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REVIEW ARTICLE

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The effectiveness of exercise programs accessible from home on children's and adolescents' emotional well-being: Systematic review & meta-analysis

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Abstract

Background: The current systematic review and meta-analysis aimed to explore the evidence base to date for exercise interventions/interventions that aim to increase physical activity using a modality that can be accessed from home (i.e., online or video-based programs), and its effects on anxiety and depression in children and adolescents.

Methods: A broad search was conducted using six databases (PubMed, Web of Science, CINAHL, PsychINFO, ERIC and Scopus) on February 23, 2022. Studies with children or adolescents between the ages 5 and 18 years were included. Of the 2527 records that were identified, nine studies met the full-inclusion criteria. Their quality was assessed by two independent researchers using the Cochrane risk-of-bias tool for randomized trials (RoB 2) and Quality Assessment Tool for Before-After (Pre-Post) Studies with No Control Group. Meta analyses were conducted for studies that specifically assessed anxiety and depression.

Results: The overall results indicated that there is some evidence suggesting the positive effects of exercise interventions delivered online in reducing children's and adolescents' anxiety ($d = -0.99$, 95% confidence interval [CI]: −1.12 to −0.86). Meanwhile, there seems to be insufficient evidence for its efficacy in reducing low mood ($d = -0.42$; 95% CI: −0.84 to 0.01). Motivational and coaching based interventions to increase levels of physical activity may be limited in their efficacy, whilst having children exercise along with a video or live sessions online appears promising.

Conclusion: The current preliminary review revealed potential benefits of at-home interventions that had children and adolescents exercise along with a video in improving anxiety.

KEYWORDS

adolescent, child, exercise, internet-based intervention, psychological well-being, review

INTRODUCTION

Emotional well-being as defined by the National Center for Emotional Wellness is "understanding and acceptance of our feelings and our ability to manage effectively through challenges and change." Effectively managing stress, low mood and anxiety is critical in maintaining emotional well-being. Frequent sports participation and its association with positive emotional well-being has long been reported.[1] A large-scale cross-sectional study on adolescents further indicated that frequent physical activity and sports participation both independently contribute to greater well-being.[2] More recent interventional studies further support that exercise improves emotional well-being for children and adolescents.[3,4] A recent systematic review on children and adolescents further revealed positive effects of exercise on depression, although the effects were small to medium.[5] Meanwhile, there have been consistent reports of increased screen time, sedentary behavior and their relationship to poorer mental health in children and adolescents.[6]

Researchers have reported that children and adolescents who did not exercise at all were twice as likely to present with psychological problems, such as anxiety and depression.[7] Furthermore, physical exercise has been found to play a protective role in adolescents developing depression and anxiety.[8,9] Whilst there are many cross-sectional studies portraying the associations between physical exercise/activity and emotional well-being in children and adolescents,[10] there seems to be very little interventional research that has been conducted to promote exercise, particularly at home.

Many of the previous studies that report the effectiveness of physical exercise in improving psychological health in children and adolescents are conducted in large-scale studies at schools[11,12] or community centers[13] and there are limited reports of how exercise or physical activity levels can be increased at home. In fact, programs that are delivered online or using a modality to increase physical activity at home appear to be scarce. Therefore, the aim of the current review and meta-analysis is to establish the evidence base for exercise programs that can be implemented at home through online or remotely assisted programs, and their efficacy in improving children and adolescents' emotional well-being. A systematic review was conducted to ensure that the methodology was replicable and to minimize any selection biases during the search process.

METHODS

Search strategy

A comprehensive search was conducted using six databases (PubMed, Web of Science, CINAHL, PsychINFO, ERIC, and Scopus) on February 23, 2022 by two independent researchers. The search strategy (see Figure 1) was as follows: an initial search conducted with exercise-related terms; a second search conducted with mode of delivery of the program that allows for its access from the home environment; a third search conducted with intervention-related terms; a fourth search was conducted with emotional-well-being-related terms; and a fifth search conducted with children/adolescent-related terms. Subsequently, a combined "AND" search was conducted with the five initial searches, extracting papers that were included in all five searches. The abstracts were read for articles where the title indicated they might have examined the efficacy of an exercise intervention that could be accessed from the home

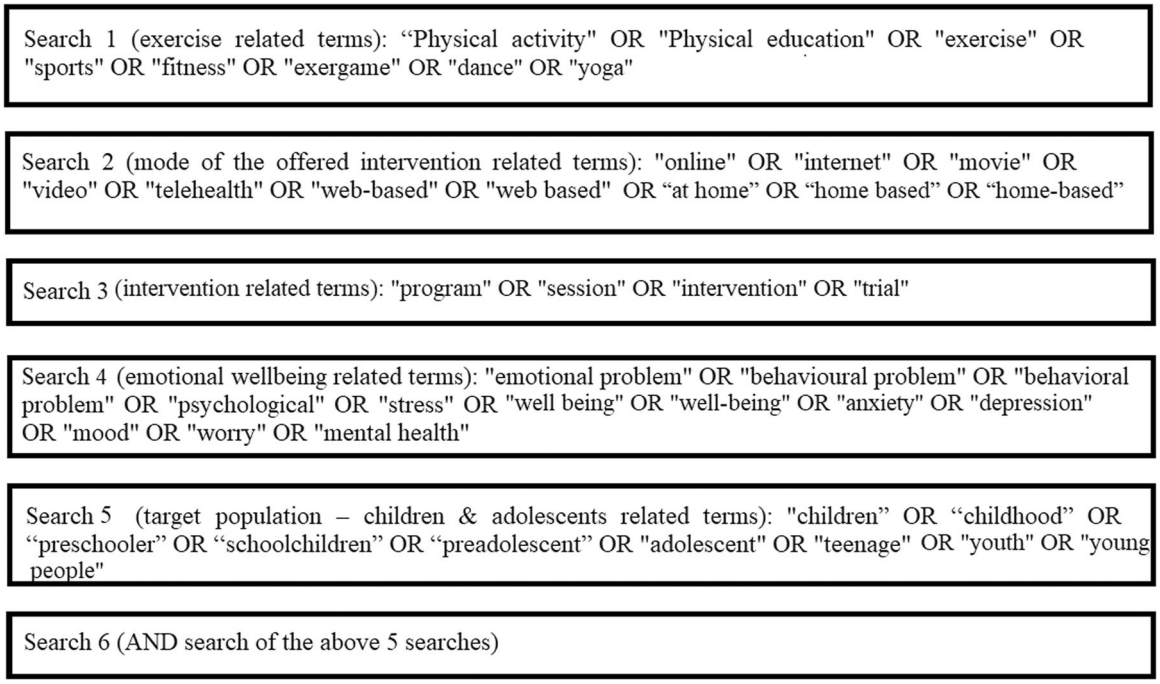

FIGURE 1 Search terms & strategy.

environment, and its effect in improving emotional well-being in children and adolescents. The entire article was retrieved and read if the abstract indicated the article potentially met the inclusion criteria. The protocol was registered with the Database for Prospective Register of Systematic Reviews PROSPERO (No. CRD42022301089).

Inclusion and exclusion criteria

Studies that investigated the direct effects of exercise intervention or interventions that increased physical activity through a modality that could be accessed from the home environment were included for the review. Inclusion criteria were as follows: (1) Participants included children or adolescents between the ages of 5 and 18 years. (2) Intervention characteristics included exercise or other programs that aimed to increase physical activity. (3) Intervention programs were provided via online or other programs accessible from the home environment. (4) Outcomes included at least one measure of emotional well-being of the child, such as stress, anxiety, or low mood levels.

Studies were excluded when they met the following criteria: (1) Programs that did not involve exercise/increased physical activity during their intervention. (2) Studies that only looked at exercise-related psychological variables (e.g., motivation, self-efficacy) or specific psychological variables related to game playing (e.g., enjoyment of games). (3) Studies that involved college students or adults that only had participants over 17 years old. (4) Studies that only published protocols but not the results. (5) Studies that are not written in English.

Data extraction

The titles and abstracts of the retrieved papers were screened and those that did not meet the eligibility criteria were excluded. Full text articles were further reviewed and the remaining records were screened according to the eligibility criteria.

The following data were extracted from the selected articles by two independent researchers: (1) year of publication, (2) number of participants (in control and intervention groups), (3) age of participants, (4) details of the control condition and the interventions, (5) duration of the intervention and the follow-up period (if applicable), and (6) psychological measures used and the main findings. Any disagreements in the extracted information were settled by consensus.

Risk of bias and quality assessment

A revised Cochrane risk-of-bias tool for randomized trials (RoB 2) was used to assess the risk of bias of the controlled trials that met eligibility criteria. RoB 2 assesses five domains of risk of bias, which can be classified into three risk categories: low risk, some concerns, and high concerns. The five domains include the following: randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. A study is considered to be low risk of bias when the risk of bias for all five domains are considered low. For each study, two independent researchers assessed the risk of bias and where discrepancy was observed, consensus was reached by discussion. If a study was deemed to have an overall "high risk of bias," it was excluded from the meta-analysis. For pre-post studies that did not have a control group, the quality of the studies was assessed using the National Heart Lung and Blood Institute[14] Quality Assessment Tool for before-after (pre-post) studies with no control group.

Statistical analyses

One study[15] was excluded from the meta-analysis due to its risk of bias being "high." The effect sizes of each of the four remaining studies with a control group was calculated, using the pre-post mean differences standardized by the post-intervention standardized deviation. The standardized deviations were extracted from each of the papers, and where it was not reported, it was calculated using standard errors or confidence intervals provided. A meta-analysis was conducted for the two anxiety-related measures that were used in two studies[16,17] and the two depression-related measures used in two studies.[18,19] As a sensitivity analysis, a meta-analysis with all four identified studies was also conducted. Forest plots were created and I^2 statistics were used to assess heterogeneity for the meta-analysis. Due to the small number of studies included in each of the analyses, a fixed-effects model was used. All statistical analyses were conducted using SPSS Version 28.

RESULTS

Study selection

The initial search produced 3801 studies. After removing duplicates, 2527 remained. Following a careful screening of the title and the abstracts, the full paper was reviewed for 57 studies. In the end, nine studies with information of 1293 participants were selected for the purpose of the current review (see Figure 2). Characteristics of each of the nine studies included are summarized in Table 1.

Participants

In the nine identified studies, the mean age of the participants varied from 10.52 to 15.5 years and the male-to-female ratio of the study participants varied, from 19.4%[23] to 91%[20] female.

Two of the nine identified studies targeted children/adolescents with comorbid conditions of juvenile dermatomyositis[20] and attention deficit/hyperactivity disorder.[22] A further three studies involved participants who were overweight (BMI > 85th percentile)[18,19,21] and another involved survivors of childhood leukemia.[19]

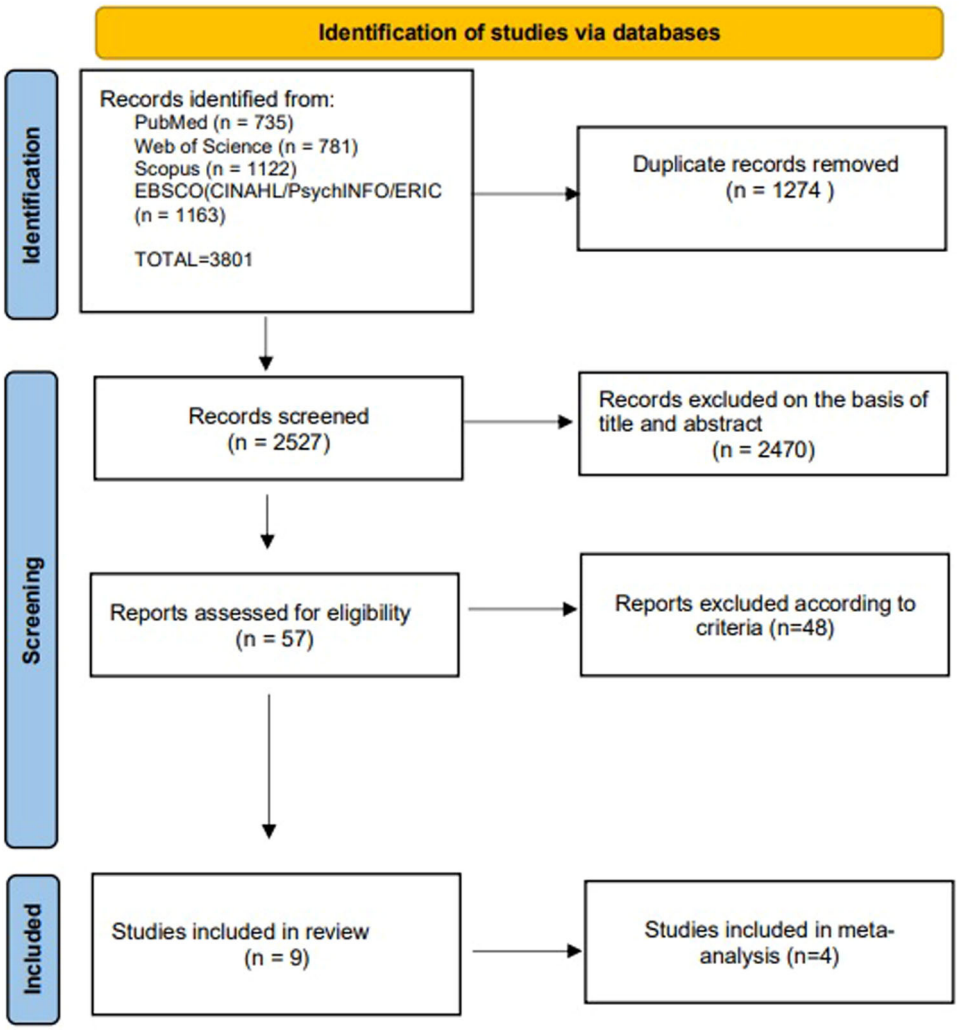

FIGURE 2 Study selection process PRISMA flow chart.

Study designs and characteristics

Five of the nine identified articles involved live online exercise programs or pre-recorded videos that were accessible online or through apps.[15–17,20,23] Four of these were conducted during home schooling or lockdowns due to the COVID-19 pandemic, whilst the study by Wong et al.[23] aimed to increase physical activity in children and adolescents using a mobile app, pre-pandemic. Three of the nine identified articles were weight-loss programs for obese or overweight individuals where participants were provided information regarding the importance and benefits of physical activity, and information to boost their motivation to increase their general physical activity levels. A mobile app[21] or a Fitbit linked to an app[22] were used to record participants' physical activity and weight whilst other studies involved participants receiving reminders to access these materials via frequent text messages[18,19] (See Table 1 for details of each intervention).

Depressive or low mood symptoms were assessed in three of the nine reviewed articles using the children's depression inventory (CDI),[24] the center for epidemiologic studies depression scale short form questionnaire (CES-D),[25] or the Positive and Negative Affect Schedule for Children (PANAS-C).[26] Three studies utilized anxiety measures: Chinese version of the Spence Children's Anxiety Scale (SCAS)[27] as well as measures with subscales that assessed anxiety (Exam Anxiety Inventory and Anxiety subscale of the Study Approach questionnaire). The remaining studies used the Strengths and Difficulties Questionnaire (SDQ)[28] as well as the Emotional Functioning subscale of the Pediatric Quality of Life Inventory (PedsQoL).[29] Three of the included studies were conducted in the USA,[18,19,22] three were in Asia,[17,21,23] one in Europe,[16] and the others were from Brazil[20] and Turkey.[15]

Study quality/risk of bias assessment

Amongst the nine studies included in the current review, the overall risk of bias was assessed for all five studies that had a control group. Three of the five studies were concluded to be at low risk of biases.[17–19] One study was deemed to have some concerns particularly in the domains of randomization process and measurement of the outcome.[16] One was

TABLE 1 Details of studies included in the review

Author	Title	Year	*n* (female %; comorbid conditions)	Age range (mean age)	Interventions (content)	Duration of the intervention	Psychological measures used & main findings
Astley, C., Sieczkowska, S.M., Marques, I.G., Ihara, B.P., Lindoso, L., Lavorato, S.S.M., Campos, L.M.A., Pereira, R.M.R., Elias, A.M., Aikawa, N.E., Kozu, K., Iraha, A.Y., Franco, T.C., Roschel, H., Queiroz, L.B., Polanczyk, G.V., Silva, C.A., Gualano, B.[20]	Home-based exercise program for adolescents with juvenile dermatomyositis quarantined during COVID-19 pandemic: a mixed methods study	2021	11 (91%; Juvenile dermatomyositis)	10–19 years old (Mean = 13.5)	3-times-a-week, aerobic and strengthening (bodyweight) training program. (1 supervised online session via WhatsApp® or Google Meets®/week, 2 unsupervised session/week). Patients instructed to provide feedback to the trainer immediately after completion of the training session. Progression occurred every 4 weeks by increasing the number of sets (3–4), repetitions (10–15) and/or duration (30–45 s).	12 weeks	Strengths and Difficulties Questionnaire (SDQ), Pediatric Quality of Life Inventory (PedsQOL) Emotional Functioning subscale **No significant effects found.**
Chew, C.S.E., Davis, C., Lim, J.K.E., Lim, C.M.M., Tan, Y.Z.H., Oh, J.Y., Rajasegaran, K., Chia, Y.H.M., Finkelstein, E.A.[21]	Use of a mobile lifestyle intervention app as an early intervention for adolescents with obesity: Single-cohort study	2021	40 (42%; overweight and obese)	10–16 years old (Mean = 13.8)	Mobile app for self-monitoring of eating, physical activity behaviors, and weight and individualized coaching sessions (15 min/weekly) by coaches. Feedback provided via push notifications, text messages, and emails. Monitoring daily physical activity levels and 60 min moderate-to-vigorous physical activity (MVPA) each day was recommended. Participants' self-report of weight, physical activity, and dietary behaviors were monitored by coaches and individualized feedback. Email with a copy of the session summary and a tailored plan for the coming week was provided.	12 weeks, & 6 month follow up	The Pediatric Quality of Life Inventory (PedsQoL; UK version 4) Emotional Functioning subscale. **No significant benefits post-intervention but just reached significant at the 6-month follow-up.**
Huang, J.S., Dillon, L., Terrones, L., Schubert, L., Roberts, W., Finklestein, J., Swartz, M.C., Norman, G.J., Patrick, K.[19]	Fit4Life: A weight loss intervention for children who have survived childhood leukemia	2014	38 (60.5%; Fit4life = 19, control=19; BMI ≥ 85th percentile)	8-18 years old (Mean age = 13)	Fit4Life (4-month web-and-text and phone counseling-based weight management program) versus control (receiving monthly printed information and fortnightly calls)	4 months	Children's Depression Inventory (CDI) **Intervention group reported improved negative mood ($p = 0.02$) but not anhedonia ($p = 0.28$)**

(Continues)

TABLE 1 (Continued)

Author	Title	Year	*n* (female %; comorbid conditions)	Age range (mean age)	Interventions (content)	Duration of the intervention	Psychological measures used & main findings
Latino, F; Fischetti, F; Cataldi, S; Monacis, D; Colella, D[16]	The Impact of an 8-Weeks At-Home Physical Activity Plan on Academic Achievement at the Time of COVID-19 Lock-Down in Italian School	2021	30 (40%; intervention = 15, control = 15)	14-15 (Mean = 14.53)	At-home workout program (60 min, twice/week) of bodyweight and cardiovascular moderate intensity exercises, (10-min warm up, 40-min sequence of movements involving rotation, abduction, and extension of body parts, followed by brief full-body cool-down exercises (10 min). Control group received only a regular program of theoretical lessons.	8 weeks	Study Approach Questionnaire (QAS)-subscale Anxiety Significant **"Time x Group' interaction Anxiety (F1,28 = 67.27, $p < 0.001$, η 2 $p = 0.70$, large effect size). Experimental group showed a significant decrease in Anxiety score ($t = -8.14$, $p < 0.001$, $d = 2.10$, large effect size).**
Patrick, K., Norman, G.J., Davila, E.P., Calfas, K.J., Raab, F., Gottschalk, M., Sallis, J.F., Godbole, S., Covin, J.R.[18]	Outcomes of a 12-month technology-based intervention to promote weight loss in adolescents at risk for type 2 diabetes	2013	101 (37 boys, 64 girls; Website only = 26, Website & group sessions= 26, Website & SMS = 24, Usual Care =25; BMI≥85th percentile)	12–16 years old (Mean = 14.3)	Web-based program focused on education about behavioral goals and promoting use of evidence-based behavior change strategies. Website only (W; monthly mailed tip sheets, access to the program website and its tutorials and weekly check-in emails), website and group sessions (WG; additional weekly calls and monthly 90 min group sessions), website and SMS (WSMS; additional bimonthly phone calls from a health counselor), and usual care (control, UC; printed materials, mailed monthly tip sheets, encouraged to attend three 1-hr group nutrition sessions during the first 6 weeks).	12 months	Center for Epidemic Studies Depression Scale Short-Form Questionnaire **Depression scores were low and remained relatively the same at 6 and 12 months, no group difference observed. Amongst girls, a negative correlation between baseline depression score and RCS of physical activity was found, adjusting for age**

TABLE 1 (Continued)

Author	Title	Year	*n* (female %; comorbid conditions)	Age range (mean age)	Interventions (content)	Duration of the intervention	Psychological measures used & main findings
Schoenfelder, E., Moreno, M., Wilner, M., Whitlock, K.B., Mendoza, J.A.[22]	Piloting a mobile health intervention to increase physical activity for adolescents with ADHD	2017	11 (54%; ADHD)	14–18 years old (Mean = 15.5)	Fitbit Flex in conjunction with (1) weekly personalized step count goals (2) social support through a Facebook group and (3) daily text messages about PA.	4 weeks	Positive and Negative Affect Schedule for Children (PANAS-C) **There was no significant change in mood valence.**
Secer, E; Demirel, N; Sam, CT[15]	The Effect of the Exercise Program on Attention Deficits and Exam Anxiety Levels of Students Preparing for the LGS Exam through Distance Education during Covid-19 Pandemic Process	2020	42 (52.4%; experimental = 21, control = 21)	12–15 years old (Mean = 13.62)	40 min of exercise 3 days/week. The exercises were transferred to the experimental group via online applicationad (e.g., YouTube)	6 weeks	Exam Anxiety Inventory (TAI) Significant difference in the post-pre anxiety scores for the intervention group.
Wong, R.S.M., Yu, E.Y.T., Wong, T.W.-L., Fung, C.S.C., Choi, C.S.Y., Or, C.K.L., Liu, K.S.N., Wong, C.K.H., Ip, P., Lam, C.L.K.[23]	Development and pilot evaluation of a mobile app on parent-child exercises to improve physical activity and psychosocial outcomes of Hong Kong Chinese children	2020	67 parent child dyads (19.4%)	6–15 years old (Mean = 10.52)	After viewing a coaching video in the app, users would automatically receive points, with more points being awarded to more difficult moves. Users were ranked by the total number of points earned through viewing the coaching videos. The top five frequent users' scores would be displayed anonymously in the in-app score board. In addition to gaming elements, push notifications and text messages were used to enhance user motivation for participation.	8 weeks (assessed at baseline, 1-month and 6-month follow-up).	The Chinese Child Health Questionnaire—Parent Form—50 (CHQ-PF50) and Chinese Strength and Difficulties Questionnaire (SDQ) Statistically significant decrease in SDQ Total Difficulties score ($d = -1.19$, $p = 0.005$), higher participation ranking was significantly associated with lower SDQ Total Difficulties score at 1-month follow-up ($\beta = -0.15$, $p = 0.030$)
Zheng, Y., Wang, W., Zhong, Y., Wu, F., Zhu, Z., Tham, Y.-C., Lamoureux, E., Xiao, L., Zhu, E., Liu, H., Jin, L., Liang, L., Luo, L.,	A peer-to-peer live-streaming intervention for children during COVID-19 homeschooling to promote physical activity	2021	954 (47.7%; intervention = 485, control = 469)	12–13 years old Mean age = 13.5	All subjects received online health information session: (1) Recommended 20-20-20 rule during study and viewing of on-screen content; (2) during recess (15 min for each recess;	2 weeks	Chinese version of the Spence Children's Anxiety Scale (SCAS) and SCAS for Parent (SCAS-P).

(Continues)

TABLE 1 (Continued)

Author	Title	Year	*n* (female %; comorbid conditions)	Age range (mean age)	Interventions (content)	Duration of the intervention	Psychological measures used & main findings
He, M., Morgan, I., Congdon, N., Liu, Y.[17]	and reduce anxiety and eye strain: Cluster randomized controlled trial				four times per day) received text messages prompting participation in exercise at home, eye relaxation, or to stretch for 10 min. (Students had access to at-home workout videos). All students were instructed by teachers to take exercise breaks according to government-issued recommendations. The intervention group used a peer-to-peer live-streaming app (the Recess and Exercise Advocacy Program [REAP]) in addition to the above.		Those who received peer-to-peer live-streaming intervention were associated with a significant reduction in self-reported anxiety compared to the controls ($\beta = -0.36$, 95% CI −0.63 to −0.08; $p = 0.02$)

considered to be at high risk of overall bias,[15] particularly due to the high number of participants who had dropped out or discontinued from the studies with no explanation provided. For this reason, this study was excluded from the subsequent meta-analysis.

Out of the four pre-post studies without a control group that was assessed for its quality, three were considered to be of "fair" quality[20,22,23] and one was deemed "poor"[21] (see Supporting Information: Appendix S1).

Overall findings

Exercise interventions delivered online

Five studies involved direct exercise interventions. The exercise frequency varied from twice a week,[16] three times a week[15,20] or more[17] and the duration of each of the sessions varied from 40 min[15] to an hour,[16,17] although Zheng and colleagues' study involved 15-min exercise breaks four times a day.[17] Wong and colleagues'[23] study involved free access to the 18 pre-recorded videos, each of them varying in length from 30 s to 3 min, over the 8-week intervention period. The duration of the intervention period also varied from 2 weeks[17] to 12 weeks.[20] Some of the studies were fully supervised,[16] whilst others had one of the three weekly sessions supervised[20] or not supervised at all.[15] The supervised sessions were mostly conducted in groups online,[16,20] whilst the unsupervised session usually required the participants to complete an exercise video program individually. Zheng and colleagues'[17] sessions were not directly supervised; however, the intervention group was encouraged to upload and share or live-stream their exercising videos and photos with their peers through an app. Furthermore, Wong and colleagues'[23] study involved parental supervision of the exercise, and the participating child-parent dyad was rewarded points for viewing the exercise videos.

Astley and colleagues'[20] study found no change in SDQ scores or Emotional Functioning scale in the PedsQL, whilst Wong and colleagues[23] reported significantly decreased SDQ scores in the intervention group. Furthermore, the remaining three studies that looked at anxiety-related measures all reported results favoring the intervention.

Interventions that encouraged physical activity through social support and improved motivation

Four of the identified studies incorporated self-monitoring and feedback/coaching-based interventions, aimed to increase physical activity or weight loss. Schoenfelder and colleagues[22] had their participants wear a Fitbit, which automatically uploaded the information to a linked app to provide the participants graphs of the data and personalized feedback. Patrick and colleagues[18] used a pedometer and encouraged their participants to report their steps weekly. Other studies required the participants to self-monitor their physical levels of activity and check in with a coach once a week for 15 min[21] or they received twice-daily texts, weekly online materials and telephone-based coaching for the first month

of their intervention.[19] Physical activity goals also varied. Schoenfelder and colleagues[22] set their standard activity goal as 10,000 steps/day for the first week and their subsequent goals were set as their average step count for the previous week plus 1% more steps for the following week. Huang and colleagues[19] set their physical activity goals to engage in at least 1 h of "moderate-to-vigorous" physical activity, as well as a daily 15,000-step goal, whilst Chew and colleagues[21] recommended their participants to work towards 60 min of moderate to vigorous physical activity each day.

Shoenfelder and colleagues[22] further encouraged social interaction with other participants where digital badges were earned if they met their weekly goals or interacted socially online (i.e., liking other's posts). In Patrick and colleagues'[18] study, they had four groups with different degrees of intervention. One group received weekly "check-in" emails to complete their online tutorials, the second group received three text messages a week that had weekly challenges and intervention goals, another group had monthly, 90-min in-person group sessions and a bimonthly phone session with a health counsellor, whilst the final group received usual care where they were encouraged to attend three 1-h group nutrition sessions during the first 6 weeks of the program. All three intervention groups had access to the online program and its tutorials that provided educational materials and weekly challenges based on the physical activity goals. The duration of the intervention ranged from 4 weeks[22] to 4 months.[19]

Huang and colleagues[19] reported a significant improvement in self-reported negative mood ($p = 0.02$) following their program, but levels of anhedonia ($p = 0.28$) showed no differences when compared to controls. Their results further indicated no benefit of the program over controls in increasing physical activity for all participants, although moderate to vigorous physical activity increased significantly in the intervention group for children who were 14 years or older. In contrast, Patrick and colleagues[18] found no treatment effects of their intervention in altering participants' physical activity, sedentary behavior or depressive symptoms. One study reported significant increase in the average weekly steps over the course of the intervention, however, the average mood state (positive and negative) remained the same.[22] Another study reported no significant changes in the time spent engaging in moderate to vigorous exercise and their emotional functioning immediately post-intervention, whereas they found these measures reached significance at the 6-month follow-up.[21]

Meta-analyses (anxiety & low mood)

A meta-analysis pooling data from two studies that had a control group and used measurement of anxiety ($n = 984$) showed strong effect sizes for their exercise intervention that was delivered online (see Figure 3a). Overall, up to 60 min of exercise twice a week or more had a large combined effect size ($d = -0.99$, 95%

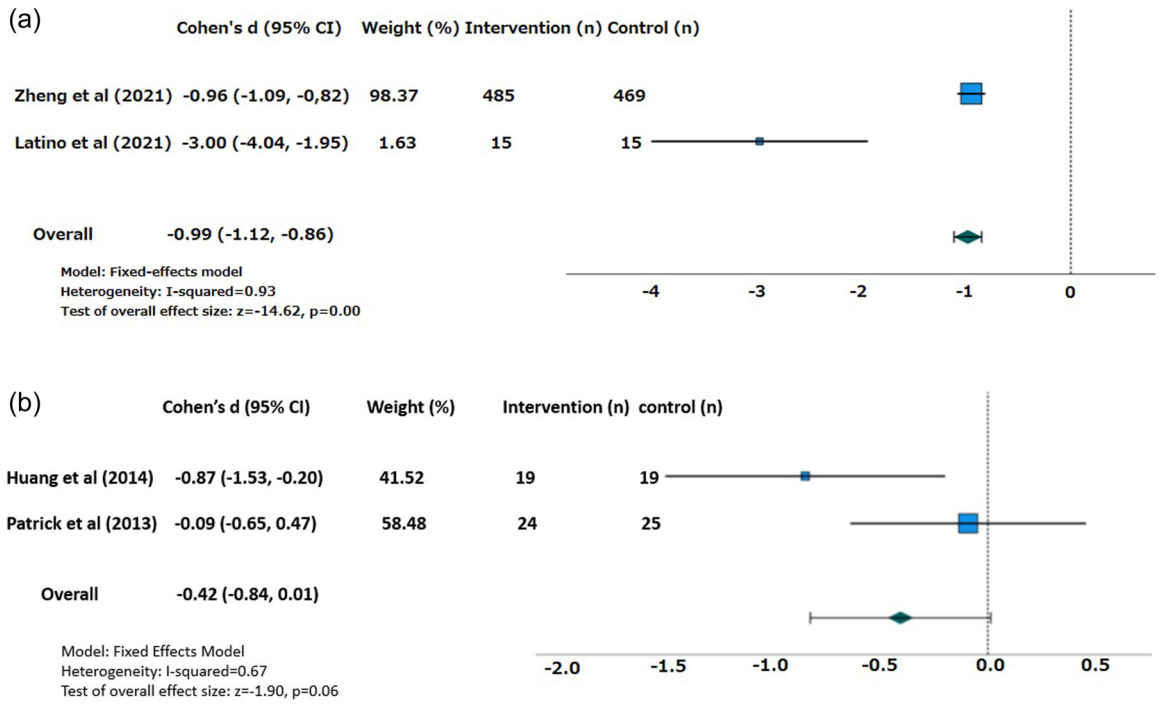

FIGURE 3 (a) Anxiety. Forrest plot showing the effects of exercise programs accessible from home on anxiety: The square box represents the effect size of each study, the diamond represents the overall effect size, the horizontal lines represent 95% confidence intervals (CI) of effect sizes, and n represents the number of participants in each group. (b) Low mood. Forrest plot showing the effects of exercise programs accessible from home on low mood: The square box represents the effect size of each study, the diamond represents the overall effect size, the horizontal lines represent 95% CIs of effect sizes, and n represents the number of participants in each group.

CI: −1.12 to −0.86) in reducing adolescents' anxiety (I^2 = 93%). Another meta-analysis was further conducted using two studies that had a control group and used a measure of depression (n = 63) (see Figure 3b). Overall, there appeared to be no significant effect of interventions that aimed to increase physical activity in reducing participating children's and adolescents' depressive symptoms (d = −0.42; 95% CI: −0.84 to 0.01, I^2 = 67%). The results from the sensitivity analysis that combined all eligible studies revealed that interventions that aimed to increase physical activity at home had a large combined effect size (d = −0.94, 95%CI: −1.07 to −0.82) in improving children's and adolescents' emotional well-being (see Supporting Information: Appendix S2).

DISCUSSION

The results from the current review and meta-analysis suggest there is some evidence that exercise interventions delivered online that can be accessed from the home environment may be beneficial in improving anxiety in children and adolescents. Meanwhile, their effects in improving low mood appear to be inconclusive. Nevertheless, this should be interpreted with much caution due to the preliminary nature of the current review. Unlike in-person exercise programs, the largest difficulty in investigating the benefits of at-home exercise or increased levels of physical activity at home is correctly assessing the levels of physical activity at home as well as ensuring compliance and completion of the exercise programs that have been set. Studies that aimed to increase physical activity and associated changes in low mood included in the current review were all self-monitoring and coaching-based interventions. However, these coaching-based interventions found no benefits of their program in increasing levels of physical activity in the first place, suggesting the difficulty in using motivational strategies to drive such behaviors in children and adolescents. In fact, Huang and colleagues[19] report that physical activity levels were higher post-intervention for their older participants (14 years or older) suggesting potential impact of age in such motivationally driven interventions. Exercise videos that can be accessed from home may be a more direct and effective way for children and adolescents to engage in physical activity.

Another interesting factor that appears to be important to the online exercise-based intervention's effectiveness was the potential "social" aspect involved in the reviewed papers. Zheng and colleagues[17] had both the intervention and the control groups have free access to exercise video and health education information but the intervention group had an additional component where the participants could live-stream their recorded exercise videos and were further encouraged to share these with other children. The study showed significant benefits of their intervention in reducing the children's anxiety levels. However, from their study, it is inconclusive if the benefits were due to the high completion rate of these exercise programs with the extra incentive to share with friends, or if the act of sharing their videos and having some social time with friends was the core component of the intervention. Previous study has reported that the benefits of vigorous physical activity in improving mental health and stress in college students were partially mediated by socialization.[30] Therefore, future research should further explore this association of frequency of exercise completion with and without the social aspect of sharing these videos and its potential benefits on children's and adolescents' emotional well-being.

The current review has a number of limitations. First, and most significantly, the sheer scarcity of its evidence base. Whilst we aimed to conduct a comprehensive search so that all papers that could potentially meet the inclusion criteria were screened, almost 95% of the searched papers did not meet the full-inclusion criteria. Therefore, the current review was able to identify very few studies that directly looked at the impact of exercise interventions that were provided online or through an app in improving emotional well-being; also, the identified papers included for the meta-analysis were highly heterogenous. Moreover, evidence for children/adolescents without any comorbid diagnosis was even more limited. These indicate the need for future large-scale, randomized controlled studies to further explore the efficacy of such exercise interventions that can be accessed from home, in improving children's/adolescents' emotional well-being.

Second, three of the four studies that utilized online technology or frequent messages to motivate participants to change their behaviors were "weight-loss" programs. Increasing physical activity was an important component of their programs but they also included providing nutrition-based information and thus were not specifically focused on increasing physical activity alone. Therefore, there is a need for more research to be conducted, exploring interventions that specifically target exercise or aim to increase physical activity at home. Setting exercise homework to be completed with parents or completing exercise videos may lead to increased physical activity in their participants at home. In fact, Wong and colleagues'[23] study, which utilized an app on the parents' phones and encouraged parents to complete the short exercise activity together with the child, reported significant improvement in the SDQ and the benefits were stronger in those who completed more activities. Therefore, future research could potentially include these components to further explore how beneficial increased physical activity at home may be in improving children's and adolescents' emotional well-being.

Lastly, and importantly, the results from the current meta-analysis must take into account the significant discrepancies in the weight of the studies included in the analysis. More specifically, Zheng and colleagues[17] had a much greater number of participants in their study, thus the meta-analysis exploring the effects of the interventions on anxiety placed over 98% of its weight to their study, hugely influencing the overall results. Therefore, more future research with a large sample investigating this association is critical to re-assess the current findings.

CONCLUSION

The current preliminary review has identified that exercise programs delivered online or through an app may have potential benefits in promoting physical activity, which may further contribute to improving anxiety levels in children/adolescents. Nevertheless, due to the scarcity in the evidence reporting potential psychological benefits of children engaging in programs to increase their physical activity levels at home, caution is needed in its interpretation. As COVID-19 has shown that governments can implement strict lockdowns to prevent infection during pandemics, there is a strong need for more research to identify potential ways to increase children's/adolescents' physical activity levels and reduce sedentary behaviors at home in such times. These programs may have potential in this respect and their psychological benefits should be further explored.

AUTHOR CONTRIBUTIONS

Rio Yamaguchi: Conceptualization, Conducting Searches, Data Curation, Assessment of Quality and Risk of identified papers, Writing Manuscript. **Takuya Kawahara**: Statistical Advice. **Tokiko Kotani**: Data Curation, Assessment of Quality and Risk of identified papers. **Rina Yazawa**: Validation. **Akane Suzuki**: Investigation, Validation. **Yukiko Kano**: Supervision. **Ayaka Ishii-Takahashi**: Conceptualization, Methodology, Project Administration, Writing-Reviewing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

ETHICS APPROVAL STATEMENT

N/A (current review did not require any specific ethics approval).

PATIENT CONSENT STATEMENT

N/A.

CLINICAL TRIAL REGISTRATION

N/A.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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