

Promoting Health among Children and Adolescents via Gamification

Subjects: **Primary Health Care**

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The rapid growth in digital technology usage among children and adolescents has highlighted the need for novel approaches to promote their physical and mental health. Promoting children and adolescents' physical and mental health through gamified techniques, these interventions can provide an interactive and engaging platform for encouraging physical activity, promoting healthy nutrition, enhancing emotional regulation, and promoting mental health. The significance of this topic stems from the pervasive use of electronic games, beginning at a young age, which makes them popular educational tools.

gamification

physical health

mental health

children

1. Introduction

The use of gamification in promoting physical and mental health in children is an innovative approach that requires a careful consideration of the technological prerequisites and disparities in digital device access. Ensuring device compatibility across smartphones, tablets, and computers is essential for broad accessibility ^[1]. Additionally, reliable internet access is a critical factor, particularly in regions with limited connectivity, as noted in a report by the World Health Organization. The design of these gamified applications must be user-friendly and appropriate for children, allowing for easy navigation and engagement. However, economic, and geographical disparities pose significant challenges. Children from different socioeconomic backgrounds may not have equal access to digital devices, and those in rural or remote areas might face additional hurdles due to less advanced technology and internet availability. Furthermore, the level of digital literacy, often tied to available educational resources, can influence children's ability to engage with digital health tools ^[2] effectively.

To mitigate these disparities, the inclusive design of gamified health applications is vital, ensuring they can operate on primary devices. Establishing community centers or schools as access points can provide opportunities for children without personal devices, a strategy recommended by UNICEF. Additionally, providing digital literacy training can help children use these tools more effectively ^[3]. Regular feedback and assessment mechanisms are crucial for evaluating gamified tools' effectiveness and engagement levels. Moreover, collecting data on usage patterns and health outcomes is essential for assessing the impact on children's health, as emphasized in ^[4]. Collaborations with educational institutions and support from government and NGOs can enhance accessibility, providing the necessary resources and infrastructure for a broader reach, as seen in the initiatives described by the Centers for Disease Control and Prevention (CDC) (2022) ^[5]. These steps are crucial in maximizing the impact and

reach of gamification in improving children's physical and mental health. Overall, ensuring accessibility and addressing disparities in digital access, literacy, and socioeconomic factors are crucial for maximizing the impact of gamified health applications on children's health and well-being, particularly in underprivileged communities.

In conclusion, while gamified health applications can potentially improve children's health and well-being, it is essential to address disparities in digital access and ensure inclusive designs to maximize their impact on all children, regardless of socioeconomic background or geographical location ^[6]. Thus, it is crucial to provide necessary resources and infrastructure, promote digital literacy, and establish collaborations with educational institutions, government, and NGOs ^[7].

Children and adolescents' well-being relies heavily on health promotion. Thanks to the increasing use of digital technology, gamification has emerged as a promising strategy for engaging and motivating young people in health-related behaviors. Several studies have investigated the efficacy of gamified interventions in promoting behavior modification and health in children and adolescents and have found that gamified interventions can effectively promote behavior change and improve health outcomes ^[8]. These interventions can leverage intrinsic motivation, making them more engaging and pleasurable for young people. A study on gamified sexual health education among adolescents in low-tech settings, for instance, found that gamified learning promoted sexual well-being more effectively and engagingly ^[9].

Likewise, a study on gamified learning for sexual health education revealed that gamification enhanced students' attitudes, knowledge, and motivation to learn ^[10]. In addition, gamified scenarios can promote healthier lifestyles among children and teenagers. Another study ^[11] found that gamification can effectively enhance this population's diet, physical activity, and sedentary behavior. A systematic review and meta-analysis found, for instance, that gamification interventions effectively improved diet, nutritional practices, and body composition in children and adolescents ^[12]. In addition, gamification has been utilized to promote active school transportation, encouraging children and adolescents to engage in physical activity ^[13]. Gamified scenarios can motivate young individuals to adopt and maintain healthful behaviors by incorporating game elements such as rewards, challenges, and goal setting.

Additionally, gamified scenarios can be tailored to address health concerns among children and adolescents. For instance, gamification has been utilized to promote adherence to national food-based dietary guidelines and increase knowledge of healthier nutritional practices ^[14]. It has also been investigated as a tool for assessing and intervening in behavioral problems such as conduct disorder, self-harming tendencies, and attention-deficit/hyperactivity disorder (ADHD) ^[15]. Gamified scenarios can help young people develop skills, knowledge, and behaviors that contribute to their overall health and well-being by providing interactive and engaging experiences.

2. Promoting Physical and Mental Health among Children and Adolescents via Gamification

The results highlight the numerous ways in which engaging and motivating learners is a well-known challenge in health education [16]. Even though healthy nutrition is essential for physical well-being, it can often appear complicated and dull to children and adolescents. Gamification is an innovative solution due to its capacity to capture and maintain interest. By making learning about healthy eating in a fun, interactive experience, children and adolescents are more likely to retain the information. One of the assets of gamified platforms is their capacity to employ a variety of learning -promoting game mechanics. Elements such as quests or challenges can be mapped to nutrition-related objectives, such as eating a certain number of fruits and vegetables daily or preparing a balanced meal. Reward systems, such as points, badges, and levels, can provide positive reinforcement, encouraging the repetition of healthy eating behaviors.

Additionally, leaderboards can cultivate a sense of healthy competition and community, thereby increasing motivation. In addition, the results of the focus groups presented in one paper [17] suggest that gamification of nutrition can improve adolescents' dietary habits. Four themes emerged from the analyses: enhanced eating behavior, increased physical activity, increased nutrition knowledge, and influencing others. Researchers also observed that after playing the game, the participants had improved nutrition knowledge and they reported influencing the eating habits of their parents, siblings, and acquaintances. Nonetheless, remarks made by participants during the focus group discussions highlighted nutrition-related misinformation. In addition, in one paper [18], the challenge was to create highly user-friendly and motivating programs to promote adherence and efficacy. This usability study aimed to evaluate and improve the usability and engagement of an unguided online intervention program to promote a healthy lifestyle and reduce the risk of eating disorders and obesity among adolescents.

Gamification could be effective [19] in enhancing nutritional knowledge regarding healthier dietary practices. To avoid and prevent chronic diseases, it is necessary to promote the development of practical educational instruments to support learning about nutrition. Also, according to a shared perspective [20], the newly developed gamified "Snack Track School" app attempts to address some of the issues identified in earlier prevention programs, which were unsuccessful in altering nutrition behaviors and anthropometrics. According to the research protocol [21], the results indicate that the app's core features should include individualized meal recommendations and assistance with meal planning, social networking for peer support, customized and convenient tracking, remote access to health care providers, features to support mental health, and an engaging user interface.

In addition, according to other research [22], the challenge of gamification is creating extremely user-friendly and motivating programs to promote adherence and efficacy. This study intended to evaluate and improve the usability and engagement of an unguided online intervention program designed to promote a healthy lifestyle and reduce the risk of eating disorders and obesity among adolescents. A mobile application employing gamification techniques was utilized to prevent obesity in the at-risk group. Gamification techniques applied to the game experience without adequate support from the design discipline may compromise the user's understanding of the actual benefits of serious games. Behind entertainment and therapy, it is mandatory to involve all stakeholders in the design process when working in this field to produce a genuine contribution to promoting healthy habits among adolescents.

Based on [23], an intervention program was conducted to determine whether the hybridization of teaching personal and social responsibility and gamification could be enhanced. The results indicate that hybridization of teaching personal and social responsibility and gamification strategies improved cognitive performance but not academic achievement. These findings emphasize the significance of promoting and empowering cognitive processes for improved academic performance. According to the qualitative findings of the paper [24], students reported increased self-confidence and empowerment in their school community and family environment. Increasing pupil engagement is essential to the success of an intervention. Lastly, in [25], the intervention, which incorporated gamification strategies and recruitment methods employing parental opt-out procedures, was acceptable to both participants and instructors. Innovative gamified interventions may be one strategy for engaging and motivating health behavior modification. All articles extracted are listed in Table below (**Table 1**).

Table 1. Empirical studies (author, sample, instrument, conclusions).

Author (Year)	Type of Study	Sample	Instrument	Conclusions
Azevedo et al. (2019) [16]	Quasi-experimental	N = 106	Gamified digital interactive platform.	Gamified digital interactive platform seems to be a useful, easily adapted educational tool for the healthy eating learning process.
Cejudo et al. (2020) [26]	Quantitative Analysis	Adolescents N = 187	Intervention program through a video game called “Aislados” for the improvement of subjective well-being, mental health, and emotional intelligence.	The results show significant differences in HRQL, positive affect, and mental health. The findings highlight the significance of promoting social and emotional learning in adolescence as a protective factor for emotional and behavioral adjustment.
Corepal et al. (2019) [25]	Randomized cluster trial Quantitative	Adolescents N = 224	ActiGraph accelerometer Warwick–Edinburgh Mental Well-Being Scale. Strengths and Difficulties Questionnaire (SDQ).	Participants and teachers liked the gamification intervention and parental optout recruitment. Innovative gamified interventions may engage and motivate health behavioral changes.
Ezezika et al. (2018) [17]	Quantitative	N = 31	An element of the gamification system was an	Focus group results indicated that gamifying

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			educational and culturally relevant board game that teaches children and youth about proper nutrition.	nutrition can improve dietary behavior in adolescents. The analyses revealed five themes: improved eating behavior, physical activity, well-being, nutrition knowledge, and influence.
Guerrero-Puerta, and Guerrero (2021) [27]	Qualitative	Single-subject study, case study	Semi-structured retrospective interviews with open-ended questions.	This article investigated the relationship between game-based teaching, at-risk students' well-being, and early school dropouts through a personal narrative. Gamification's protective effects against ESL during gamification and their disappearance are examples.
Lepe et al. (2019) [24]	Quasi-experimental, mixed methods Inductive content analysis and ANOVA	N = 142; Comparison N = 170	The EMPOWER consisted of ten 30 min PSE lessons.	The qualitative results showed that students felt empowered to have a voice in their school and family communities. Increasing student engagement is key to intervention success.
Melero-Cañas et al. (2021) [23]	A 9-month group-randomized controlled trial Quantitative	N = 150	NIH Examiner battery (University of California-San Francisco, CA, USA), Stroop Color, and the Word Test Academic Achievement: Grades in mathematics and language.	This intervention program examined TPSR-gamification hybridization improvement. Hybridization with TPSR and gamification improved cognitive performance but not academic performance. These findings suggest that academic success requires cognitive empowerment.

Author (Year)	Type of Study	Sample	Instrument	Conclusions
Nitsch et al. (2019) [18]	The study used a think-aloud task, semi-structured interview, and sociodemographic and System Usability Scale questionnaire	Girls and boys aged between 14 and 18 years	SUS Questionnaire Think-Aloud Task and Semi-Structured Interview Visual Design KIDCOPE Questionnaire Online program "Healthy Teens @ School"	To encourage adherence and effectiveness, programs must be user-friendly and motivating. This usability study assessed and improved an unguided online intervention program to promote a healthy lifestyle and reduce adolescent eating disorders and obesity.
Pernencar et al. (2018) [22]	Experimental	N = 165 adolescents	Participants created a character, completed a mission, and fed the character; the TeenPower platform (back office and mobile app) developed with the direct support of an interdisciplinary team.	Risk group obesity prevention mobile app using gamification. Ineffective gamification in games without design support may obscure serious games' benefits. To promote healthy adolescent habits through entertainment and therapy, all stakeholders must be involved in design.
Rivera et al. (2018) [21]	A qualitative study	N = 19 adolescents	Interview protocol, included major themes related to app functionality: healthy eating, social support, self-monitoring, communicating with HCPs, supporting mental health, gamification and incentives, and user interface (UI) design.	The study suggests that the app should include personalized meal recommendations, social networking for peer support, convenient tracking, remote access to HCPs, mental health features, and an engaging UI.
Suleiman-Martos et al. (2021) [12]	Meta-analysis	Children and adolescents	Randomized controlled trials, intervention as a playful game component, gathering data on the effect of the intervention on eating habits, knowledge, and body composition.	Gamification may help improve nutritional knowledge and healthy eating habits. Developing effective nutrition educational tools is essential to preventing chronic diseases.

Author (Year)	Type of Study	Sample	Instrument	Conclusions
Van Lippevelde et al. (2016) [20]	Quantitative	N = 1400 adolescents	mHealth intervention based on Mapping protocol.	The new gamified “Snack Track School” app addresses issues from previous prevention programs that failed to change nutrition behaviors and anthropometrics.
Espinosa-Curiel et al. (2022) [28]	Randomized controlled trial with pre–post design and intervention and control groups	Participants 8–11 years	The intervention was playing six 30 min sessions with HelperFriend over a period of 4 weeks.	HelperFriend is practical and acceptable for young children and may improve knowledge, healthy behavior intention, and diet. To prove its efficacy, more well-powered randomized controlled trials are needed.
Tark et al. (2019) [29]	Non-controlled, prospective, interventional, qualitative	N = 9 Participants 7–12 years	The intervention used the Triumf mobile health game for psychological and treatment support, cognitive challenges, and disease-specific information. This 60-day intervention averaged 66.6 psychological support or education visits. Most participants collected city items, indicating exploration. Depression, anxiety, and general health problems decreased statistically during the intervention.	Patients highly rated the mobile health game for usability and acceptability. General health problems and depression and anxiety symptoms decreased statistically and trended downward during the intervention. The study showed that a game environment can provide comprehensive supportive care to pediatric cancer and other chronic disease patients.
Haruna et al. (2018) [30]	Randomized control trial comparing GBL and gamification with traditional teaching as a control condition	N = 120 Participants 11–15 years	-	-
Rodriguez-Ayllon et al. (2019) [31]	Meta-analysis	Participants: 2–18 years	The study did not specify the exact interventions that the participants received. It focused on examining the effect of physical activity	Physical activity interventions can improve adolescents’ mental health, but more research is needed on

Author (Year)	Type of Study	Sample	Instrument	Conclusions
			interventions on mental health outcomes in children and adolescents.	effects on children's mental health. Increasing physical activity and decreasing sedentary behavior may protect children and adolescents' mental health. Sedentary behavior and increased psychological ill-being and lower psychological well-being were associated in longitudinal and cross-sectional studies.
Afonso et al. (2020) [32]	Pilot study	N = 21 Participants age: 3–6 years	The app gives parents tailored advice on their young children's eating, drinking, moving, and sleeping habits, using gamification mechanics for parents and a serious game for their 3–6-year-old children. The pilot study included all intervention group parents using the app.	Healthcare centers can help parents encourage healthy lifestyles for their kids. Parental acceptance of the app was high, with a median score of seven out of ten. The pilot study found that intervention group parents used the app frequently and 71.4% of users were retained.
Manzano-León et al. (2021) [33]	The study design is quasi-experimental, longitudinal, and used mixed methods	N = 100 Participants: Children <12 years old	The intervention involved participation in leisure activities, physical activity, and games as part of the family leisure program called "Lunae Magic School" for Spanish families with children under 12 years old during the COVID-19 lockdown.	The study found that family leisure program participation reduced parents' anxiety and perception of their children's physical and emotional discomfort. The qualitative analysis suggested that gamification and the variety of activities created fun and flow despite confinement. The study found that family leisure was important, but more research is needed on implementing similar programs.

Author (Year)	Type of Study	Sample	Instrument	Conclusions
del Río et al. (2019) [34]	This three-year, quasi-experimental, longitudinal study had two annual phases and non-random assignment to experimental and control groups	N = 46 Participants 6–12 years	Healthy habit training and obesity education for 60 min using traditional motor games, an active video game with healthy habit content, two weekly 30 min physical activity sessions at home with a commercial video game (Wii Fit Plus), and a 90 min educational session for parents, mothers, and/or guardians on healthy lifestyle habits, obesity as a disease, and false beliefs were	The study found significant improvements in children's knowledge of healthy nutrition and Mediterranean diet adherence, with the experimental group adherence being better than the control group. Both groups' healthy eating knowledge improved over time, surpassing their previous evaluations.
Gao et al. (2019) [35]	The study design is a two-arm, 9-month experimental design with repeated measures	N = 81 Participants 9–10 years	Intervention school students played 50 min of active video games (AVG) weekly for 9 months. Eight Xbox 360 or Wii AVG stations in a gym had developmentally appropriate AVGs like Just Dance, Wii Fit, Gold's Gym Cardio Workout, and Kinect Sports. Four kids played at each station every 10 min. Teachers monitored intervention kids' program attendance.	<ul style="list-style-type: none"> - AVG intervention increased school-day energy expenditure and social support significantly compared to the control condition. - The intervention group had increased daily caloric expenditure and mean MET values. - The intervention did not improve outcome expectancy or self-efficacy as expected.
Timpel et al. (2018) [36]	Phase II, single-center, two-arm, triple-blinded, randomized controlled trial Blinding: Patients, doctors, dietitians, outcome evaluators, and data analysts Randomization: 1:1, permuted blocks of four, school-stratified	N = 108 Participants 12–18 years old	The intervention consisted of a smartphone application that provides tracking and gamification elements, including diaries for food intake, exercises, and daily steps, along with personalized games and activities to educate adolescents about healthy habits. Both the control and intervention arms received text messages one week prior to clinic appointments as well as phone contact the day before.	<ul style="list-style-type: none"> - A smartphone app with a gamification approach to promote healthy lifestyle and weight loss in overweight and obese adolescents will be tested. - The proposed study is expected to fill a gap in the literature on the mid-term effects of gamification-based weight control interventions in adolescents, providing valuable insights for future research.

Author (Year)	Type of Study	Sample	Instrument	Conclusions
Peña et al. (2020) [37]	School-based, parallel cluster-randomized controlled trials with multicomponent gamification interventions are used	N = 2333 Participants 10–12 years	The intervention included a multicomponent gamification strategy with healthy challenges, gamification incentives, rewards, and an online platform for monitoring progress.	The gamification strategy appears to prevent childhood obesity and reduce systolic blood pressure in school children in Santiago.
Mamede et al. (2021) [38]	Cluster randomized controlled trial	N = 298	The intervention consisted of a 5-week gamification phase encompassing a gamified digital app with social support features, followed by a 5-week physical nudges phase, including motivational and point-of-choice prompt nudges.	- The gamified digital intervention with social support features significantly increased the step count of office workers compared with an active control.- Physical nudges in the workplace were insufficient to promote the maintenance of behavior changes achieved during the gamification phase.
Bremer and Cairney (2018) [39]	-	Participants 4–11 years	-	- Movement skill may have a positive influence on broad domains of health.- Intervening in movement skills may enhance the development of all children.
Maher et al. (2022) [40]	The study was a three-group RCT with allocation concealment	Participants 18–65 years	The intervention included a Facebook-integrated smartphone app for physical activity. Participants are encouraged to log 10,000 steps per day in the app for 100 days. Gamified apps included leaderboards, virtual gifts, hierarchical status, and challenges.	- Gamified apps had longer usage than non-gamified apps, but goal adherence was not significantly different. The leaderboard and status pages were the most popular gamification features, and overall use was associated with greater improvement in objectively measured physical activity but not self-reported activity.

Author (Year)	Type of Study	Sample	Instrument	Conclusions
Đorđić et al. (2019) [41]	Longitudinal study, pre- and post-intervention assessment	N = 3278 Adolescents 10.0–18.9 years	The 45 min educational session with a trained instructor included a general introduction to guidelines, a 30 min PowerPoint presentation of diet and exercise advice, and a discussion/counseling forum to answer individual questions. The educational intervention promoted positive health behaviors and prevented negative ones by providing unbiased information on healthy diets and physical activity according to USDHHS/USDA guidelines. Active learning methods like brainstorming, problem-solving, and discussion encouraged participation. Each participant received a health message and infographic leaflet.	-
Fang et al. (2019) [42]	The study design was a randomized controlled trial with stratified random sampling	N = 420 Participants 6–12 years	-	<ul style="list-style-type: none"> - Traditional supervised exercise is effective in improving metabolic disease risk factors. - Mobile technologies provide an opportunity for low-cost interventions. - The novel exercise intervention with WeChat support has the potential to improve metabolic health and change unhealthy behaviors in the long term.
Coknaz et al. (2019) [43]	The study design was a randomized controlled trial with a parallel design	N = 106 Participants 8–12 years	Intervention: Active video games for 12 weeks.	Active video games improved weight, BMI, reaction times, and self-perception in inactive and tech-obsessed kids. In the active video

Author (Year)	Type of Study	Sample	Instrument	Conclusions
				game group, qualitative analysis showed high enjoyment, which may motivate continued play. Active video games helped children develop physically, socially, intellectually, and personally, according to the study.
Tang et al. (2020) [44]	A pilot cluster randomized controlled trial using 2 intervention and 2 control schools. School location and population size determine intervention or control group assignment	N = 326 Participants 10–12 years	Intervention: 4 weekly lessons on healthy eating and exercise support at school and online peer instructor, leader, and 6th grader training. Four 50 min lessons on food choices, movement matters, healthy lifestyles, and PEPS Actions. Behavior reinforcement monitoring and social network support peer system in PEPS Project on Facebook offers peer support. Sports fairs offered to all 6th graders. After class, students and institutions gave feedback.	The intention was use the study's findings to develop a larger-scale trial; the generation of evidence was used to develop feasible and acceptable approaches for interventions to prevent excess weight gain, and the findings were used to inform a larger-scale trial to examine a multicomponent, school- and home-based lifestyle promotion intervention.
Bianchi-Hayes et al. (2018) [45]	Non-controlled, single-arm pilot study with a multimodal intervention for parent–adolescent dyads	N = 9 Adolescents 14–16 years	Parent–adolescent dyads received personal activity trackers, configuration of tracker settings and apps, follow-up phone calls based on tracker data, and home-based smart scales for a 10-week multimodal intervention. Participants were also asked about their PA habits, barriers to change, exercise and health beliefs, sleep patterns, and fitness goals.	Parent–adolescent PA success rates were highly correlated. Teenagers and parents met step and active-minute goals at least a third of the time, with parents meeting them more often. The step-count and active-minute success rates correlated significantly.
Rose and Soundy (2020) [46]	The integrative review and systematic search included studies on underprivileged	N = 5886 Participants 9–16 years	The interventions included multi-sports, yoga, combined martial arts/group sports, dance, aerobic exercise, low-risk	MVPA affects the mental health of disadvantaged children and adolescents, autonomy support

Author (Year)	Type of Study	Sample	Instrument	Conclusions
	children, with moderate to vigorous physical activity (MVPA)		boxing, and muscle-building sports. The intensity was moderate to vigorous, the duration was 30 min to six hours, and the frequency was daily to weekly. Mainly noncompetitive group physical activity was included.	promotes positive change, and age and gender affect the association. The review found that MVPA improves mental health and well-being in disadvantaged children and adolescents, but longitudinal studies and studies on specific types of physical activity are needed.
Bowling et al. (2021) [47]	The study design was a randomized controlled trial (RCT) with a pilot feasibility and acceptability trial design	N = 23 Participants 12–17 years	An Xbox One with Kinect motion sensor, a 12-week Xbox Live subscription, and three exergames (Just Dance 3, Shape Up 3, and Kinect Sports Season 2) were provided. Participants had 3 weekly exergaming sessions and 6 real-time telehealth coaching sessions.	This pilot study adapted and expanded an evidence-based exergaming and telehealth coaching intervention to improve PA, diet, video game play time, and sleep in youths with mental health and neurodevelopmental disorders and evaluated its feasibility and acceptability, including PA engagement. - PA improved and MVPA declined less after the intervention compared to controls. - The COVID-19 pandemic disrupted in-person learning and clinical care, making remote health behavior interventions for youth with NPDs a need. AGS may be a promising solution.
Van Woudenberg et al. (2020) [48]	Randomized controlled trial, clustered design, three groups, registered a priori in the Dutch Trial Registry, DANS archive	N = 446 Participants 9–16 years	Interventions for study participants: 1. Social network intervention: 15% of participants were asked to create physical activity vlogs. 2. Mass media intervention:	The social network intervention did not prove to be effective in increasing physical activity in adolescents, and no differences were observed between the social network

Author (Year)	Type of Study	Sample	Instrument	Conclusions
			Participants watched vlogs of unfamiliar peer. 3. All participants received a research smartphone and wrist accelerometer.	intervention and mass media intervention. The study did not provide evidence that the social network intervention was more effective in increasing physical activity in adolescents compared to the mass media intervention or no intervention.
Zhou et al. (2018) [49]	The study design was a cluster randomized controlled trial (RCT) with a 2 × 2 factorial design	Participants 12–14 years	The study participants received the following interventions: Arm 1: School physical education intervention (SPE) with increased MVPA and VPA during school hours and provided nutrition education. - Arm 2: Afterschool program intervention (ASP) to increase MVPA and VPA after school and engage parents in supporting healthy habits at home via social media. Arm 3: SPE/ASP combined.	The study found that varying amounts of MVPA and VPA had an incremental effect on study outcomes using a 2 × 2 factorial design. It also addressed questions and debates surrounding school-based PA intervention research and incorporated current evidence and best practices to examine the effects of increasing PA doses in middle school students.
Kolb et al. (2021) [50]	Scoping review targeting systematic reviews and meta-analyses	Participants 6–17 years	-	The study identified physical health indicators for children and adolescents based on physical activity and sedentary behavior. Key study indicators included body composition, cardiometabolic biomarkers, fitness, harm and injury, and bone health. The study noted that sedentary behavior and health indicators are less consistent than physical activity.

Author (Year)	Type of Study	Sample	Instrument	Conclusions	
Cadenas-Sanchez et al. (2021) [51]	Cross-sectional, longitudinal, and intervention designs were used in this systematic review and meta-analysis	Participants 2–18 years	-	Physical fitness was linked to youth mental health to a small to medium degree. Additional longitudinal and intervention studies are needed to prove causation. Cross-sectional studies predominated, indicating the need for more robust causation studies.	
Schleider et al. (2019) [52]	Randomized controlled trial with three interventions, mixed-effects linear models, and using ANOVAs	N = 159 Participants 12–16 years	-	-	
Agam-Bitton et al. (2018) [53]	The study design was a cluster randomized controlled trial, with a multi-site component	N = 259 Participants 13.3–14.3 years	Nine weekly 90 min sessions were led by female education or nutrition undergraduate or graduate students. The intervention encouraged adolescent self-esteem, positive body images, and media literacy. Overall, the mixed-gender group had higher body esteem, lower perceived current body image, and a smaller gap between current and ideal body images than the other two groups.	-	World
Jamnik and DiLalla (2019) [54]	Longitudinal design, multi-informant measures, prospective cohort study	N = 326 Participants 12–20 years	-	Preschool-aged internalizing problems are linked to adolescent health outcomes. More internalizing problems were linked to worse health outcomes regardless of age. Adolescent overeating and health issues were significantly predicted	Health sis of an pbell, alysis. J. ampo,

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Author (Year)	Type of Study	Sample	Instrument	Conclusions	
				by parent-reported internalizing at age 5.	omote
Gordon et al. (2020) [55]	Cluster RCT, intervention/control groups, block randomization, school-based social media literacy program evaluation	Participants 12–14 years	Australian secondary school grades 7–8 received a four-lesson social media literacy program. Participants were assessed at baseline, five weeks, six months, and 12 months later.	The study highlighted the negative impacts of social media on youths and outlines a novel approach using a school-based social media literacy program to mitigate these impacts.	content, n -l. atic
Olive et al. (2019) [56]	A longitudinal cluster-randomized controlled trial was used	N = 821 Participants 7–12 years	The PE intervention was 4 years of specialized instruction. As a physical education program, the intervention's frequency and dose were not specified.	The specialist-taught PE intervention initially decreased body dissatisfaction and depressive symptoms in children, but these effects were not sustained over the 4-year study period. Additionally, there was evidence of an overall increase in depressive symptoms over the 4 years for girls only.	for s. loping earn. cation ames
Barkin et al. (2018) [57]	A randomized clinical trial with a parallel design and a controlled intervention and control group was conducted	N = 610 Participants 3–5 years	The intervention included a 36-month, family-based, community-centered program, with 12 weekly skills-building sessions, monthly coaching telephone calls for 9 months, and a 24-month sustainability phase providing cues to action.	The 36-month multicomponent behavioral intervention did not change BMI trajectory in underserved preschoolers in Nashville, Tennessee, compared to a control program. Intervention group children consumed fewer calories than control group children. Intervention parents took their kids to more community centers than control parents.	J.-P.; ary ero- f Diet, ew and e us
Bansal et al. (2021) [58]	Randomized, controlled, prospective, non-	N = 537 Participants 10–12 years	Each intervention group child received four monthly online one-on-one sessions from five standardized	The pre-adolescents in the intervention group experienced weight loss, had reduced	nts with e control

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Author (Year)	Type of Study	Sample	Instrument	Conclusions	
	blinded, single-site, observational		instructors for four months. To reduce screen time and promote self-care, the intervention targeted overweight and obese 10–12-year-old Indian pre-adolescents.	screen time and significant weight and obesity reductions in, and improved diet control.	the geria.
Viggiano et al. (2018) [59]	Randomized controlled trial, pilot study	N = 1313 Participants 7–14 years	The intervention was playing Kaledo over 20 sessions.	Kaledo helped primary school students (7–11 years old) learn about nutrition and change their diets. At 8 months, the treated group had a lower BMI z-score, were participating in more exercise, and a better diet.	ation of Eating on Tools t. J. voort, BMC
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