Physical activity promotion apps for adolescents. Narrative review of key behavior change techniques and central features

Aplicaciones para la promoción de la actividad física en adolescentes. Revisión narrativa de las técnicas clave para el cambio de conducta y sus características principales

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Abstract

Introduction: Previous research has not explored features and behavior change techniques (BCTs) in physical activity (PA) promotion interventions among adolescents, including mobile health (mHealth) applications. Purpose: This study aims to conduct a narrative literature review of adolescent PA promotion apps, examining their theoretical foundations, key BCTs, primary features, and their influence on PA adherence and maintenance. Methods: The review includes peer-reviewed studies published from 2012 to December 2024, employing qualitative and quantitative methodologies. Included studies examined healthy adolescents, focusing on PA app features and their relationship to PA promotion. Results: A total of twenty-one studies were analyzed: ten reviews, eight qualitative studies, and three app quality assessments. Findings indicate that mHealth tools and wearable trackers yield variable impacts on PA engagement. Conclusion: Future research must adopt higher methodological standards. Comparative studies on PA interventions require caution due to limitations such as insufficient research, inadequate compliance assessment tools, potential biases, and the absence of randomized controlled trials. The inconsistent outcomes from current intervention studies highlight the necessity for developing PA programs guided by intervention mapping or the Behavior Change Wheel, emphasizing high-quality methodologies tailored to specific target demographics.

Keywords

Mobile adolescents; behavior change techniques (BCTs); health applications (mHealth); narrative review; physical activity.

Resumen

Introducción: Investigaciones anteriores no han explorado características ni técnicas de cambio de comportamiento (BCT) en las intervenciones de promoción de la actividad física (AF) entre adolescentes, incluidas las aplicaciones de salud móvil (mHealth). Objetivo: Este estudio tiene como objetivo realizar una revisión narrativa de la literatura sobre aplicaciones de promoción de AF para adolescentes, examinando sus fundamentos teóricos, BCT clave, características principales y su influencia en la adherencia y el mantenimiento de la AF. Metodología: La revisión incluye estudios revisados por pares publicados desde 2012 hasta diciembre de 2024, empleando metodologías cualitativas y cuantitativas. Los estudios incluidos examinaron a adolescentes sanos, centrándose en las funciones de las aplicaciones de AF y su relación con la promoción de la AF. Resultados: Se analizaron un total de veintiún estudios: diez revisiones, ocho estudios cualitativos y tres evaluaciones de calidad de aplicaciones. Los hallazgos indican que las herramientas de salud móvil y los rastreadores portátiles producen impactos variables en la participación de la AP. Conclusiónes: Las investigaciones futuras deben adoptar estándares metodológicos más altos. Los estudios comparativos sobre intervenciones de AF requieren cautela debido a limitaciones como investigación insuficiente, herramientas de evaluación de cumplimiento inadecuadas, sesgos potenciales y la ausencia de ensayos controlados aleatorios. Los resultados inconsistentes de los estudios de intervención actuales resaltan la necesidad de desarrollar programas de AF guiados por el mapeo de intervención o la Rueda de Cambio de Comportamiento, enfatizando metodologías de alta calidad adaptadas a grupos demográficos específicos.

Palabras clave

Actividad física; adolescentes; aplicaciones móviles de salud (mhealth); revisión narrativa; técnica de cambio de comportamiento (TCC).

Introduction

Research has consistently shown that maintaining an active lifestyle during childhood and adolescence is critical for achieving optimal health, growth, and development. Additionally, the amount of physical activity (PA) during adolescence can have a significant impact on one's risk factors for chronic diseases later in life (Hallal et al., 2006). Unfortunately, recent reports suggest that a fraction of 15-year-old adolescents living in European Union (EU) countries are meeting the recommended levels of PA (Guthold et al., 2020; OECD & EU, 2020). Recent global estimates indicate that 81% of adolescents are not meeting the World Health Organization's recommended PA levels for good health. This statistic has not improved over the past decade (Bull et al., 2020). The COVID-19 pandemic and subsequent lockdowns have only exacerbated the issue, with physical activity levels decreasing for all age groups, particularly children (Runacres et al., 2021). Therefore, it is crucial to focus on intervention efforts targeted at this population.

The importance of PA for public health has been emphasized by recent guidelines. Governments are advised to allocate resources towards policies and research that increase PA opportunities for individuals (Santos et al., 2023; van der Ploeg & Bull, 2020). With insufficient PA being a prevalent issue globally, it is imperative to devise interventions that can effectively boost PA levels in the short term and prevent age-related declines (van Sluijs et al., 2021).

Studies have found that mHealth interventions can result in modest to moderate improvements in PA for adults. However, the impact may decline over time (Mönninghoff et al., 2021) Although apps aimed at promoting PA can be effective in altering user behaviour, it can be challenging for healthcare providers and individuals to evaluate the calibre of the multitude of mHealth apps available in app stores (Milne-Ives et al., 2020).

Given the widespread use of smartphones among teenagers (Candussi, 2023), these gadgets provide a practical means to engage with younger populations and provide programs that monitor and encourage PA (Romeo et al., 2019). In 2021, 95 % of young people aged 16-29 years in the EU reported using the internet every day compared to 80 % of the whole adult population. In 21 EU Member States, the share was at least 95 % (Eurostat, 2021). Currently, technology-based programs represent an appealing and promising option for children and adolescents to promote PA (Baumann et al., 2022; Taj et al., 2019). Furthermore, the global wearable activity tracker market has grown tremendously over the past decade. Thus, the body of research examining the use of wearable activity trackers for measuring and intervening in PA has expanded rapidly (Ferguson et al., 2022). Considering the availability and economical accessibility of mHealth, it has become an effective means of delivering behaviour change interventions (Barisch-Fritz et al., 2023; Guo et al., 2020).

As smartphones become more prevalent and equipped with motion-tracking capabilities, the popularity of gamification apps designed to boost physical activity is on the rise. These apps incorporate game-like features such as point systems, competition, and rules to motivate users. By making activities more like games, gamification can provide the same level of motivational support. In health and fitness settings, gamification has been shown to increase motivation for activities (Koivisto & Hamari, 2019). However, there is limited empirical evidence supporting the effectiveness of mHealth-based gamification interventions, particularly with adolescents and over longer periods (Xu et al., 2022).

To build effective and safe interventions it is suggested that it should be based upon the behaviour change theory, because it may I) provide a deeper understanding of the behaviour and the factors that influence it, II) provide a roadmap for how to change behaviour and the underlying mechanisms of behaviour change, III) help in the evaluation of behaviour change interventions, and IV) help in the development of interventions that are tailored to the specific needs of the population (Gourlan et al., 2016).

To develop classification systems for specifying the content of behavior change interventions aiming to influence human behaviors, efforts have been made to build cumulative evidence about ‘what works’. Examples include behaviour change techniques (BCTs), defined as planned processes that are the smallest parts of the content of a behaviour change intervention that are observable, replicable and on their own have the potential to bring about behaviour change (Michie et al., 2013).

Studies have been testing the effect of behaviour change techniques (BCTs), in PA promotion with pregnant women (Ma et al., 2023), adults (Lin et al., 2022; Patterson et al., 2022) and adolescents and young adults (Sawyer et al., 2019), and weight management programs (Awoke et al., 2022), but not in healthy adolescents. In addition, there is also quite some research on PA promotion in adolescents and young adults with chronic cardiorespiratory conditions (van Sluijs et al., 2021), although mHealth can only facilitate small to moderate improvements in PA levels. (Mönninghoff et al., 2021). However, to our knowledge, no study has approached the inclusion of BCT in PA promotion interventions in adolescents, MHealth or otherwise.

The purpose of the present study is to undertake a narrative literature review of apps to promote PA in adolescents, to identify a) if the app is theory-based or not; b) key BCTs and central features C) the effect in promoting PA adherence and maintenance.

Method

This narrative review aims to summarize existing literature on the research question in a comprehensive manner. While not explicitly systematic, it includes a summary of published studies in the field (Baethge et al., 2019). The following inclusion criteria were used for each study: (1) published in English and Spanish as peer-reviewed empirical research between 2012 and December 2024; (2) research methods used conducted qualitative research, quantitative research, and reviews; (3) examined healthy adolescent participants; (4) described the use and the features of PA apps; and (5) examined the relationships between PA apps and PA or its impact on PA promotion. The electronic search of English and Spanish language papers was conducted on PubMed and SPORTDiscus. Sources were searched with the title key terms and used in combination: "adolescent*" OR "youth" OR "youngsters" OR "teen*" OR "minor*" AND "PA" OR "physical activity" OR "exercise" OR "sport" AND "app" OR "smartphone" OR "e-health" OR "mobile health" OR "m-health" OR "games" OR "gamification".

Results

This report includes a total of 21 papers, with five from the USA, three from Australia, China and Germany, two from the UK, and one from Belgium, France, Luxembourg, Portugal, and Spain. Out of these, 10 studies were reviews, four had meta-analytic procedures, 8 studies had qualitative data collection (focus groups or interviews), and three evaluated the quality of PA promotion apps. Studies were reviewed in agreement with the two objectives: to analyse (1) theories, key BCTs, and other features of PA apps; and (2) the effect in promoting PA adherence and maintenance.

Theory in PA apps

Data collated within the review outlines that although some studies do not identify the theoretical foundation of the approach, (Table 1. PA app theoretical background data from reviews), several interventions were based on one or more theories of behaviour change and integrated frameworks (Kok et al., 2015; Michie et al., 2011).

Table 1. PA app theoretical background data from reviews

Behaviour Change Theory	Reference
Behavioural economics (k=2)	(Mazeas et al., 2022)
Control theory (k=1)	(Mazeas et al., 2022)
Health action process approach (k=1)	(Mazeas et al., 2022)
Self-Determination theory (k=7)	(Baumann et al., 2022; Mazeas et al., 2022)
Self-Persuasion theory (k=1)	(Baumann et al., 2022)
Self-Regulation theory (k=3)	(Baumann et al., 2022)
Social cognitive theory (k=11)	(Böhm et al., 2019; Daryabeygi-Khotbehsara et al., 2021; Mazeas et al., 2022)
Theory of planned behaviour (k=2)	(Baumann et al., 2022; Mazeas et al., 2022)
Transtheoretical model (k=6)	(Baumann et al., 2022; Mazeas et al., 2022)

The most frequently identified theories were the social cognitive theory (Bandura, 1982), the self-regulation theory (Bandura, 2005), the self-determination theory (Ryan & Deci, 2000), the theory of planned behaviour (Ajzen & Driver, 1991), and the transtheoretical model of behaviour change

(Prochaska & Marcus, 1994). To promote behaviour change, some interventions use a combination of at least two different theories. In what concerns the report on the BCTs, the taxonomy of BCTs is also mentioned (Michie et al., 2011). Due to high methodological heterogeneity and reporting gaps, the potential increased effect of theory-based versus atheoretical interventions is not present in the literature.

BCTs and other features included in PA apps

Data from qualitative studies collected using focus groups, interviews, and reviews, characterises the BCTs and features that are commonly present in PA apps (Table 2. Preferred BCTs and/or other features identified as appealing through qualitative studies). Goal setting and planning, coaching, feedback, and self-monitoring/ tracking were features identified by adolescents as being attractive, motivating, and interesting (Domin et al., 2022; Braun et al., 2024; Gomes et al., 2024). Adolescents preferred an easy-to-use interface with a simple and modern design. Customization and data precision were appreciated (Domin et al., 2022; Braun et al., 2024; Ghosh et al., 2024). Other focus group data collected with teenagers highlighted the importance of competition and fair in-game rewards (Pope et al., 2017).

Based on the findings from the "PEGASO Fit for Future mHealth" intervention (Martin et al., 2020), it seems that personalisation, simple language, accessible tutorials, clear purpose, rewards, varied gamified activities, and peer support are all important features that people want in a PA app. These suggestions make sense, as they would help make the app more engaging, motivating, and easy to use. According to a recent study conducted on the "Zombie Run" game, the gamification and narrative appeal of the game are particularly attractive to young individuals (Farič et al., 2021). The study revealed that many participants enjoyed incorporating an element of enjoyment into their physical activity routine or using the game to distract themselves from the physical effort of exercise. The immersive and engaging narrative, as well as the well-developed characters in the game, were also found to be highly appealing to users. However, features such as mood and sleep tracking, sharing workout results on social media, and digital avatars were not well-received by participants and were not found to be effective in motivating users (Farič et al., 2021). In the study conducted by Daryabeygi-Khotbehsara and co-workers (2021), the "Active2Gether" intervention was reported using three different arms. These included Active2Gether-full, which involved tailored coaching messages, self-monitoring, and social comparison, Active2Gether-light, which only included self-monitoring and social comparison, and the Fitbit app control condition, which only involved self-monitoring. It was interesting to observe that the various approaches did not have a different impact on the outcomes of the intervention compared to the group using only Fitbit. According to a recent focus group study with 8 adolescents aged 16-18, certain features such as mood and sleep tracking, sharing workout results on social media, having a digital avatar and coach, and receiving rewards were viewed negatively and deemed pointless and unhelpful (Domin et al., 2022).

Table 2. Preferred BCTs and/or other features identified as appealing through qualitative studies

Behavior Change Technique	Reference
Action planning	(Domin et al., 2022; Gomes et al., 2024)
Challenge/ competition	(Pope et al., 2017)
Feedback	(Domin et al., 2022; Gomes et al., 2024; Paganini et al., 2021; Thornton et al., 2021)
Gamification	(Farič et al., 2021; Ghosh et al., 2024; Martin et al., 2020; Paganini et al., 2021)
Goal setting	(Braun et al., 2024; Domin et al., 2022; Paganini et al., 2021; Thornton et al., 2021)
Information/ education	(Ghosh et al., 2024; Paganini et al., 2021)
Prompts/ nudges	(Gomes et al., 2024; Paganini et al., 2021)
Rewards	(Farič et al., 2021; Gomes et al., 2024; Martin et al., 2020; Pope et al., 2017; Thornton et al., 2021)26/02/2025 11:51:00
Self-monitoring/ Tracking	(Braun et al., 2024; Domin et al., 2022; Gomes et al., 2024; Paganini et al., 2021; Thornton et al., 2021)
Social support	(Braun et al., 2024; Ghosh et al., 2024; Gomes et al., 2024; Martin et al., 2020)
Feature	Reference
Aesthetic features	(Domin et al., 2022; Ghosh et al., 2024; Pope et al., 2017)
Customization and personalization	(Braun et al., 2024; Domin et al., 2022; Ghosh et al., 2024; Paganini et al., 2021)
Relaxation	(Paganini et al., 2021)
Simplicity and accessibility	(Domin et al., 2022; Paganini et al., 2021; Pope et al., 2017)
Technical aspects/ training programs	(Braun et al., 2024; Domin et al., 2022; Paganini et al., 2021)

Results from reviews describe several features included in PA promotions apps (Table 3. BCTs and other features suggested by data from reviews). Some of them are more closely related to behaviour change theory, using of goal setting, action planning, self-monitoring, and feedback (Baumann et al., 2022). Alternatively, other apps used a limited theoretical foundation and focused on aspects of gamification (Mazeas et al., 2022) and rewards (Daryabeygi-Khotbehsara et al., 2021).

Table 3. BCTs suggested by data from reviews.

Behavior Change Technique	Reference
Action and/or coping planning	(Baumann et al., 2022; Böhm et al., 2019)
Behavioural contract	(Brannon & Cushing, 2015)
Competition and/or challenges	(Baumann et al., 2022; Xu et al., 2022)
Contingent rewards and/or threat	(Baumann et al., 2022; Brannon & Cushing, 2015; Schoeppe et al., 2017)
Feedback	(Baumann et al., 2022; Böhm et al., 2019; Daryabeygi-Khotbehsara et al., 2021; Schoeppe et al., 2017; Xu et al., 2022)
Gamification	(Böhm et al., 2019; Lee et al., 2021; Mazeas et al., 2022; Xu et al., 2022)
General encouragement	(Schoeppe et al., 2017)
Goal setting	(Baumann et al., 2022; Böhm et al., 2019; Daryabeygi-Khotbehsara et al., 2021; Xu et al., 2022)
Identity building	(Baumann et al., 2022)
Instruction	(Baumann et al., 2022)
Instructions	(Baumann et al., 2022; Schoeppe et al., 2017)
Prompts	(Daryabeygi-Khotbehsara et al., 2021)
Rewards	(Daryabeygi-Khotbehsara et al., 2021)
Self- monitoring	(Baumann et al., 2022; Brannon & Cushing, 2015; Böhm et al., 2019; Daryabeygi-Khotbehsara et al., 2021; Schoeppe et al., 2017)
Social comparison	(Baumann et al., 2022; Schoeppe et al., 2017)
Social support	(Baumann et al., 2022; Brannon & Cushing, 2015; Xu et al., 2022)

According to the study conducted by Schoeppe and colleagues (2017), the most prevalent characteristics of mobile apps were directions, motivation, incentives, and performance feedback. The research also found that the number of technical features and behaviour change techniques (BCTs) included in an app directly correlated with its quality ratings. To evaluate app quality, the Mobile App Rating Scale (MARS) was used, which evaluates apps based on four domains: engagement, functionality, aesthetics, and information quality. These domains measure aspects such as entertainment value, user-friendliness, visual appeal, and accuracy of information. Each item is rated on a 5-point scale, and a score for each domain is calculated as the average of the items in that domain. The overall score is then determined by averaging the four domain scores.

A literature review conducted by Daryabeygi-Khotbehsara et al. (2021) identified several constructs of social cognitive theory. These included outcome expectancies, risk awareness and planning, efficacy-building affirmations, social support, and evoking anticipated reward or regret. Habit formation, monitoring and feedback on behaviour, and social rewards were also described (Daryabeygi-Khotbehsara et al., 2021). Habit, performance expectancy, facilitating conditions, price value, and effort expectancy were positively associated with the intention to use fitness apps and subsequently. Intentions to use fitness apps were positively related to intentions of being physically active (Yang & Koenigstorfer, 2021).

By incorporating gameplay and game principles into health promotion interventions, individuals are more likely to engage with the material. This can be done through adding gamification to non-game interventions or designing digital games specifically for health promotion. However, it's important to note that game design should be appropriate for specific age groups. A review of studies found that 60% of the studies (30 out of 50) combined gamification with wearable devices to improve physical activity behaviour change, while half of the studies used behaviour change theories or principles to design gamified PA interventions. The most used game elements included goal setting, progress bars, rewards, points, and feedback (Xu et al., 2022).

Impact of PA promotion apps

Commercial apps aimed at improving children's diet, and physical activity, and reducing sedentary behaviour have moderate quality. However, average user ratings showed significant, small correlations with MARS scores (Gil-Espinosa et al., 2022; Paganini et al., 2021; Schoeppe et al., 2017).

Table 4. PA app overall quality data from reviews.

Reference	Purpose	Method	Results
(Schoeppe et al., 2017)	Evaluated the content and quality of apps to improve diet, physical activity and sedentary behaviour. Examined relationships of app quality ratings with the number of features and BCTs used.	Australian Apple iTunes and Google Play Store, Nov 2016 25 apps (18 PA)	MARS has moderate overall quality but scored higher in functionality. Most apps incorporate some BCTs, but higher quality apps have more features and BCTs.
(Paganini et al., 2021)	Reviewed and analyzed the content and quality of physical activity apps	German Google Play and App Store, Feb 2018 312 apps	PA apps were deemed to have a moderate level of quality. Minor correlation between the ratings given by users and those determined by MARS. The extent of content and features offered by the apps had a greater bearing on their overall quality, as opposed to their app store or pricing.
(Gil-Espinosa et al., 2022)	Searched for PA and sports apps. Assessed features, content and quality. Analyzed the relationships between appa and PE curriculum.	Google Play Store, Mar 2021 18 apps	Data indicated that the overall PA app quality was moderate to high (average score of 4 on MARS).

It was noted that BCTs such as providing consequences for behaviour, providing information on other's approval, intention formation, self-monitoring, and the use of a behavioural contract were significant positive predictors of PA effect size in studies with adolescents. Additionally, providing instruction was negatively predictive of the effect size of PA (Brannon & Cushing, 2015).

The quasi-experimental studies demonstrated a decrease in SB and an increase in physical activity, including light physical activity (LIPA), walking steps, walking time, moderate-to-vigorous physical activity (MVPA), and non-walking exercise time. According to randomized controlled trial studies, there was an increase in the number of steps taken and in the amount of time spent walking (Daryabeygi-Khotbehsara et al., 2021). According to a meta-analysis, smartphone interventions have the potential to increase physical activity and step count in children and adolescents (He et al., 2021) (Wang et al., 2024).

Upon thorough review of multiple studies, it has been determined that the integration of mHealth technology can yield beneficial results in terms of physical activity outcomes for adolescents. However, such benefits appear to be less significant when compared to studies that included a control group. As such, it is recommended that researchers who seek to utilize mHealth technology to enhance physical activity levels among adolescents involve the target population in the creation and development of their interventions from the outset (Lee et al, 2019.

Studies have revealed that incorporating gamification strategies can enhance physical activity adherence among adolescents. A study found that a gamified intervention was effective in promoting physical activity (Patricio et al., 2020). However, few interventions integrate popular gamification strategies such as those seen in Pokémon GO and asynchronous competition within social media platforms like Nike+ and Strava. While mHealth interventions have improved physical activity outcomes for adolescents over time, the variability of study designs and chosen outcome measures make it challenging to fully comprehend their impact (Lee et al., 2019). Another review (Mazeas et al., 2022) shows that gamified interventions are not only efficient in changing behaviour but also more effective than other behavioural interventions. Nevertheless, the long-term effects are weaker and have only a small to very small effect size. Despite this, meta-analyses confirm that gamified interventions are promising for promoting physical activity across various populations. Moreover, the effects seem to persist even after the follow-up period, suggesting that gamified products are effective compared to equivalent non-gamified physical activity interventions (Xu et al., 2022). While gamified interventions can increase physical activity participation, results are mixed, and changes are modest, which could be attributed to the heterogeneity across studies.

Table 5. PA app overall effect in PA promotion data from reviews

Reference	Results
(Baumann et al., 2022)	Evidence suggests that mHealth interventions can moderately reduce insufficient PA in children and adolescents, but not sedentary behavior. (SB). Research shows that personalized approaches to physical activity significantly reduce the prevalence of insufficient levels of physical activity (Cohen d=0.33; 95% CI 0.08-0.58; Z=2.55; P=.01), while interventions with low levels of individualization (Cohen d=−0.06; 95% CI −0.32 to 0.20; Z=0.48; P=.63) or targeting SB (Cohen d=−0.11; 95% CI −0.01 to 0.23; Z=1.73; P=.08) indicated no overall significant effect.
(Böhm et al., 2019)	No evidence was found to support the effectiveness of wearable activity trackers on PA-related outcomes.
(Brannon & Cushing, 2015)	Several factors were discovered to significantly impact the effect size of physical activity (PA). These factors include consequences of behaviour (OR = 1.36, p < .05), information on others' approval (OR = 1.44, p < .05), intention formation (OR = 1.22, p < .05), self-monitoring (OR = 1.22, p < .05), and the use of a behavioural contract (OR = 1.53, p < .05). Conversely, providing instruction (OR = 0.75, p < .05) was found to have a negative effect on study effect size.
(Daryabeygi-Khotbehsara et al., 2021)	Reduction in SB (1 study; P=.08), along with an increase in light PA (1 study; P=.002), walking steps (3 studies; P=.003, P=.06 and P<.001), walking time (2 studies; P=.06 and P=.02), moderate-to-vigorous PA (2 studies; P=.08 and P=.81), and non-walking exercise time (1 study; P=.31).
(He et al., 2021)	The use of smartphone intervention improved physical activity significantly when compared to the control group (standardized mean difference [SMD] 0.44, 95% CI 0.11-0.77, P=.009), especially for total PA (weighted mean difference [WMD] 32.35, 95% CI 10.36-54.33, P=.004) and daily steps (WMD 1185, 95% CI 303-2068, P=.008), but not for MVPA (WMD 3.91, 95% CI −1.99 to 9.81, P=.19).
(Lee et al., 2019)	In 12 of the 16 studies interventions with a mHealth component led to a general improvement in PA outcomes over time. When considering studies with a control group, only 5 out of 13 showed a significant intervention effect, and an additional 5 out of 13 showed improvement among all groups.
(Lee et al., 2021)	Of the 27 studies that examined the impact of Pokémon GO on players' PA, 19 found that it had a positive effect.
(Mazeas et al., 2022)	The meta-analysis revealed a small to medium summary effect of gamified interventions on PA behaviour (Hedges g=0.42, 95% CI 0.14-0.69). The effect was significant when compared with inactive control groups, such as waiting lists (Hedges g=0.58, 95% CI 0.08-1.07), and active control groups (Hedges g=0.23, 95% CI 0.05-0.41). The long-term effect (average follow-up 14 weeks) was weaker, with a very small to small effect (Hedges g=0.15, 95% CI 0.07-0.23).
(Paganini et al., 2021)	An efficacy study could not be identified for any of the included apps.
(Wang et al., 2024)	mHealth app–based interventions significantly improved total physical activity (TPA; SMD 0.29, P<.001), reduced sedentary behavior (SMD −0.97, P=.006), and lowered body mass index (BMI; −0.31 kg/m^2, P=.12). Interventions also enhanced muscle strength (SMD 1.97, P=.04) and agility (SMD −0.35, P=.006). Effects on moderate to vigorous physical activity (MVPA; SMD 0.11, P<.001), waist circumference (0.38 cm, P=.65), muscular power (SMD 0.01, P=.81), cardiorespiratory fitness (SMD −0.20, P=.11), muscular endurance (SMD 0.47, P=.10), and flexibility (SMD 0.09, P=.58) were not statistically significant.
(Xu et al., 2022)	This systematic review revealed mixed findings for the efficacy of gamification interventions for improving PA and SB. Studies reported mixed results on step counts, LIPA, MVPA, and SB. However, most of the non-controlled studies (6/8, 75%) revealed that gamified interventions might positively affect time spent in overall PA.

Conclusions

The aim of this study was to examine the existing literature on apps that promote PA among adolescents. The study aimed to identify the underlying theories, key behaviour change techniques, and features of these apps, as well as their effectiveness in promoting adherence to and maintenance of physical activity. Implementing a narrative review is chosen as it provides a comprehensive overview of a subject, without being restricted by a specific research question or a predefined protocol, and it can explore gaps and controversies in the literature. It is important to consider some limitations of this study as it is a narrative review. The results may be influenced by the author's biases, and it does not provide a clear quality assessment of the included studies, which can affect the validity and generalizability of the review. Additionally, it does not address the quality or strength of evidence of the included studies, which can affect its applicability and usefulness.

Data from this study highlight that intervention programs using mHealth tools or wearable activity trackers have mixed effects on physical activity, stressing the need for future studies with higher methodological quality. Caution is necessary due to the small number of studies, poor compliance measurement instruments for PA, risk of bias, missing RCTs, and the heterogeneity of intervention programs, which may affect the comparability of the studies and their effects. There is a clear need for future studies to develop PA interventions grounded on intervention mapping, the Behaviour Change Wheel for intervention development, frameworks like RE-AIM for intervention development, and high-quality methodological study design for specific target groups (e.g., adolescents, and ethnic minorities) to establish meaningful evidence.

Recommendations for future app development

- Identify factors that promote users' app engagement according to the literature, and according to target group preferences/ tailored to specific population groups,
- Ground app development on health behaviour change theories, guiding the features to be developed.
- Design the app with well-defined BCTs and test which combination is most effective for specific child and adolescent populations based on the chosen theory.
- Develop the interventions in collaboration with end-users (children and adolescents).
- Include gamification elements (such as points, leader boards, and progress bars), as they have the potential to increase motivation and engagement in PA.
- Pilot-test popular apps with diverse BCTs in child and adolescent populations to enhance app development.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

HVP contributed to the design, search, data extraction, quality assessment, and manuscript. DSS, MS, PD, MLF, MNS, ALP, and LG contributed to the manuscript and supervision of the overall process. All authors contributed to the article and approved the submitted version.

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