin, siendo las herramientas tecnológicas más utilizadas las aplicaciones móviles conocidas como mHealth. Objetivo: Analizar el potencial del uso de apps móviles basadas en hábitos saludables (ejercicio, dieta y hábitos de sueño) como herramientas eficaces para reducir los síntomas de ansiedad, depresión y estrés autopercibido en población adulta. Método. Se realizó una revisión sistemática siguiendo las directrices PRISMA. La revisión incluyó los ensayos clínicos aleatorizados encontrados en PubMed, Medli-ne y PsycINFO, con un total final de 10 estudios. Los criterios de inclusión solicitaron ensayos clínicos aleatorizados (ECA) escritos en inglés, con población adulta, que utilizaran apps móviles relacionadas con hábitos saludables y analizaran sus efectos sobre los síntomas ansiosos, depresivos y de estrés. Resultados y conclusiones.*

Correspondence:
Marina Wobbeking Sánchez

Universidad de Salamanca
mwobbeking@usal.es

Los resultados sugieren que el uso de apps que influyen en la adherencia a hábitos saludables parece reducir las puntuaciones de ansiedad, depresión y estrés percibido. Sin embargo, se necesita más investigación para identificar los hábitos específicos que mejoran los factores psicológicos indicados a través de la mHealth.

Palabras clave: *Apps; problemas emocionales; hábitos de vida; revisión*

Introduction

Globally, mental health has a high incidence of morbidity and mortality due to anxiety disorders and depression, which are among the top ten health problems worldwide (WHO, 2022). Furthermore, the COVID-19 pandemic led to a 25% increase in the prevalence of these emotional problems worldwide (WHO, 2022). Multiple studies link unhealthy lifestyle habits (unhealthy diet, sedentary lifestyle) with the presence of higher levels of anxiety, stress, and depression in individuals (Delgado et al., 2022; Ramón et al., 2019).

However, the implementation of healthy habits, such as physical activity (PA) or proper nutrition, is considered an effective intervention to improve mental health and well-being. In fact, PA can directly influence biological, social, and psychological factors and is considered a protective element (Torres, 2022). In this regard, the Physical Activity Guidelines Advisory Committee (American College of Sports Medicine, 2018) stated that members of the adult non-clinical population who engage in regular physical activity are 45% less likely to experience symptoms of clinical depression, and between 28% and 48% less likely to experience symptoms of anxiety.

In addition, recent studies link a healthy diet and good sleep hygiene patterns with improved psychological well-being in individuals (Estrella & Torres, 2015; Goldschmied et al., 2020; Leyton et al., 2018). The benefits of PA and a healthy diet in terms of mental health and the control of psychological disorders are numerous, and these habits also correlate with the inhibition of sympathetic nervous system stimulation and diseases associated with stress, depression and anxiety. Despite this evidence, interventions aimed at diet and exercise are not commonly applied as first a preventive strategy or medical or therapeutic treatment. Indeed, the administration of medication remains the first resort (Musil et al., 2018).

In recent years, the use of technology has been considered to help monitor, prevent, and treat various health problems. Among the most widely used technological tools are mobile applications (apps) that include health-related content and form part of what is known as m-Health (mobile health), a term that was codified in 2011 by the World Health Organization (WHO) to refer to what was beginning to be "medical and public health practice supported by mobile devices, such as mobile phones, monitoring devices, personal digital assistants and other wireless devices" (p. 6). These apps are used all over the world, and their wide diffusion and easy access make them attractive for psychiatric and psychological care. Additionally, they are thought to have the potential to generate behavioral changes (Khazaal, 2019). Today, there are numerous virtual assistants such as "mHealth, Smart Care" and Wysa, an app that is designed to address problems of stress, anxiety and sleep and provides relaxation exercises. Another example is the app "Pacifica", which was designed by psychologists and focuses on controlling stress through cognitive behavioral therapy (CBT) and relaxation techniques. Another app entitled Mental Health Test includes more than 25 tests that diagnose depression, addiction, schizophrenia and panic attacks. (Aguilera-Sosa et al., 2022; Escobar-Viera et al., 2021).

The area of mHealth includes a wide variety of apps, including mobile apps developed to encourage and promote good health practices and habits in the general population. There has also been a significant increase in the use of these apps due to the COVID-19 pandemic and the resulting situation, which is considered a turning point for the entire field of digital health (Collado-Borrel et al., 2020; Duarte & Delgado, 2022).

The continuous and unstoppable transformation of our technological era have benefitted society in many aspects, but they also bring with them disadvantages that put people's physical and mental health at risk (Ubago et al., 2022). For this reason, the number of applications, devices and systems that help to regulate and control these complications continues to increase.

Meanwhile, daily or regular physical exercise offers physical and psychological benefits that are positive for people's overall health and quality of life (Alba-Leonel & Hernández-Falcón, 2022; Araque-Martínez et al., 2021). This fact seems to have its organic explanation in the changes that PA produces in the brain (Rodríguez-Hernández et al., 2011).

Other systematic reviews have examined the efficacy of mHealth in adults over 65 (Chou et al., 2023) and in adults (under 65) using mHealth, based on psychological interventions (Serrano Ripoli et al., 2022). This article goes beyond earlier systematic reviews that were based on the use of mHealth applications that use psychological techniques. Specifically, this research sought to determine, through a systematic review of the scientific literature, the effects and benefits of apps aimed at PA, diet and their potential to improve depression, anxiety and self-perceived stress.

The review question proposed in this study is the following: are healthy-habit-based mHealth apps that do not specifically include psychological techniques effective at reducing symptoms of depression, anxiety and stress in the adult population?

Materials and methods

In this study, we conducted a systematic review of the scientific literature published in the last 10 years on the use of mobile apps based on healthy habits (PA, diet and/or sleep hygiene) and their effectiveness at reducing symptoms of depression, anxiety and/or self-perceived stress in the adult population. The guidelines of the PRISMA statement (Moher et al., 2009; Urrutia & Bonfill, 2013) for the implementation of systematic reviews were followed (Figure 1).

The following is a description of the development process, with its different stages: The initial search was conducted on 14 January, 2023, using the following descriptors: "mobile applications or apps or mobile

apps or mHealth or eHealth", "healthy life habits or exercise or diet" and "mental health or depression or anxiety or stress"; and using AND and OR as Boolean operators. The search was carried out on the databases Medline, Scopus, Pubmed, PsycINFO and Web of Science. This search yielded a large number of results, although many were not specifically connected to the topic in question.

The second search was conducted on 15 January, 2023. This search was narrower, as the descriptor "mental health" was eliminated. This term was thought to be too general and to have yielded results that were not strictly related to stress, depression and anxiety. In addition, the descriptor "physical activity" was added. Additionally, in this second search we decided to eliminate the Scopus database (as it had found the fewest studies) and the Web of Science database (which had yielded fewer results than Medline). Both of the eliminated databases are of a generalist nature. The choice was made to use the Pubmed and PsycINFO databases because the former is related to health sciences and therefore to the subject of healthy habits, and the latter specializes in the field of psychology.

The combination of terms that yielded the best results from all the databases was the following: ((mobile applications [Title/Abstract] OR apps [Title/Abstract] OR mobile apps [Title/Abstract] OR mhealth [Title/Abstract] OR ehealth [Title/Abstract] AND (healthy life habits [Title/Abstract] OR physical activity [Title/Abstract] OR exercise [Title/Abstract] OR diet [Title/Abstract])) AND (anxiety [Title/Abstract] OR depression [Title/Abstract] OR stress [Title/Abstract]). Specifically, a total of 433 results were obtained, with 321 results belonging to the Medline database, 57 to Pubmed and 55 to PsycINFO.

The term mHealth was combined with the word apps or mobile apps in order to avoid other mHealth interventions such as web-based platforms or other broader uses of the term.

The search terms used for interventions based on healthy habits were specific and were mainly based on diet, PA and physical exercise, as these healthy behaviors are the most prominent or the most relevant. The same can be said for psychological symptomatology, where the three specific descriptors used were depression, anxiety and stress.

Then, before making the final selection of studies, the following inclusion and exclusion criteria were established.

Inclusion criteria

Studies were included if they met the following requirements:

- They were randomized controlled trials (RCTs).
- Open access and subscription-based publications.
- Articles written in English, as this is the main language used in scientific texts.
- Using mobile apps related to healthy habits (PA, diet and/or sleep hygiene).
- Analyzing the effects of healthy-habit-related mobile apps related on anxious and depressive symptoms and stress, as the aim is to find out whether this type of application is useful for working on emotional problems without the need for psychological intervention.
- They were aimed at the adult population.

Exclusion criteria

Studies with the following characteristics were excluded:

- Those that were not RCTs: non-empirical research, systematic reviews, single case studies, books, or manuals.
- Articles written in a language other than English.
- Research that did not include the use of mobile apps, even if it used other types of ICTs to promote healthy habits.
- Studies using mobile apps that, in addition to promoting healthy habits, use psychological intervention techniques (mindfulness, behavioral activation and cognitive-behavioral therapy), since the aim is to find out which healthy habits contribute to improving anxious-depressive symptomatology and reducing stress without intervention.
- Articles whose participants belonged exclusively to the older adult population (over 65 years of age) or the child and/or adolescent population (under 18 years of age).

After using the aforementioned criteria, 335 articles were discarded by reading the title alone, and another 18 were eliminated because they were duplicated in two or more databases. We then proceeded to read the abstracts, which allowed us to discard 60 articles for the following reasons: for not using a mobile app or relying solely on a web application (n=3), for using psychological intervention techniques in addition to intervention through healthy habits (n=16), for assessing psychological variables other than anxiety, depression or stress (n=8), for assessing how psychological intervention affects habit change and not the other way around (n=3), for not being an RCT (n=18), for having a sample not belonging to the adult population (n=3), for not addressing the subject matter of the study (n=6) or for being a study that had not yet been developed (n=3). Finally, the 20 articles that were selected were read in full, after which it was decided to eliminate a further 10 studies. Some were excluded because they were not yet implemented (n=4) and others because they used psychological intervention techniques as part of the mobile app intervention (n=6). Therefore, in the end, 10 articles were selected for the systematic review. All of them examined the use of healthy-habit-based mobile apps and its relationship to the variables of anxiety, depression or self-perceived stress, although in some cases these were secondary variables in the studies.

Two of the authors searched for studies and, together with two other authors, excluded those that did

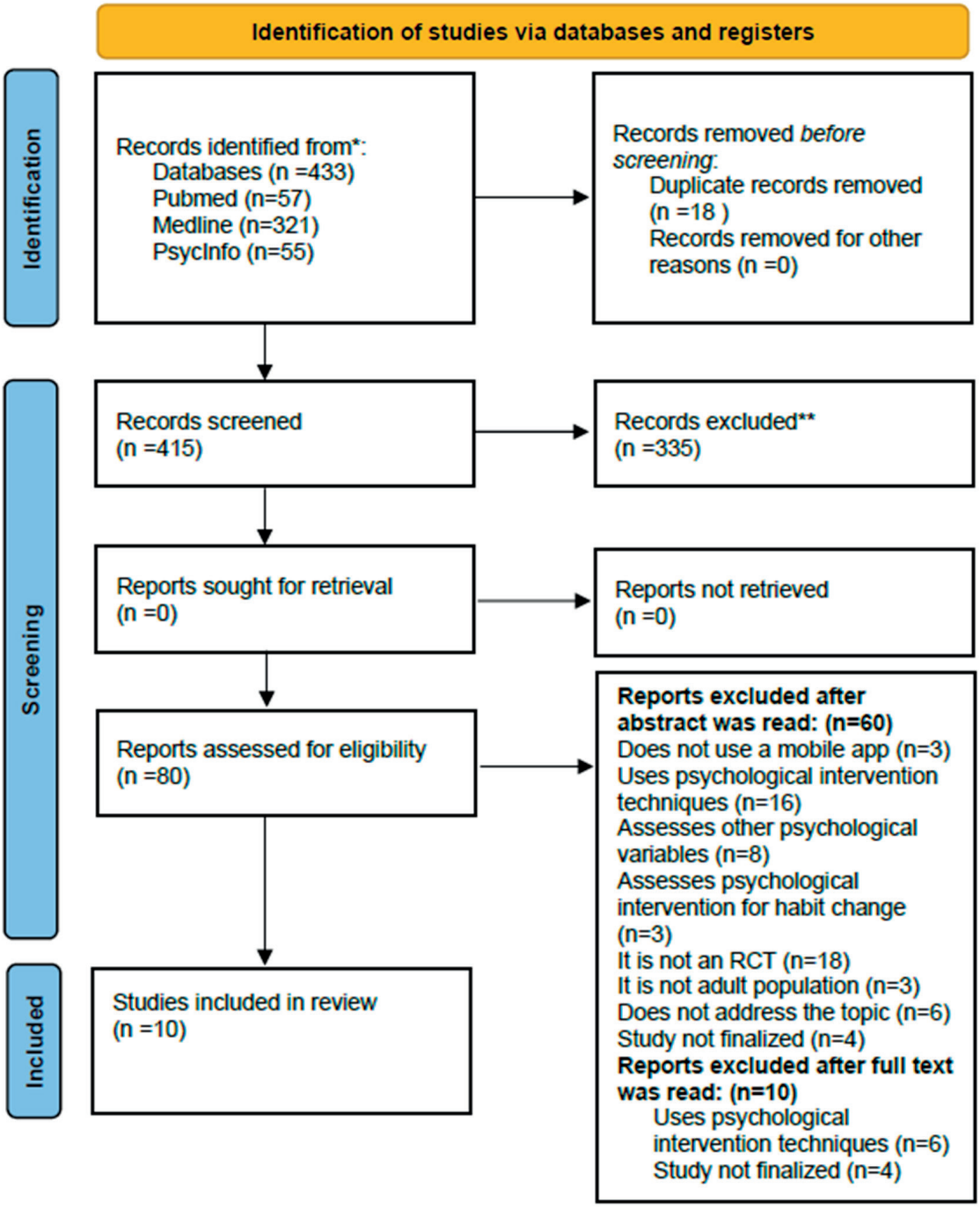

Figure 1. PRISMA flow chart of the review.

Note: From McKenzie, M.J., Bossuyt, J.E., Boutron, P.M., Hoffmann, I., Mulrow, C.D., Shamseer, L., Tetzlaff, J., Akl, E., Brennan, S., Chou., R., Glanville, J., Grimshaw, J., Hróbjartsson, A., Lalu, M., Li, T., Loder, E., Mayo, E., McDonald, S., McGuiness, L.A., Stewart, L…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ, 372*(71). http://doi.org/ 10.1136/bmj.n71

not meet the inclusion criteria and chose which studies to include. Another author then reviewed them and agreed with the selection of studies for inclusion. Finally, third author conducted the risk of bias assessment. The searches were conducted by researchers in a blind and independent manner, as recommended by PRISMA.

A new search was conducted on 12 January 2024 to update the review, but no new studies were found that met the inclusion/exclusion criteria.

Quality Assessment

The qualities of all the studies included in this review were assessed by using the six basic criteria of the Cochrane Risk of Bias Assessment Tool (Higgins et al., 2011). This consists of screening for biases such as random sequence generation, allocation concealment, incomplete outcome data, selective reporting, and other biases (appendix 1). Blinding was excluded from scrutiny, as this criterion is difficult to adhere to in mental health interventions (Donker et al., 2013).

Table 1. Characteristics of the research included in the review

Authors	Type of sample	Main App Functionalities	Psychological variables analysed	Evaluations tools	Intervention time	Main conclusion
Haufe et al. (2020)	n= 314 subjects with metabolic syndrome (+ 18 years old). Germany. EG: 160 24 women 136 men 28 dropouts CG: 154 21 women 133 men 12 dropouts	App with individual training goals, recommended heart rates for endurance activities and tips for increasing PA in everyday life.	Anxiety and depression.	HADS	6 months.	The severity of depression decreased for the EG and CG, with a greater decrease over time in the EG subjects. Anxiety severity decreased for EG and CG, with a greater decrease over time in the EG subjects.
Brindal et al. (2019)	n= 88 subjects (20-67 years old). Australia. EG: 45 33 females 12 males 9 dropouts CG: 43 33 women 10 men 18 dropouts	App (MotiMate) with more persuasive and interactive features to help users track their weight, food intake and PA, with daily data entry prompts, via notifications, including a mood and stress workshop tool. Monitoring app (tracking only, excluding mood and stress), in terms of its effect on weight, diet and psychological well-being.	Anxiety, depression, and stress.	DASS-21	24 weeks. Follow-up at baseline, 4, 8, 12 and 24 weeks.	There was a significant difference linked to the large decrease in anxiety between baseline and week 4 in CG. Neither depression nor stress varied significantly by week or application.
Kelechi et al. (2020)	n= 25 subjects with impaired functional mobility (+ 18 years old). USA. EG 1 (Footfit): 12 8 females 4 males 1 dropout EG 2 (Footfit +): 12 6 women 6 men 0 dropouts	Footfit app with 6-week progressive exercise proposal and triaxial accelerometer. In contrast to the app (Footfit), Footfit+ with additional communication function between patient and provider.	Depression	GDS	6 weeks.	Scores showed a reduction in GE and CG depression levels at baseline follow-up and after the 6- week intervention.
Lee et al. (2022)	n= 28 with Autism Spectrum Disorder (ASD) (+ 18 years old). USA. EG 1 (PuzzleWalk): 12 9 females 3 males 3 dropouts EG 2 (Google Fit): 12 6 women 6 men 1 dropout	PuzzleWalk app to increase PA and reduce sedentary behaviour in adults with ASD. Google Fit app that uses a sensor embedded in a smartphone device to automatically track PA, including steps and active minutes. It also allows users to keep a diary and record a variety of forms of PA.	Anxiety.	BAI	2 months.	Overall, participants felt relatively less anxiety during the week of the start of the intervention.
Mascarenhas et al. (2018)	n= 67 inactive women (18-60 years old). USA. GE: 30 30 women 0 men 1 dropout CG: 34 34 women 0 men 2 dropouts	PA guided by apps (Nike+, Sworkit...) of the participants' choice.	Anxiety and depression.	PROMIS-T score	8 weeks.	The EG, compared to the CG, experienced statistically significant changes in anxiety and depression over the 8 weeks.
Murawski et al. (2019)	n= 160 with insufficient PA and poor sleep quality (18-55 years old). Australia. EG: 80 66 females 14 males 21 dropouts at 3 months 45 dropouts at 6 months CG: 80 62 females 18 males 7 dropouts at 3 months 20 dropouts at 6 months	Balanced App with personalised goal setting, daily log with dynamic feedback and comprehensive educational content for PA (i.e. moderate to vigorous intensity PA, daily steps and resistance training) and sleep.	Anxiety, depression and stress.	DASS-21	6 months. Follow-up at baseline, 3 months and 6 months.	No significant differences in depressive symptoms were observed at any of the time points. The EG reported significantly lower severity of stress symptoms relative to CG at 3 months, with a further increase in magnitude at 6 months. Furthermore, differences in anxiety symptoms at 6 months were statistically significant in favour of the CG.

Authors	Type of sample	Main App Functionalities	Psychological variables analysed	Evaluations tools	Intervention time	Main conclusion
Wang et al. (2022)	n= 122 women with at least two of the three criteria indicated (oligoovulation or anovulation, hyperandrogenism and polycystic ovaries (+ 18 years old). China. EG: 61 61 women 0 men 10 dropouts CG: 61 61 females 0 males 12 dropouts	Mobile health app based on lifestyle modification, called Home of PCOS, including PA and dietary guidelines.	Anxiety and depression.	SAS and SDS	12 months. Follow-up at baseline, 6 months and 12 months.	There were no statistically significant differences in anxiety and depression scores between groups at baseline. Anxiety scores in the SG decreased significantly from baseline to month 12. Depression scores in the SG decreased significantly from baseline to month 12.
Wayne et al. (2015)	n= 97 with type II diabetes and glycosylated haemoglobin/ haemoglobin A1c (HbA1c) level of ≥7.3 % (56.3 mmol/mol) (+ 18 years old). Canada. EG: 48 31 females 17 males 7 dropouts CG: 49 39 women 10 men 7 dropouts	Connected Wellness Platform App with health-related goal setting and progress tracking. Participants could track key metrics, in particular blood glucose levels, frequency/ duration/intensity of PA, food intake and mood.	Anxiety and depression.	HADS	6 months. Follow-up at baseline, 3 months and 6 months.	Similar improvements were detected for the groups on the depression subscale, although the CG showed a significantly lower score on the anxiety subscale, while the EG did not.
Young et al. (2020)	n= 319 subjects with type 2 diabetes and HbA1c of 6.5 % (48 mmol/mol) or higher (+ 18 years old). USA. EG: 160 73 women 81 men 26 dropouts CG: 154 75 women 84 men 6 dropouts	MyFitnessPal app to record and track nutritional intake.	Depression, anxiety and stress.	PHQ-9, PROMIS and PSS	3 months. Follow-up at baseline, 3 months and 9 months.	EG participants showed a decrease in depressive symptoms compared to CG at 3 months, with no significant difference in anxiety levels. Differences in depression scores between the two groups at 9 months were not maintained. For the depression severity measure, the CG experienced slightly greater depressive symptoms over time, while in the EG it decreased at 3 months. There was no change in perceived stress.
Zheng et al. (2022)	n= 45 subjects with chronic low back pain (18-65 years old). China. EG: 22 14 women 6 men 2 dropouts CG: 23 12 women 8 men 3 dropouts	App with exercise prescription and educational content (Ding Talk).	Anxiety and depression.	GAD-7 and SDS	6 weeks.	Participants were able to use mHealth- based education with their anxiety and depression after treatment, but the improvement only lasted until week 6.

Results

The studies were reviewed in relation to five aspects (see table 1) linked to the objectives of our research. A summary of the results of the studies selected in this systematic review can be found in Table 1. This description aims to facilitate the understanding and integration of the results.

Firstly, it is important to highlight the high degree of heterogeneity in terms of the type of population samples and the multiple different kinds of mobile apps used in the studies selected for the review. Specifically, the population samples used in the different studies ranged from some that included participants with no pathology to others that covered a wide range of pathologies including metabolic syndrome (Haufe et al., 2020), chronic lower back pain (Zheng et al., 2022), type II diabetes (Wayne et al., 2015; Young et al., 2020), oligoovulation (Wang et al., 2022), impaired functional mobility (Kelechi et al., 2020) and ASD (Lee et

al., 2022). The participants in the different studies include both genders (women and men), except for the studies by Mascarenhas et al. (2018) and Wang et al. (2022), whose samples consisted only of women.
Secondly, it should be noted that the only healthy habit that appeared as an intervention in all of the studies was PA.

However, several of the studies did attempt to analyze results related to other healthy habits such as diet [Brindal et al., 2019; Wang et al., 2022; Wayne et al., 2015; Young et al., 2020) or sleep (Murawski et al., 2019). Furthermore, the duration of the RCTs analyzed ranges from a minimum of 6 weeks (Kelechi et al., 2020; Zheng et al., 2022) to a maximum of 12 months (Wang et al., 2022). With regard to the psychological variables investigated, it can be seen that two of the studies obtained results related to anxiety, depression and stress [34, 33]; six of the studies present conclusions on anxiety and depression (Haufe et al., 2020; Mascarenhas et al., 2018; Wang et al., 2022; Wayne et al., 2015; Young et al., 2020; Zheng et al., 2022) and two of them analyze results exclusively on anxiety (Lee et al., 2022) or depression (Kelechi et al., 2020).

The following is a brief description of the results obtained for the different study variables:

Anxiety

The level of anxiety was lower in the EG than in the CG in four of the studies analyzed (Brindal et al.,2019; Mascarenhas et al., 2018; Murawski et al., 2019; Wang et al., 2022). Likewise, the study by Lee et al. (2022), which compared two treatment groups with two different apps that encouraged PA practice, concluded that anxiety levels were reduced in both cases.

In the study by Haufe et al. [26], significant differences in anxiety level were observed between the EG and CG only in the long term, and two other studies found reductions in the anxiety level of the participants in both the EG and CG (Wayne et al., 2015; Zheng et al., 2022).

Depression

Depression levels showed improvement in the EG compared to CG in research by Mascarenhas et al. (2018); Wang et al. (2022) and Young et al. (2022). This was also the case in the study by Haufe et al. (2020), in which no short-term improvements were observed, but improvements were observed in the long term. In addition, research by Kelechi et al. (2020), which compared a group using an app (EG1) and another using the same app with the addition of a communication function between provider and user (EG2), showed that in both groups depressive symptomatology decreased after treatment. Depressive symptomatology was reduced in both groups (EG and CG) in another two of the studies (Wayne et al., 2015; Zheng et al., 2022). Meanwhile, in two more studies the levels of depression remained the same as before treatment in both groups (EG and CG) (Brindal et al., 2019; Murawski et al., 2019).

Perceived stress

Perceived stress was lower after the intervention in the CG than in the EG in two of the studies that examined this variable (Brindal et al., 2019; Murawski et al., 2019).

Discussion

The aim of this study was to analyze the potential of the use of healthy-habit-based mobile apps (PA, diet and/or sleep hygiene) to effectively reduce depressive and anxiety symptoms and self-perceived stress in an adult population.

It is important to note that almost no studies assessed change in anxious or depressive symptomatology and stress reduction as their main objective. In most cases, these variables were analyzed as secondary in the research.

Overall, the app-based interventions included in this systematic literature review have provided promising indications of their efficacy at improving depressive symptomatology, anxiety and self-perceived stress in users.

Improvements in depression, anxiety and stress levels were found in most of the studies. However, in some of the studies, no significant improvement was seen when comparing the EG and CG. This may be explained by the fact that in the study by Wayne et al. (2015), both groups used a health coach who encouraged the participants, while in the study by Brindal et al. (2019) and the one by Zheng et al. (2022) participants in both the EG and the CG received an mHealth intervention via a mobile app and there were only small differences in the content of the apps.

In two of the studies (Brindal et al., 2019; Murawski et al., 2019), no improvements in depression levels were observed, although these studies did find improvements in variables (anxiety and/or stress). No explanation for this inconsistency has been found.

We should also highlight the scarcity of studies related to this subject, which may be due to two factors. Firstly, this is a highly specific subject. Secondly, the most commonly used apps tend to be based on psychological techniques to intervene in emotional problems. In fact, this was the main reason for discarding most of the studies in the review, as described in the material and methods section.

The aim of this study was to find out whether simpler apps, based simply on healthy habits, were effective at reducing anxiety, depression, and stress without the use of psychological techniques such as cognitive restructuring or exposure with response prevention. These psychological techniques are effective at improving emotional problems, but they are complex to understand and/or implement for a large part of the population and are often unknown to health professionals other than psychologists and psychiatrists.

The results of this research are like those of other systematic reviews such as the one by Rathbone and Prescott (2017), whose objective was to study the ef-

ficacy, usability, and feasibility of mobile apps and SMS messages as mHealth interventions for self-guided care. These authors concluded that mobile apps can feasibly be used in the context of physical and mental health interventions and that they have a good degree of usability. Specifically, this review shows promising evidence that apps, when used as a method of self-care, have the potential to reduce symptoms of stress, depression and anxiety, as well to as reduce visits to healthcare facilities and professionals. It is true, however, that this review includes apps related to psychological intervention techniques, unlike the present research.

It is also relevant to compare the results of the present research with those of other systematic reviews based on Cognitive Behavioral Therapy (CBT), considered the most effective treatment for depression or anxiety. CBT studies have found that the use of multimedia applications is just as effective as face-to-face interventions (López-López et al., 2019), which reinforces the potential of the use of mobile apps as a method of intervention for emotional problems. In particular, applications based on CBT or mindfulness are most often used with the aim of working on anxiety or depressive symptoms in the population, although these applications vary widely, and studies are needed to evaluate their quality and effectiveness (Leong et al.,2022).

In a meta-analysis, Serrano-Ripoli et al. (2022) point out that mHealth applications based on psychological interventions produce moderate reductions in symptoms of depression, which indicates that even apps designed specifically to address emotional problems, based on psychological therapy, do not find results of greater efficacy in the treatment of the variables studied than apps related to PA, diet, and sleep.

Other systematic reviews of programs to improve habits without using a mobile app have found improvements in the levels of depression as a result of PA (Pearce et al., 2022), which coincides with the results extracted from the present study, since most of the studies analyzed in this review use PA as the main intervention element of the mobile app. Likewise, an association has been found between the Mediterranean diet and the reduction of symptoms or appearance of Axis I disorders (especially depression and anxiety) (Madani et al., 2022).

Furthermore, it should not be forgotten that, in most countries, the use of psychotropic drugs is the main treatment of choice for anxiety and depressive symptoms. This includes the use of benzodiazepines and antidepressants, which are not free of harmful side effects for individuals, constituting a public health problem (Votaw et al., 2019). In this sense, it seems relevant to promote tools that promote interventions that do not lead to adverse consequences for the population in the medium to long term.

In view of the above, it is important to consider the use of health-habit-based mobile apps as a tool to prevent and improve depressive and anxious symptoms and stress in the population.

Although the advantages of using ICTs are evident (accessibility and equity, continuity of care, comfort, adherence), there are also challenges that we have to take into account. For example, we should consider issues such as confidentiality, risks of dependence, reaction to emergencies, prejudices and resistance, and the influence of the doctor or psychologist on the patient's improvement, among others (Soto-Pérez et al., 2016).

Limitations

The most notable limitation found in this study is the limited number of articles evaluating the effectiveness of mHealth interventions based on healthy habits where the main objective was the reduction of depressive symptoms, anxiety and/or stress. The fact that this was not the main concern of a given study may have meant that the design of the intervention programmed and/or the mobile app was not aimed at this aspect, and this may have affected the results analyzed.

The limited number of articles included in the review may also imply a lack of representativeness of the population. However, it is true that almost all continents are represented in the studies. The countries participating in the studies were China, Canada, the USA, Australia and Germany.

Another important limitation is the heterogeneity of the population sample in terms of the diversity of their pathologies, which could have biased the response to the intervention.

Finally, it is necessary to mention the fact that most of the studies assess depression and anxiety, while only two of them assess perceived stress, indicating that the latter variable is under-represented in the study.

Future perspectives

Firstly, it would be appropriate to carry out studies using scales whose main objective is to study the use of mobile apps based on healthy habits and aimed at improving levels of depression, anxiety, and stress. These studies should also use a more homogeneous adult population (without pathologies, for example). Likewise, the potential benefits of mobile apps that combine the intervention based on healthy habits with CBT and/or mindfulness should be explored to see if these apps improve the variables studied.

Conclusions

In conclusion, healthy-habit-based mobile app treatment (especially using PA) for depressive symptomatology, anxiety, and stress, represents a promising paradigm for the fields of psychology and medicine.

The growing number of experimental studies demonstrating the efficacy of apps based on healthy habits highlights their therapeutic potential. The use of such apps could help minimize the adverse effects of psychotropic drugs. They are also a low-cost intervention that

can be administered to the general population as a preventive and treatment action, which is very relevant, given the limited resources available for mental health care. Therefore, such apps could represent an effective resource to be considered in primary care, although the limitations indicated in the study do not allow us to have sufficient evidence to prescribe only mHealth tools with content based on healthy habits for the improvement of the described emotional symptoms.

Therefore, the use of apps based on healthy habits by doctors is recommended as a supplemental aid or tool to add the usual treatment of patients with anxious and depressive symptoms and high levels of stress, with the aim of reducing the consumption of psychotropic drugs.

Moreover, using these apps is a strategy that can be employed worldwide, due to the prevalence of mobile phone use among the population.

Finally, the use of this type of app can help to reduce healthcare costs by reducing the number of visits to healthcare centers and professionals.

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