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The Impact of School-Based Interventions on Adolescents' Digital Use and Mental Wellbeing: A Systematic Review and Arm-Based Random-Effects Meta-Analysis

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Abstract

Adolescents' excessive and problematic digital use and its impact on negative wellbeing outcomes are a major concern for researchers, practitioners and families. Although school-based interventions targeting adolescents' digital use and mental wellbeing may bring behavioral changes and mental wellbeing improvements, their effectiveness is insufficiently understood. This study conducted a pre-registered systematic review and meta-analysis (PROSPERO: CRD420250648902) of school-based interventions among adolescents aged 12–18. Searches across six electronic databases (October 2023; updated February 14, 2025) identified 17 eligible studies, with 11 contributing to meta-analyses, including cluster RCTs, non-randomized trials, and pre–post studies. We applied arm-based random-effects models to report changes from baseline in both digital use and mental wellbeing outcomes. Results show that school interventions are largely effective at reducing screen time relative to the control group, while evidence for problematic digital use is inconclusive. For mental wellbeing, interventions confer advantages for anxiety and depressive symptoms as well as life satisfaction and psychological difficulties, compared to the control group. Sensitivity analyses yield consistent patterns, whereas funnel tests suggest no strong publication bias. Overall, this study indicates that school-level interventions reduce screen time and improve mental wellbeing indicators, while effects on problematic use remain mixed.

Keywords School-based interventions · Digital use · Mental wellbeing · Adolescents · Systematic review · Meta-analysis

Introduction

In today's digitalized world, online social media platforms have become increasingly prevalent in adolescents' lives (Scott et al., 2024; Verduyn et al., 2022), offering a wide range of online activities (e.g., socializing, gaming, sharing content, learning activities) that can be both beneficial and harmful for youth wellbeing (Livingstone & Helsper, 2010; Ólafsson et al., 2013; Schoon et al., 2024; Van Rooij et al., 2010). While social media can foster online communication and social support (Best et al., 2014), it may also contribute to negative social comparisons, fear of missing

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out, and exposure to harmful content (Burnell et al., 2019; Fioravanti et al., 2021; Livingstone et al., 2017; McComb et al., 2023). In response, various policies and guidelines have been introduced to prevent the harmful effects of risky digital use, including recommendations to limit screen time, encourage offline activities, and implement protection software programs that restrict access to risky online content (Mac Cárthaigh, 2020; O'Neill, 2013; Oh et al., 2022). Many interventions have relied on parents as the primary agents of change (e.g., Feng et al., 2024; Lin et al., 2021), an approach shown to be effective particularly among younger children (Marsh et al., 2014; Selman & Dilworth-Bart, 2024). However, during adolescence, schools represent a crucial setting for shaping daily routines and socialization patterns, positioning them as key agents for intervention delivery (Dekkers & Luman, 2023). Previous research has demonstrated that school-based interventions can effectively improve sedentary behaviors and active lifestyles (Demetriou & Höner, 2012; Kriemler et al., 2011; Owen et al., 2017), healthy eating habits (Medeiros et al., 2022; Van Cauwenberghe et al., 2010), and mental health outcomes (Cilar et al., 2020; Paulus et al., 2016). Nevertheless, evidence remains limited regarding the effectiveness of school-based interventions in promoting healthier digital use habits among adolescents (e.g., reduced smartphone use, problematic social media use) and improving mental wellbeing outcomes (e.g., life satisfaction, anxiety, depressive symptoms). Existing reviews have also been limited by heterogeneous age groups, insufficient differentiation between types of digital use and wellbeing outcomes, and fragmented methodological approaches. To address these gaps, the present study conducts a systematic review and meta-analysis focused specifically on adolescents aged 12–18, examining the effectiveness of school-based interventions in promoting healthier digital use behaviors and improving mental wellbeing across a broad range of intervention designs.

Conceptualizing Adolescent Digital Use

Adolescent digital use has been defined and measured differently across studies. Screen time is the most common measure used by researchers, which refers to the duration of time spent using digital devices, such as the total screen time in hours per day and frequency of use, such as how often a mobile device is used in a week. Screen time can relate to either device- or context-specific use (e.g., social media use, computer use) or total combined use (Browne et al., 2021; Vandewater & Lee, 2009). Other studies investigate various forms of digital use. These forms refer to the types of activities (e.g., gaming, chatting, scrolling) or the specific contexts of online media use, such as social media platforms or educational content (Browne et al., 2021; Celik et al., 2025; Winstone et al., 2022). Subjective experiences with digital devices and media, such as problematic digital use, are also considered to be key elements of digital use behaviors (Almourad et al., 2020; Busch & McCarthy, 2021; Steele et al., 2020). The literature on problematic digital use is similarly diverse in its terminology and conceptual focus, with studies referring to constructs such as problematic internet use, social media addiction, smartphone addiction, or more broadly digital or screen addiction (Montag et al., 2021; Kuss & Griffiths, 2017; Panova & Carbonell, 2018). These constructs share the aim to capture broader difficulties related to individuals' engagement with digital technologies, such as problematic behavioral patterns (e.g., losing control over use) or the negative consequences of use (e.g., disruptions to daily functioning) (Almourad et al., 2020).

Conceptualizing Adolescent Mental Wellbeing

Mental wellbeing can be summarized as a construct indicating individuals' positive feelings and psychological functioning, as well as a lack of suffering from any negative psychological health problems (Ryan & Deci, 2001). This brief definition suggests two broader dimensions of adolescent mental wellbeing to be treated as separate but interdependent constructs: positive mental wellbeing and negative mental wellbeing. Positive mental wellbeing is defined and examined through concepts such as life satisfaction, positive affect, self-esteem, and connectedness (Bentley et al., 2019; Diener, 2000). By contrast, negative mental wellbeing is mainly understood as the severity of mental illness indicators such as symptoms of anxiety and/or depressive symptoms, psychological distress, negative affect, and poor emotion regulation (Collishaw, 2015). Each of these concepts can be measured in numerous ways, usually through age-specific self-report tools for adolescents. Related global measurements of mental wellbeing include the Strengths and Difficulties questionnaire (SDQ) (Goodman, 2001) and the Positive and Negative Affect Scale (PANAS) (Watson et al., 1988), which incorporate both positive and negative wellbeing constructs. Other measurements assess only positive mental wellbeing, like the WHO-5 wellbeing index (Black et al., 2023; Rose et al., 2017; Topp et al., 2015) or negative wellbeing, such as the Children's Depression Inventory (Kovacs, 1992), and the Screen for Child Anxiety Related Emotional Disorders scale (SCARED) (Birmaher et al., 1997).

The Relationship Between Adolescent Digital Use and Mental Wellbeing

Previous research has examined how different types of digital use link to adolescent mental wellbeing outcomes. Previous

studies have found that adolescents' digital behaviors that involve positive connectivity and educational media content can carry mental and social benefits (Haddock et al., 2022; Zhou & Cheng, 2022). However, factors associated with risk-inducing digital use (e.g., lack of safety and privacy in digital media; high exposure to cyberbullying) have been reported to have detrimental consequences for adolescents' mental wellbeing outcomes (Li et al., 2024; Livingstone et al., 2017). With regards to the intensity of screen time, studies found that heavy levels of digital use are associated with adolescents' negative mental health outcomes (e.g., Bohnert & Gracia, 2021; Gracia et al., 2023; Paulich et al., 2021; Santos et al., 2023; Twenge & Campbell, 2018), although several studies suggest that the strength of such association is rather small, context–dependent and bidirectional (Odgers & Jensen, 2020; Orben & Przybylski, 2019; Valkenburg et al., 2022). In the literature, there is more consensus that adolescents' addictive or compulsive digital media use leads to higher risks of experiencing mental health problems (Cai et al., 2023; Celik & Gracia, 2026; Kurniasanti et al., 2019; Sohn et al., 2019). However, the literature on the interventions on digital use is limited to capture whether targeting to change digital habits could also promote positive mental wellbeing and alleviate negative mental wellbeing.

The Effectiveness of School-Level Interventions on Digital Use and Wellbeing

Schools are effective contexts to change adolescents' lifestyles and behavioral outcomes through interventions (Dekkers & Luman, 2023; Lopez-Fernandez & Kuss, 2020). Theoretically, considering that adolescents' attitudes and lifestyles are particularly susceptible to peer influence (Giletta et al., 2021; Mollborn & Lawrence, 2018) and knowing that their daily life is strongly shaped by school-based routines (Oh et al., 2022; Yeun & Han, 2016), schools can be assumed to play a key role in fostering social support and changing norms about adolescent digital behavior and health-related lifestyles. From a practical perspective, the availability of school facilities and staff that are already trained in youth development could reduce the cost and increase the effectiveness of intervention programs (Greenberg & Abenavoli, 2017). Another advantage of school-based interventions, compared to community or family-based interventions, is that schools offer consistent schedules and standardized routines that greatly facilitate the study implementation.

To date, evidence on how school-level interventions targeting adolescents' digital use affect their digital habits and wellbeing outcomes is inconclusive. Previous reviews on school-level interventions in this area have primarily adopted a physical health focus. As a result, many studies operationalized "screen time" as a sedentary-behavior proxy, combined with total sedentary time within the same construct. For example, one study (McMichan et al., 2018) synthesized classroom physical-activity trials where screen time was treated as one of several indicators constituting sedentary behavior, without estimating effects separately. Another study (Rodrigo-Sanjoaquín et al., 2025) evaluated 24-h movement interventions in which screen time was included under the broader sedentary-behavior category alongside accelerometer-measured sitting and sleep outcomes, again without distinct coefficients. Likewise, one more recent study (Guo et al., 2025) pooled school-based behavior-change interventions where screen time was classified as a subdomain of sedentary behavior, but the meta-analysis was conducted at the sedentary-behavior level. While these studies are relevant to the adolescent health literature, they cannot explain how school programs or interventions could directly reshape digital use (e.g., reducing recreational screen exposure or problematic patterns) or mental wellbeing (e.g., life satisfaction, anxiety), as they did not prioritize mental-health endpoints beyond movement frameworks. This gap led scholars to call for further research on school-based treatments targeting digital use to examine their impact on adolescents' digital habits and mental wellbeing (Lopez-Fernandez & Kuss, 2020; Rodrigo-Sanjoaquín et al., 2025; Throuvala et al., 2019), a question that is not yet conclusively answered in the existing literature (Mac Cárthaigh, 2020; Oh et al., 2022).

Current Study

To date, the existing literature lacks comprehensive evidence on whether school-level interventions targeting digital use are effective tools to promote positive changes in adolescents' digital routines and online experiences, as well as in their mental wellbeing outcomes. The main goal of this systematic review and meta-analysis is to address this gap by exploring the effectiveness of school-based interventions targeting adolescents' digital use behaviors and then to examine whether these types of interventions contribute to improving adolescents' mental wellbeing outcomes. This study investigates the existing studies that utilize schools for changing adolescents' digital use behavior, such as screen time and problematic use, and focus on both positive and negative mental health outcomes. The primary research questions are: Are school-based interventions targeting adolescents' digital use effective in changing their digital use patterns? (Research Question 1a); Are school-based interventions addressing adolescents' digital use effective in improving their mental wellbeing? (Research Question 1b). As a secondary research question, this study also asks:

What mechanisms and frameworks are used in school-based interventions targeting digital use patterns and mental wellbeing? (Research Question 2).

Methods

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) and the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2024). The protocol for this systematic review and meta-analysis was registered both at the Open Science Framework (https://doi.org/10.17605/OSF.IO/CZGKX) and PROSPERO (CRD420250648902).

Search Strategy

Six electronic databases (Web of Science, PubMed, PsycINFO, CINAHL, EMBASE, and ERIC) were searched in October 2023, and a second round of database search was conducted on the 14th of February 2025. The PICO (Population, Intervention, Comparator, and Outcome) framework was used to inform the search strategy (Schardt et al., 2007). The search strategy was built around these 5 concepts and their synonyms: (1) adolescents; (2) smartphone; (3) mental health; (4) intervention; and (5) school-based. The full search strategy is reported in Table A1. All searches had English language restrictions and no publication date limit. Considering the limited number of studies conducted in this research area, articles that employed different designs, such as randomized controlled trials (RCTs), non-randomized trials, or pre- and post-intervention designs, were included.

Eligibility Criteria

The inclusion criteria comprised of: (1) studies on adolescents between the ages of 12–18 or secondary school students; (2) school-based interventions targeting adolescents' digital use and mental wellbeing, where the exposure or training program was delivered within the school settings; (3) studies that use at least one indicator of digital use (e.g., screen time, smartphone use, social media use, problematic internet use) and at least one indicator of mental wellbeing (e.g., depressive symptoms, anxiety, life satisfaction, quality of life) as outcome. The exclusion criteria comprised: (1) studies conducted in any context other than secondary schools; (2) studies that employed a cross-sectional, cohort, or any qualitative research design; (3) studies that did not directly measure any indicator of digital use or mental health; and (4) studies that only measured physical wellbeing outcomes (e.g., sedentary behaviors, obesity, sleeping problems).

Screening Process

The title/abstract of the studies yielded by the database search were imported into Covidence software (Covidence, Melbourne, Australia), which automatically removed the duplicates. Two authors (SC and GT) independently screened the titles and abstracts of the included studies. The full text of the articles that were deemed eligible for inclusion was then independently screened by two other authors (SE and PGV) in the full-text screening. Any discrepancies in any of these steps were discussed between the authors until an agreement was reached. A backwards citation was used to screen all records referenced by any relevant systematic review found during the full-text screening process. These systematic reviews were screened for the included studies to find articles that were missed by the database searches.

Data Extraction

Two authors (SC and PGV) independently extracted the data from included studies. This data included descriptive information of the studies (authors, country, year of publication), intervention characteristics (intervention design, theoretical framework, duration, data collection timepoints), sample characteristics (sample size in total and per intervention group, gender distribution, mean and standard deviation of age), and means and standard deviations for outcomes of interest. Such outcomes included mental health domains (such as anxiety and depressive symptoms), wellbeing indicators (such as life satisfaction and strengths and difficulties); and screen time indicators (such as, total time spent on screen) and attitudes on digital use (e.g., problematic social media use, addictive behaviors).

Risk of Bias Assessment and GRADE

Two extractors independently assessed the quality of the intervention studies following the Risk of Bias 2 (RoB2) for studies that used an RCT design and the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) for studies that employed a non-randomized design (Sterne et al., 2019). Next, two coders employed the GRADE approach to assess the overall quality of the evidence base (Guyatt et al., 2008), which was previously employed by other meta-analytic approaches as well (e.g., Ku et al., 2025; Ntoumanis et al., 2024). This tool assesses five domains: overall risk of bias, inconsistency, indirectness, imprecision, and publication bias. After grading each of the five domains as

either "serious" (i.e., problematic) or "non-serious" (non-problematic) (Guyatt et al., 2008), the quality of evidence was assessed starting from high quality of evidence and downgrading it by as many levels as the number of serious grades in the domains (Balshem et al., 2011). For example, if an outcome of interest had only one "serious" domain, the quality of evidence was downgraded by one, going from high to moderate. If an outcome of interest had two "serious" domains, the quality of evidence was downgraded by two, going from high to moderate, and from moderate to low. Any discrepancies in the data extraction process were discussed among the extractors.

Data Analysis Plan

Narrative Synthesis

Results from the articles that were not suitable for inclusion in the meta-analytic synthesis, such as articles that did not report enough data to extract means and standard deviations, were summarized using a narrative approach. In these types of studies, the nature of the interventions and the findings of the paper were described.

Meta-Analysis

Six different arm-based random-effects meta-analyses (synthesizing arm-level outcomes) were conducted in total, one for each of the outcomes of interest for which there were enough data, including (1) total hours per day of screen time, (2) problematic use, (3) anxiety, (4) depressive symptoms, (5) life satisfaction scores, and (6) strengths and difficulties – psychological difficulties scores.

Comparative (RCTs and non-randomized control trials) studies contributed with both arms, and single-arm studies (pre- and post-intervention without control) contributed with the intervention arm only. A treatment indicator in meta-regression estimated the intervention effect while accounting for between-study heterogeneity, evaluated using the I^2, which measures the extent to which the results of studies are consistent. Thresholds for the interpretation of I^2 followed the Cochrane Handbook for Systematic Review and Meta-Analysis recommendations: 0% to 40%, might not be important; 30% to 60%, may represent moderate heterogeneity; 50% to 90%, may represent substantial heterogeneity; 75% to 100%, considerable heterogeneity (Higgins et al., 2024).

In the meta-analyses, articles that provided data for the intervention and the control groups and articles that provided data for the intervention only were all included. Following Hopkins and Rowlands (2024)'s recommendations for standardizing differences in means in meta-analyses, the extracted data were standardized. For the meta-analyses of questionnaire scores (problematic use, anxiety, depressive symptoms, life satisfaction/flourishing, and SDQ), all the means and standard deviations were rescaled into a common scale, ranging from 0 to 100, and we calculated the mean difference (post-intervention minus pre-intervention) for the control and the intervention groups. This approach was deemed necessary to improve interpretability, considering that all the questionnaires used to collect such measures had different scale anchors (for example, scales from 0 to 40, or from 0 to 18).

For the meta-analyses regarding the screen time outcomes (hours/day), the percentage changes from baseline to post-intervention were calculated for the control and the intervention groups. Regarding the screen time measures (hours/day), considering that the normal distribution of these measures could not be assumed with the available data, a log-transformation of the percentage changes were done prior to the analyses by using the following formula: $100 \times \log[1 + (\text{mean change/baseline value})]$. Further, the standard errors of the log-transformed percentage change by log-transforming the division of the standard deviation change (Higgins et al., 2019) over the square root of the sample size were calculated. Therefore, the log-transformed percentage changes and the log-transformed standard errors for each of the outcomes of interest were meta-analyzed using the R Studio package *metafor* (Viechtbauer & Cheung, 2010), and the random-effects solutions are expressed in log-transformed percentage. Back transformations were calculated using the following formula: $100 \times \exp^{x/100} - 100$.

The magnitudes of the percentage changes in the outcomes of interest were evaluated using Cohen's *d* thresholds. These score and percentage changes were converted into equivalents of Cohen's thresholds for small ($d = 0.2$), moderate (0.5), large (0.8) magnitudes, and very large (1.2). (Cohen, 1988). Each equivalent score and percentage change threshold were calculated by multiplying the relevant Cohen's *d* threshold value by the mean of observed baseline standard deviations for each study estimate (both control and intervention groups) included in the meta-analysis (Hopkins, 2009).

Considering that different studies were included in the different meta-analyses, different thresholds resulted from the different outcomes, as the mean of the observed baseline standard deviation changed based on the included studies. The resulting thresholds for small, moderate, and large effects for each of the outcomes are reported in Table A2. Sampling uncertainty was expressed as a 95% confidence interval (CI).

The precision-of-estimate approach was adopted in this study rather than relying on the p-value as a sole way to interpret the results. This approach offers a more nuanced

interpretation of the level of evidence for substantial and trivial magnitudes using the entire range of the CI, and it is commonly used in meta-analyses of questionnaire scores (see Madigan et al., 2023). The magnitude of the effects was interpreted by evaluating the lower and upper 95% CI and the area of the sampling distribution, which are aligned with the p-values. If the 95% CI limits crossed both trivial positive and trivial negative thresholds, the sampling uncertainty for the effect was considered inconclusive; otherwise, sampling uncertainty was deemed conclusive and interpreted based on how much area of the sampling distribution fell into *positive substantial* and *trivial* magnitudes (Hopkins, 2022). Thresholds for interpreting sampling uncertainty and deciding whether an effect had weak, some, good, very good, or strong conclusive evidence are reported in Table A3.

Sensitivity Analyses and Publication Bias

To calculate the SD change from before to after the interventions, the correlation of the outcome of interest at each of the measurement points was necessary (Higgins et al., 2024). Because this data was not reported in the articles included in the analyses, we used a correlation value of 0.5. To test whether results differ depending on the selection of the correlation coefficient, sensitivity analyses using the values 0.2 and 0.8 were conducted. Further, the Egger tests for both the control and intervention arms using the standard errors as predictors were conducted to check for potential publication bias (Egger et al., 1997). This approach has been consistently employed in meta-analyses (e.g., Ku et al., 2025; Ntoumanis et al., 2024), and also used in meta-analyses utilizing the arm-based approaches (Tarantino et al., 2025). Funnel plots for publication bias, both for the intervention and control groups, were further created.

Results

Study Selection and Characteristics

The results of the search strategy are displayed in Fig. 1. The initial search yielded 1284 articles, and after the screening stages, a total of 17 studies were included in the systematic review, of which 11 provided data for the meta-analyses. Notably, there were two articles produced from the same intervention design and dataset: one article reporting the digital use outcome (O'Dean et al., 2024) and one article reporting mental wellbeing outcomes (Smout et al., 2024).

Table 1 presents the characteristics of the included studies. The majority of the articles were from Australia (Babic et al., 2016; Lubans et al., 2016; O'Dean et al., 2024; Smout et al., 2024; Wilksch et al., 2015). Two studies were conducted in South Korea (Choi et al., 2020; Kim et al., 2018) and one study was conducted in each of the following countries: Brazil (Barbosa Filho et al., 2019), China (Du et al., 2010), Finland (Aittasalo et al., 2019), Israel (Kor & Shoshani, 2023), Malaysia (Ke & Wong, 2018), Netherlands (Busch et al., 2013), Peru (Sharma et al., 2018), Switzerland (Das-Friebel et al., 2019), Thailand (Manwong et al., 2018), and Türkiye (Bağatarhan & Siyez, 2022). Six studies used specific eligibility criteria for sampling participants; three studies only included participants who indicated problematic digital use (Bağatarhan & Siyez, 2022; Du et al., 2010; Kim et al., 2018), two studies included participants with high screen time (Babic et al., 2016; Lubans et al., 2016), and one study excluded participants with any mental health problems (Manwong et al., 2018).

Most studies adopted a clustered RCT design, with an additional three studies having control groups that were not randomly assigned (Busch et al., 2013; Choi et al., 2020; Sharma et al., 2018), and two studies adopted a pre- and post-intervention design (Ke & Wong, 2018; Kim et al., 2018). The length of the studies varied greatly; the shortest studies were a month long (Das-Friebel et al., 2019; Kim et al., 2018), and the longest study spanned across three school years (Kor & Shoshani, 2023; Sharma et al., 2018).

Table 2 summarizes the types of intervention designs that were tested in the included studies. All studies had in common that they targeted digital use and at least one dimension of mental wellbeing as either their primary or secondary outcomes, but studies adopted different designs and approaches, showing an interesting diversity of interventions. Nine interventions developed training sessions or updated existing health education programmes to be delivered in schools (Aittasalo et al., 2019; Babic et al., 2016; Barbosa Filho et al., 2019; Busch et al., 2013; Kor & Shoshani, 2023; Lubans et al., 2016; Manwong et al., 2018; O'Dean et al., 2024; Sharma et al., 2018; Smout et al., 2024; Wilksch et al., 2015) and seven studies introduced group-based therapy sessions (Bağatarhan & Siyez, 2022; Choi et al., 2020; Das-Friebel et al., 2019; Du et al., 2010; Ke & Wong, 2018; Kim et al., 2018; Manwong et al., 2018; Sharma et al., 2018). Additionally, several studies included some form of parental education and/or teacher training (Babic et al., 2016; Bağatarhan & Siyez, 2022; Barbosa Filho et al., 2019; Das-Friebel et al., 2019; Du et al., 2010; Lubans et al., 2016; Sharma et al., 2018) components to the intervention designs. Two intervention designs also utilized online tools such as smartphone apps (Lubans et al., 2016; O'Dean et al., 2024; Smout et al., 2024) and e-messages (Babic et al., 2016). The most common theoretical frameworks across the studies were the Cognitive-behavioral approach (Bağatarhan & Siyez, 2022; Du et al., 2010; Ke

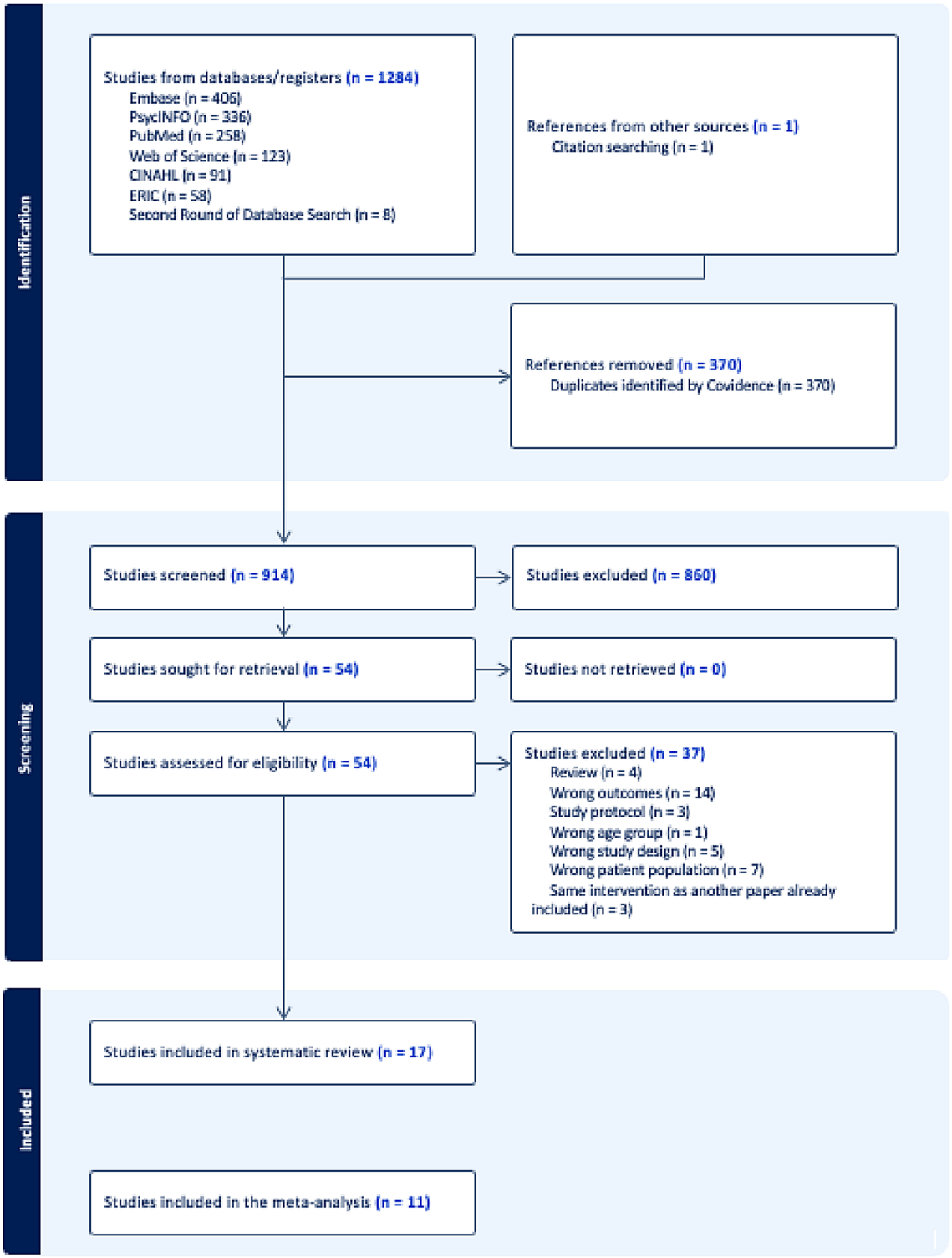


Fig. 1 Prisma Flow Diagram

Table 1 Characteristics of the Studies Included

Authors, year	Country	Design	*N*	Gender, n (%)	Mean age, years (SD)	Inclusion criteria
Aittasalo et al., 2019	Finland	Multimodal cluster RCT	1550	705F, 845 M	13.9 (0.5)	All eighth graders from participating secondary schools
Babic et al., 2016	Australia	Cluster RCT	322	211F, 111 M	14.4 (0.6)	Students who reported more than 2 h a day of screen-time
Bağatarhan & Siyez, 2022	Turkiye	Multimodal cluster RCT	52	Not reported	15–16, no more information is given	Students at risk of internet addiction according to the Internet Addiction Scale
Barbosa Filho et al., 2019	Brasil	Cluster RCT	1085	526F, 559 M	Ages 11–13: 574, Ages 14–18: 511	All students from participating secondary schools
Busch et al., 2013	Netherlands	Pre-post with control group	356	183 F, 173 M	16, no more information is given	All students from participating schools
Choi et al., 2020	South Korea	Case–control study	49	41F, 8 M	16, no more information is given	All sophomore students from participating schools
Das-Friebel et al., 2019	Switzerland	Cluster RCT	352	163F, 189 M	15.09 (1.65)	All students from participating secondary schools
Du et al., 2010	China	Cluster RCT	56	11F, 45 M	15.39 (1.69) Intervention 16.63 (1.23) Control	Students who meet Beard's diagnostic criteria for Internet addiction
Ke & Wong, 2018	Malaysia	Pre-post without control group	45	16F, 29 M	15.69 (1.08)	Voluntary sampling, priority given to students with problematic internet use levels
Kim et al., 2018	South Korea	Pre-post without control group	17	10F, 7 M	12–17, no more information is given	Students who met Young's diagnostic criteria for problematic internet use
Kor & Shoshani, 2023	Israel	Cluster RCT	1670	809F, 861 M	12.96 (2.01)	All students from participating secondary schools
Lubans et al., 2016	Australia	Cluster RCT	361	361 M, all boys	12.7 (0.5)	All students from participating secondary schools
Manwong et al., 2018	Thailand	Cluster RCT	245	129F, 116 M	13.30 (0.68)	All students from participating secondary schools except those with any diseases or physical or mental health problems
O'Dean et al., 2024 and Smout et al., 2024	Australia	Cluster RCT	6639	3280F, 3359 M	12.7 (0.50)	All students from participating secondary schools who spoke English fluently
Sharma et al., 2018	Peru	Pre-post with control group	Pre: 587 Post: 1532	Pre: 310F, 277 M Post: 895F, 623 M	Ages 11–14: 661, Ages 15–20: 592 Not reported: 12	All students from participating secondary schools
Wilksch et al., 2015	Australia	Cluster RCT	1316	840F, 476 M	13.21 (0.68)	All students from participating secondary schools

RCT: Randomized controlled trial

& Wong, 2018; Kim et al., 2018), Self-determination theory (Babic et al., 2016; Lubans et al., 2016; O'Dean et al., 2024; Smout et al., 2024), and positive psychology (Ke & Wong, 2018; Kor & Shoshani, 2023).

Narrative Synthesis of the Studies Excluded from the Meta-Analysis

Six studies were excluded from the meta-analysis because they did not report adequate data to be meta-analyzed. Three of them investigated a multi-component health education program that targets multiple factors of youth wellbeing. Busch et al. (2013) conducted a pilot study for their health education program and compared the intervention group to a sample of another cohort from the same participating school. Even though pilot studies do not test efficacy, the results, reported as the median scores within each group, showed that the intervention group had higher mental well-being compared to the control cohort, and boys in the intervention group had lower computer screen time compared to the control cohort. Sharma et al. (2018) implemented a pre-post intervention design with a non-random control group to assess the effectiveness of a school-wide health program, which also involved health check-ups, psychological counselling to at-risk students, and parent and teacher trainings. They found that students in the intervention schools had

Table 2 Intervention Characteristics of the Included Studies

Authors, year	Intervention Characteristics			Digital Use		Mental Health	
	Content	Framework	Duration	Variables	Type of measure	Variables	Type of measure
Aittasalo et al., 2019	Behavioral theory-driven content during three health education lessons	Health Action Process Approach	4 weeks	Excessive screen time	Time (days)	Confidence in reducing screen time	Categorical levels
Babic et al., 2016	eHealth messaging (main), interactive seminar, a behavioral contract and parental newsletters	Self-determination theory	6 months	ASAQ	Time (minutes/day)	SDQ—Difficulties subscale; KPDS; Flourishing Scale	mean score
Bağatarhan & Siyez, 2022	Cognitive-behavioral prevention program for participants. Psycho-education program for parents (group 1 only)	CBT	8 sessions	YIAT	mean score	OCS	mean score
Barbosa Filho et al., 2019	Health education for students and families and teacher training	Socio-cognitive theory; Socio-ecological theory	5 months	Screen time (TV and computer use/gaming)	Time (<2 h a day)	NA, despite being mentioned in research methods publication	NA, idem
Busch et al., 2013	Health school policy and health education	Health promoting school approach	3 years	CIUS; Screen time: TV, computer, gaming	CIUS: mean score; ST: Time (hrs)	SDQ	mean score
Choi et al., 2020	20 min long meditation program sessions in the morning, two times a week	Mind subtraction meditation	12 weeks	Korean Smartphone Addiction Proneness Scale	mean score	Stress scale; Stress Coping (emotion focusing subscale)	mean score
Das-Friebel et al., 2019	25 min psychoeducative school-based intervention, parent information	NA	4 weeks	Bedtime electronic media use	frequency	General Depression Scale; SDQ—Hyperactivity/ Attention subscale	GDS: Frequency; SDQ: mean score
Du et al., 2010	School-based group CBT, psychoeducation for teachers, and parent training	CBT	8 sessions	Internet Overuse Self-Rating Scale	mean score	SDQ; Screen for Child Anxiety Related Emotional Disorders	mean score
Ke & Wong, 2018	Weekly CBT in a group format by registered school counsellors	Positive psychology; CBT	8 weeks	PIUQ	mean score	SIAS DASS	mean score
Kim et al., 2018	Group CBT, 2 sessions per week	CBT	1 month	IAS	mean score	CDI STAI	mean score
Kor & Shoshani, 2023	Training in self-awareness, addiction resistance, problem solving, emotion regulation, etc. Delivered by trained teachers	Positive psychology; addiction prevention	2 years	Screen Time Scale: Daily screen use	Time (hrs /day)	GSI; Brief Multidimensional Students' Life Satisfaction Scale; PANAS-C	mean score
Lubans et al., 2016	Professional development for teachers, sport sessions, seminars, a smartphone app, and parental strategies for reducing screen time	Self-Determination Theory	20 weeks	Recreational screen time	Time (minutes/day)	Flourishing Scale	mean score
Manwong et al., 2018	Group activity-based motivational enhancement therapy and health education	Group-based motivational enhancement therapy	8 weeks	Average duration of social media usage; SMAT	Time (hrs /day); mean score	Center for Epidemiologic Studies-Depression Scale; SDQ	mean score

Table 2 (continued)

Authors, year	Intervention Characteristics			Digital Use		Mental Health	
	Content	Framework	Duration	Variables	Type of measure	Variables	Type of measure
O'Dean et al., 2024 and Smout et al., 2024	6 health education online modules, internet-based feedback, optional teacher-facilitated activities and smartphone app	Self-Determination Theory; Social cognition and Social influence	approx. 6 weeks	Screen Time: TV, device use	Time (hrs /day)	Patient Health Questionnaire; PROMIS Anxiety Pediatric; KPDS	mean score
Sharma et al., 2018	Health education, check-ups, a canteen, counselling for high-risk students, mini-gyms, teacher training, parent workshops	NA	18 months	Sedentary behaviors (TV, gaming, Internet)	Time (>2 h a day)	Psychological Distress	mean score
Wilksch et al., 2015	Two lessons per week. Three programs: Media Smart; Life Smart; Helping, Encouraging, Listening and Protecting Peers	NA	4 weeks	Screen Time (TV, DVD, Internet, computer, console)	Time (hrs /day); mean score	Child Depression Inventory – Short Form	Frequency

Only variables of our interests are reported for brevity. CBT: Cognitive-behavioral therapy. NA: not reported in the article

ASAQ: Adolescent Sedentary Activity Questionnaire. CIUS: Compulsive Internet Use Scale. IAS: Internet Addiction Scale. PIUQ: Problematic Internet Use Questionnaire. S-MAT: Social Media Addiction Test. YIAT: Young Internet Addiction Test

CDI: Children's Depression Inventory. DASS: Depression Anxiety Stress Scale. GSI: Global Severity Index. KPDS: Kessler Psychological Distress Scale. OCS: Online Cognition Scale. SDQ: Strengths and Difficulties Questionnaire. SIAS: Social Interaction Anxiety Scale. STAI: State-Trait Anxiety Inventory. PANAS-C: Positive and Negative Affect Scale-Children

stable screen time and reduced depressive symptoms at post-measurement, and students in the control schools had increased screen time and stable depressive symptoms at post-measurement. Barbosa Filho et al. (2019) used a socio-cognitive and socioecological approach and tested their health education program in socioeconomically disadvantaged youth in Brazil. They observed a decrease in screen time in the intervention group, but this was not significantly different, compared to the control group. This study did not report on mental wellbeing outcomes, although the variables were reported to be measured in their research methodology publication (Barbosa Filho et al., 2019).

The other three studies had a narrower focus on targeting various health predictors. Wilksch et al. (2015) investigated the effectiveness of three versions of a four-week-long educational program mainly targeting early adolescents' eating disorders and obesity risk factors, including screen time and depressive symptoms. None of the intervention groups reported a significant decrease in screen time or depressive symptoms compared to the control group, with the exception that the boys in the intervention group that targets media internalization, perceived pressure to be thin/muscular, and weight concern had significantly lower depressive scores at the 12-month follow-up measurement point compared to the control group. Das-Friebel et al. (2019) conducted a pilot clustered RCT to examine the effects of a psycho-educative seminar on sleep quality predictors, including electronic media use before sleep, and depressive symptoms. Their results showed a significant decrease in electronic media use in the intervention group compared to the control group. However, they did not find a significant reduction in depressive symptoms. Finally, Aittasalo et al. (2019) used a health action process approach and developed three education lessons involving behavioral theory-driven content that aims to reduce sedentary behaviors, including screen time. The lessons were delivered by the previously trained teachers. The intervention did not change the average screen time between the intervention and control groups. The secondary outcomes were the psychosocial indicators, including intent and confidence in reducing screen time, which were also not significantly changed across the intervention and control groups.

Risk of Bias

Figures A1 and A2 show the results of the RoB2 assessment for the studies included in the meta-analyses. The majority of the studies had some concerns due to potential bias arising from the randomization process (Aittasalo et al., 2019; Babic et al., 2016; Das-Friebel et al., 2019; Lubans et al., 2016; Manwong et al., 2018; Wilksch et al., 2015), and one study had a high risk of bias in the randomization process due to assigning participants across the two intervention conditions based on parental consent (Bağatarhan & Siyez, 2022). One study had a high risk of bias due to the selection of the reported results (Barbosa Filho et al., 2019), as they omitted mental wellbeing indicators that were reported in

their methodology article from their study. The remaining studies yielded a low risk of bias.

Figures A3 and A4 report the results of the ROBINS-I assessments for the studies included in the meta-analyses. Three studies had moderate risk of bias; two studies had no information on the bias due to deviations from the intended interventions domain (Busch et al., 2013; Choi et al., 2020), and one had moderate risk on the bias due to selection of participants domain (Sharma et al., 2018) because they did not differentiate students who did or did not have data on the pre- and post- assessments. The remaining studies yielded a low risk of bias.

Meta-Analysis

Screen Time (Hours/Day)

Five studies reported data for screen time (Babic et al., 2016; Kor & Shoshani, 2023; Lubans et al., 2016; Manwong et al., 2018; O'Dean et al., 2024), resulting in 10 estimates. There was strong conclusive evidence against the intervention effect for the control groups (Δ=9.1%; 95% CI: 2.6% to 15.5%; p=0.006), which reported an average increment of screen time of 8.7% hours/day after the intervention (this value is logarithm back-transformed). There was weak conclusive evidence for the intervention effect for the intervention groups (Δ=-3.7%; 95% CI: –10.0% to 2.7%; p=0.259), which indicated an average decrease of screen time of 3.6% hours/day after the intervention (this value is logarithm back-transformed). The difference between the groups at post-intervention indicated strong conclusive evidence for the intervention effect, with a logarithm back-transformed difference in screen time of 12% (Δ=-12.7%; 95% CI: –16.2% to -9.3%; $p<0.001$), as presented in Table A4 and Fig. 2. Heterogeneity was moderate ($I^2=40.4\%$).

Problematic Digital Use

Five studies reported data for problematic digital use (Internet, smartphones, and social media) (Choi et al., 2020; Du et al., 2010; Ke & Wong, 2018; Kim et al., 2018; Manwong et al., 2018), resulting in eight estimates. Although these studies use scales for measuring different aspects of problematic digital use, the analyzed measurements are comparable in the ways they assess the problematic nature of adolescents' digital use since the questionnaires include a broader range of indicators of problematic digital use, such as *withdrawal*, *obsession/loss of control*, or *negative impact on life.* There was inconclusive evidence for changes for both the intervention (Δ=-6.2; 95% CI: –16.6 to 4.27; $p=0.247$), the control groups (Δ=-4.7; 95% CI: –15.4 to 6.0; $p=0.392$). However, the contrast between the groups provided weak conclusive evidence for the intervention effect in favor of the intervention group (Δ=-1.4; 95% CI: –5.4 to 2.5; $p=0.468$), indicating that at post-intervention, the intervention group decreased ~ 1.4 points more compared to the control group. (Table A4 and Fig. 3). Heterogeneity was substantial ($I^2=92.0\%$).

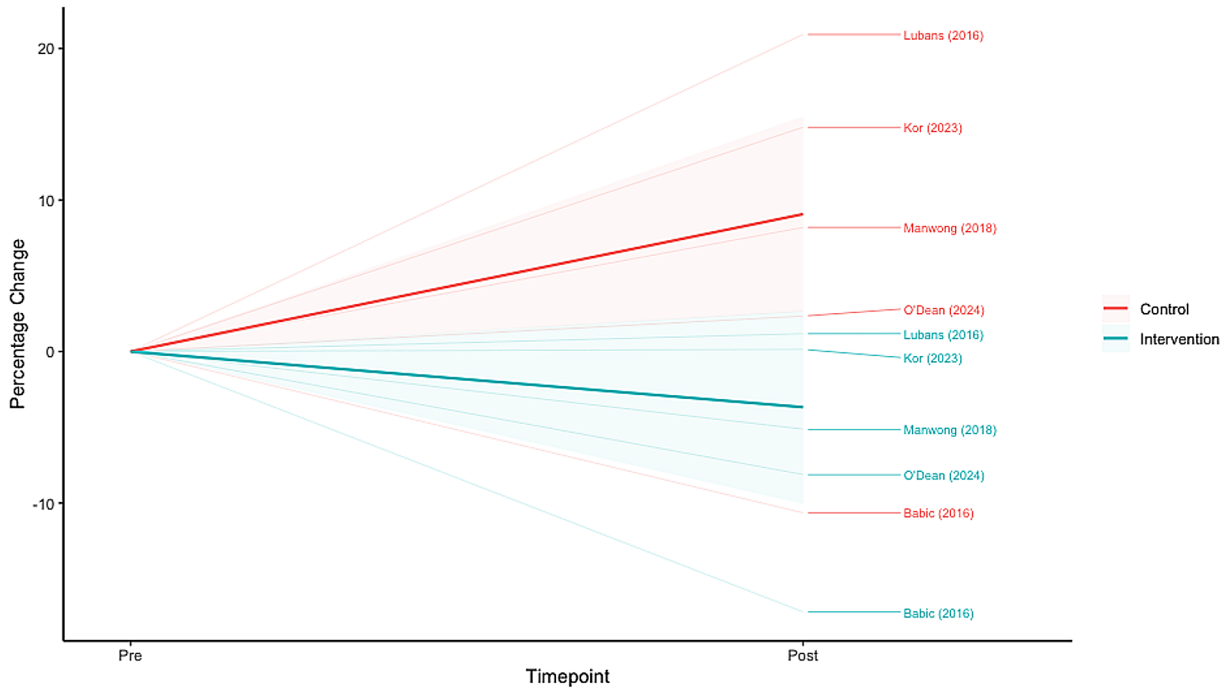


Fig. 2 Percentage Change in Screen Time from Pre- to Post- Intervention: Control vs. Intervention. Pooled change (starts at 0) using SE=0.5. Faint lines=individual studies; bold lines=pooled trajectories; light fill=95% CI for pooled change

Anxiety

Seven studies were included in the meta-analysis assessing anxiety scores (Babic et al., 2016; Choi et al., 2020; Du et al., 2010; Ke & Wong, 2018; Kim et al., 2018; Kor & Shoshani, 2023; Smout et al., 2024), resulting in 15 estimates. Table A4 and Fig. 4 display the changes in anxiety scores after the intervention. There was very good conclusive evidence for the intervention effect (Δ=-4.8; 95% CI: –9.1 to 0.6; $p=0.026$), resulting in a reduction in anxiety scores in the intervention groups of~5 points on a scale ranging from 0 to100. In contrast, the evidence of the change in the control groups was weak, but still conclusive (Δ=-3.2; 95% CI: –7.4 to 1.1; $p=0.145$). The difference between the groups at post intervention resulted in strong conclusive evidence for the intervention effect, indicating a significant reduction in anxiety scores in the intervention group compared to the control group (Δ=-1.7 95% CI: -2.3% to -1.0; $p<0.001$). Heterogeneity was substantial ($I^2=81.1\%$), indicating that approximately 81% of the observed variability in effect estimates across studies was attributable to true between-study differences rather than sampling error.

Depressive Symptoms

Five studies reported data for depressive symptoms scores (Ke & Wong, 2018; Kim et al., 2018; Kor & Shoshani, 2023; Manwong et al., 2018; Smout et al., 2024), resulting in eight estimates. There was some conclusive evidence against the intervention effect in the control group (Δ=1.1; 95% CI: –2.8 to 5.11; p=0.575), resulting in an increment in the depressive symptoms scores. There was weak conclusive evidence for the intervention effect in the intervention groups (Δ=-2.3; 95% CI: –6.2 to 1.7; $p=0.255$), indicating a reduction of 2.3 points (on the scale 0 to 100) in the depressive symptoms scores. As shown in Table A4 and Fig. 5, the difference between the groups at post intervention showed strong conclusive evidence for the intervention effect (Δ=-3.4; 95% CI: –4.4 to -2.5; $p<0.001$), indicating a significant difference of~3.4 points in the depressive symptoms scores between the groups. Heterogeneity was substantial ($I^2=85.7\%$), suggesting that most of the variability in effect sizes across studies reflects true differences between studies rather than random variation due to sampling error.

Life Satisfaction

Three studies reported data for life satisfaction scores (Babic et al., 2016; Kor & Shoshani, 2023; Lubans et al., 2016), resulting in six estimates. There was strong conclusive evidence against the intervention effect in the control group (Δ=-2.8; 95% CI: –4.9 to -0.7; $p=0.009$), indicating a decline in the life satisfaction scores, and very good conclusive evidence for the intervention effect in the intervention group, which showed an increase in life satisfaction (Δ=2.0; 95% CI: -0.1 to 4.0; $p=0.061$). As illustrated in Table A4 and Fig. 6, the meta-analysis revealed strong

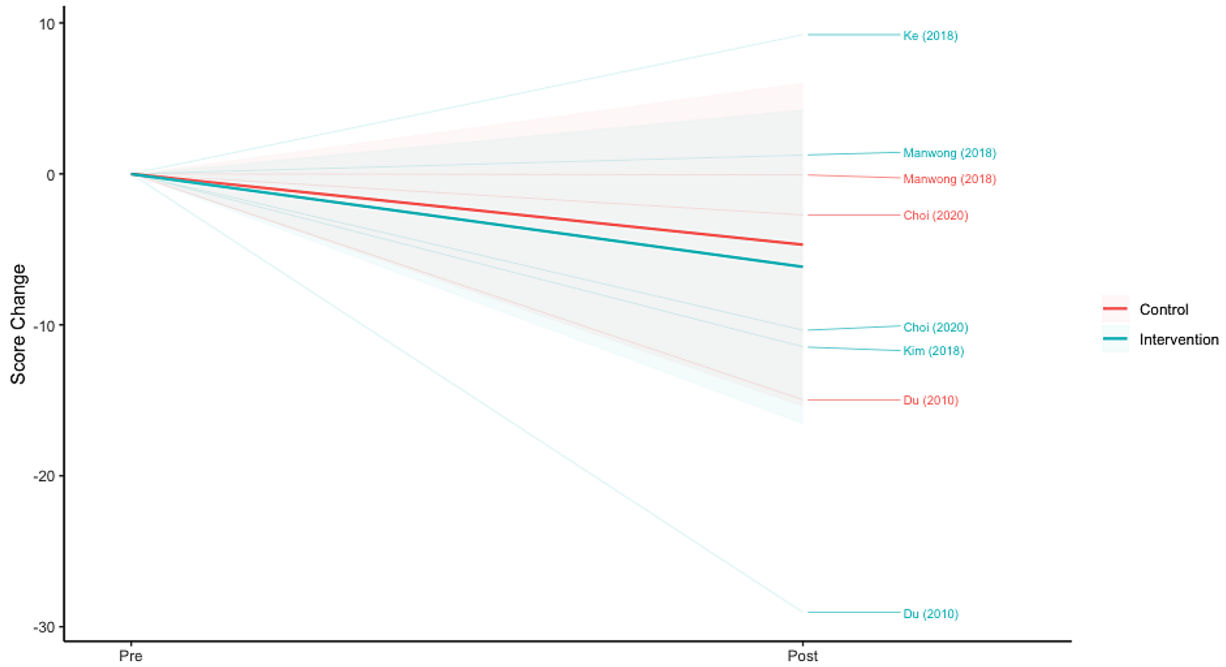


Fig. 3 Percentage Change in Problematic Use from Pre- to Post- Intervention: Control vs. Intervention. Pooled change (starts at 0) using SE=0.5. Faint lines=individual studies; bold lines=pooled trajectories; light fill=95% CI for pooled change

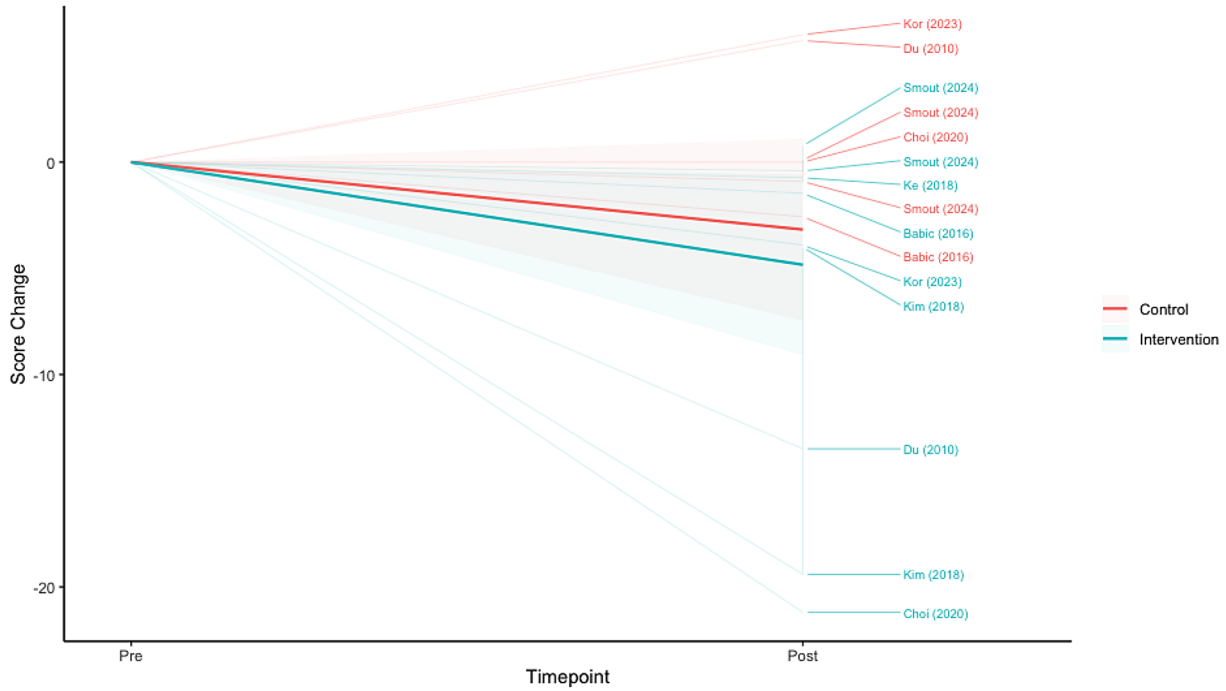


Fig. 4 Percentage Change in Anxiety from Pre- to Post- Intervention: Control vs. Intervention. Pooled change (starts at 0) using SE = 0.5. Faint lines = individual studies; bold lines = pooled trajectories; light fill = 95% CI for pooled change

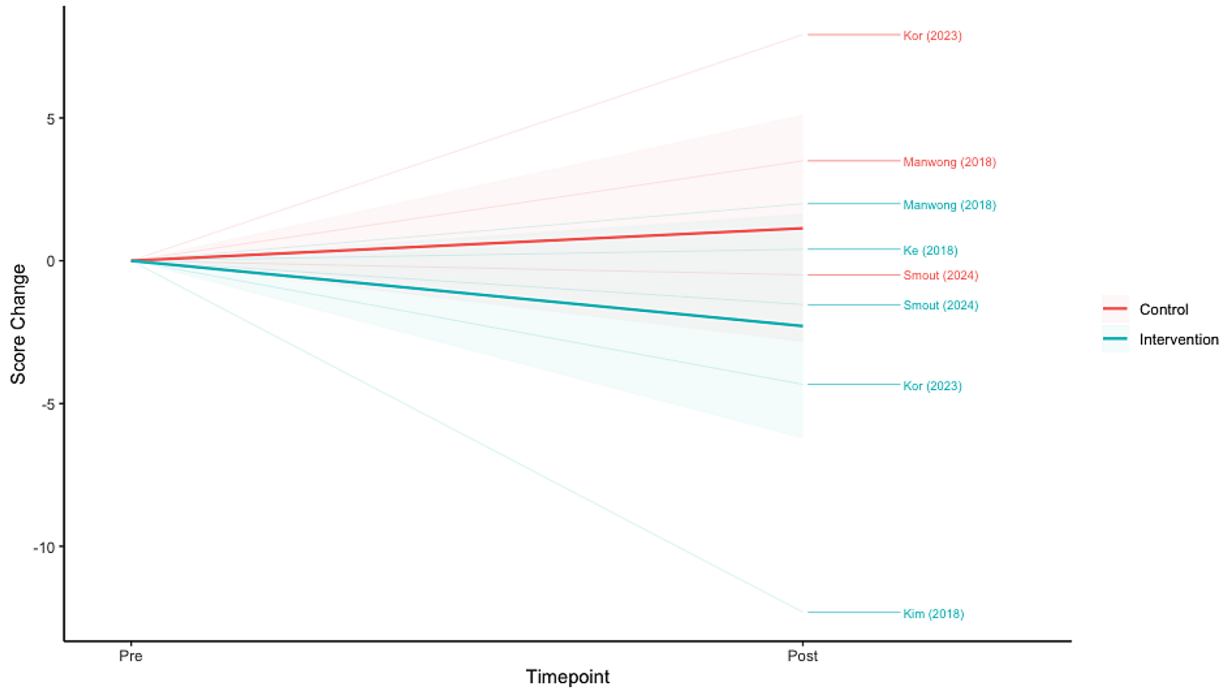


Fig. 5 Percentage Change in Depressive Symptoms from Pre- to Post- Intervention: Control vs. Intervention. Pooled change (starts at 0) using SE = 0.5. Faint lines = individual studies; bold lines = pooled trajectories; light fill = 95% CI for pooled change

conclusive evidence for the intervention effect (Δ = 4.7; 95% CI: 3.3 to 6.2; $p < 0.001$), indicating a significant increment in life satisfaction scores in the intervention group compared to the control group. Heterogeneity was moderate ($I^2 = 41.8\%$), suggesting that a meaningful proportion of the variability in effect estimates across studies reflects real between-study differences rather than sampling error,

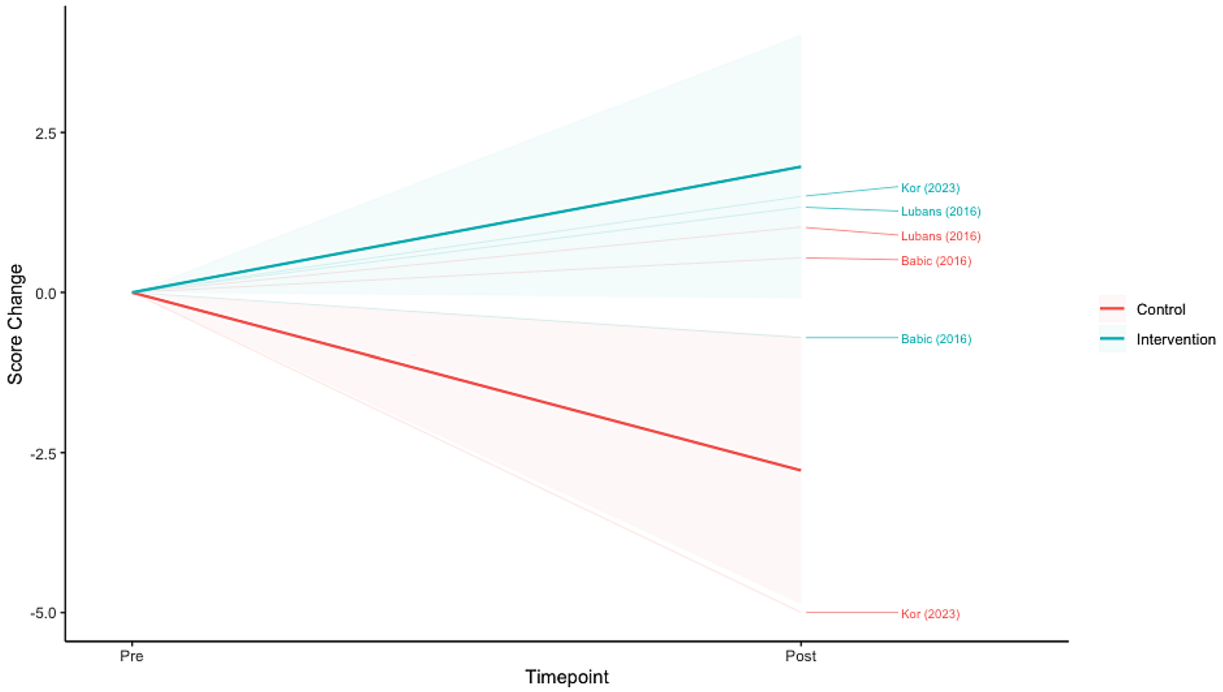


Fig. 6 Percentage Change in Life Satisfaction and Flourishing from Pre- to Post- Intervention: Control vs. Intervention. Pooled change (starts at 0) using SE = 0.5. Faint lines = individual studies; bold lines = pooled trajectories; light fill = 95% CI for pooled change

although random variation still accounts for a substantial share of the observed dispersion.

Strengths and Difficulties

Three studies reported data for SDQ – psychological difficulties scores (Babic et al., 2016; Choi et al., 2020; Du et al., 2010; Manwong et al., 2018), resulting in six estimates. There was some conclusive evidence for the intervention effect in the control groups (Δ=-0.5; 95% CI: -3.6 to 2.6; p=0.764) and very good conclusive evidence for the intervention effect in the intervention groups (Δ=-3.0; 95% CI: -6.1 to 0.1; p=0.055). As illustrated in Table A4 and Fig. 7, the meta-analysis revealed very good conclusive evidence (Δ=-2.6; 95% CI: -4.8 to -0.3; p=0.024), indicating a significant reduction in SDQ scores in the intervention group compared to the control group. Heterogeneity was substantial (I^2=71.1%), indicating that a large proportion of the variability in effect estimates across studies is attributable to genuine between-study differences rather than sampling error, suggesting meaningful inconsistency in the observed effects.

Sensitivity Analyses and Publication Bias

Table A5 shows the results of the sensitivity analyses using correlation coefficients of 0.2, 0.5, and 0.8. Overall, the results are consistent with our main meta-analysis findings, which used the correlation value of 0.5. Table A6 shows the complete Egger test results for each of the outcomes of interest. Figure A5 illustrates the funnel plots for the screen time outcome. Test results indicate no evidence of funnel asymmetry in the control arm (z=-0.74, p=0. 457) and in the intervention arm (z=-0.53, p=0. 594), meaning there is no clear evidence of funnel asymmetry in these arm-specific analyses. Given only 5 arms per group and high heterogeneity (Control I^2=83.75%; Intervention I^2=61.69%), these findings should be interpreted cautiously. Figure A6 illustrates the funnel plots for the problematic use outcome. Test results were significant for the intervention arm (intervention: z=-4.11, p<0.001), meaning there is evidence of funnel asymmetry in the intervention group. Figure A7 illustrates the funnel plots for the anxiety outcome. The test results showed no evidence of funnel asymmetry for the control arm (k=6; z=0.08, p=0.933) and asymmetry for the intervention arm (k=9; z=−2.46, p=0.014). Figure A8 illustrates the funnel plots for the depressive symptoms. The test results were not significant for either arm (control: z=0.44, p=0.658; intervention: z=-0.75, p=0.453), indicating no clear evidence of funnel asymmetry. However, given the small number of studies, these findings should be interpreted cautiously. Figure A9 illustrates the funnel plots for life satisfaction and flourishing outcomes. The test results were not significant for either arm (control: z=0.84, p=0.400; intervention: z=−0.789, p=0.430). Heterogeneity is negligible in the intervention arm (I^2=0%), but with only three studies per arm, these results should be interpreted cautiously. Figure A10 illustrates the funnel plots for the SDQ – psychological difficulties

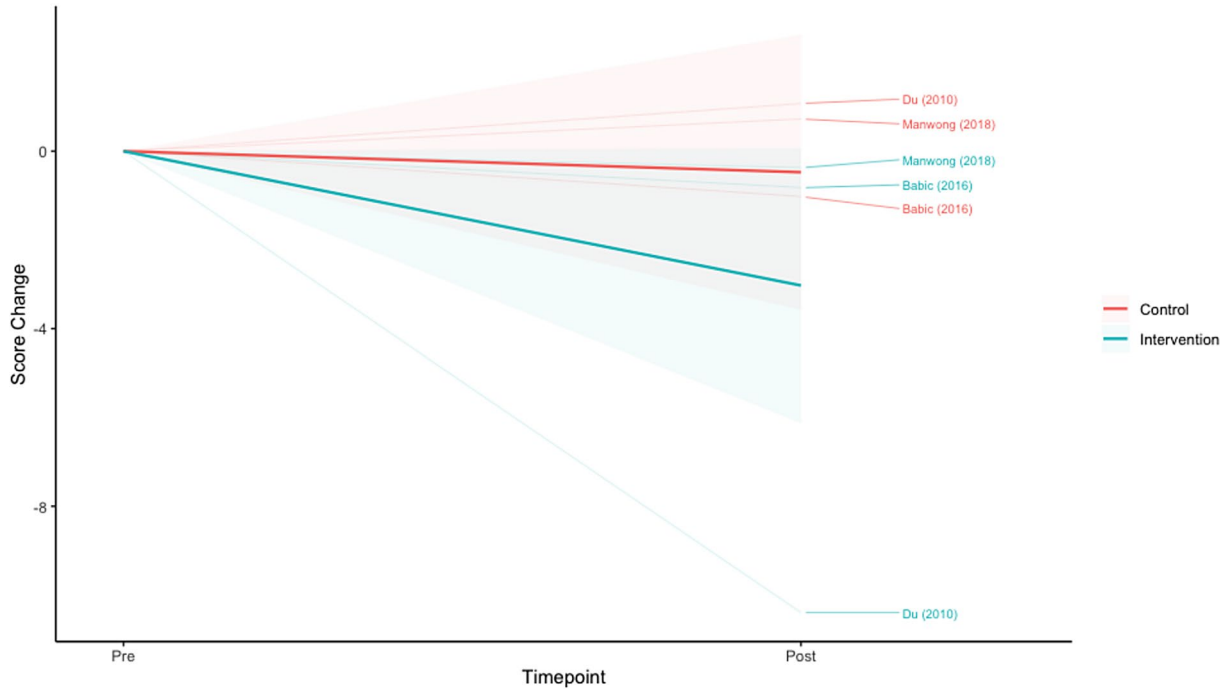


Fig. 7 Percentage Change in Strengths and Difficulties Questionnaire—Psychological Difficulties from Pre- to Post- Intervention: Control vs. Intervention. Pooled change (starts at 0) using SE = 0.5. Faint lines = individual studies; bold lines = pooled trajectories; light fill = 95% CI for pooled change

outcome. The test results showed no evidence of funnel asymmetry for the control arm ($z = 0.280$, $p = 0.780$) and asymmetry for the intervention arm ($z = -4.84$, $p < 0.001$). However, given that the number of studies is rather low across the analyses ($k = 3$), these results should also be interpreted cautiously.

Quality of Evidence

We assessed the quality of evidence using the GRADE approach. Notably, the quality of evidence was not downgraded for screen time (hours/day) and life satisfaction; it was downgraded once and reported as moderate SDQ – psychological difficulties; twice and reported as low for depressive symptoms; and thrice and reported as very low for screen time (problematic use) and anxiety. The overview of the reasons for downgrading the quality of evidence for the outcomes of interest is reported in Table A7.

Discussion

Although previous research has identified that digital use could be harmful for adolescents' mental wellbeing, the intervention literature omits a comprehensive picture of how school-based interventions can impact different types of adolescent digital use and mental wellbeing outcomes. Critically, many studies have treated digital engagement and sedentary behaviour jointly in their analysis, which impedes to test the specific effect of school-level interventions on digital behaviour (Guo et al., 2025; McMichan et al., 2018; Rodrigo-Sanjoaquín et al., 2025). This study has conducted a systematic review and meta-analysis to examine the effectiveness of school-based interventions targeting digital use on adolescents' digital use patterns and their mental wellbeing. Contrary to previous reviews, this study examines the effect of school-based interventions on both specific forms of digital use (e.g., screen time, problematic social media use) and distinct mental well-being outcomes (e.g., anxiety, depressive symptoms, life satisfaction, psychological difficulties). Broadly, the meta-analyses suggest that school-based interventions could help to reduce screen time and improve mental wellbeing, although results need a more nuanced inspection.

The findings indicate that school-based interventions are effective tools for changing adolescents' digital use patterns, specifically in reducing screen-based time. Results from the meta-analyses showed that, after the intervention, hours per day of screen time increased by 8.7% in the control groups and decreased by 3.6% in the intervention groups, showing a significant difference between the groups at post-intervention of 12% (back-transformed percentage change). Problematic digital use reduced by 6.2 points (on a scale from 0 to 100) in the intervention group and by 4.7 points in the control group. Even though these decreases were not significant within group, the analysis revealed weak statistically significant

differences between the groups at post-intervention, with the intervention group decreasing ~ 1.4 points more than the control group. The analyses addressing screen time separately critically contribute to previous literature on this topic, as most previous meta-analyses have investigated the effectiveness of school-based interventions on sedentary behaviors, wherein screen time is part of several components measured within an umbrella construct of sedentary time (Lai et al., 2025; Rodrigo-Sanjoaquín et al., 2025). Regarding problematic use, while the results lack enough statistical power to be conclusive, they are in line with some research indicating that school-based interventions are effective tools in reducing problematic digital use (Ayub et al., 2023; Yeun & Han, 2016), albeit future studies that could include more observations and participants are needed. Overall, the finding that school-based interventions targeting digital use led to reduced screen time supports previous scholarship suggesting that schools, with their highly structured daily routines and strong peer effects on changing norms, are effective spaces to change student behaviors within the context of interventions (Dekkers & Luman, 2023; Giletta et al., 2021; Lopez-Fernandez & Kuss, 2020).

This study found conclusive evidence for the effectiveness of the school-based interventions in improving positive mental wellbeing and reducing negative mental wellbeing indicators, although evidence of improvements slightly varied in each wellbeing measure. For negative mental wellbeing measures, the anxiety score declined by 4.8 points and the depressive symptoms score declined by 2.3 points in the intervention groups. In the control groups, anxiety scores decreased by 3.2 points, whereas depressive symptoms scores increased by 1.1 points. Further, psychological difficulties were reduced by 3 points in the intervention groups, compared to a negligible reduction of 0.5 point in the control groups. This contrast was statistically significant and indicated that at post-intervention, the difference between the two groups was 2.6 point. In relation to the positive mental wellbeing, the findings showed that school-based interventions are helpful in improving life satisfaction, which increased by 2 points in the intervention groups, compared to a 2.8-point reduction in the control groups. While previous studies have indicated that school-based interventions can be effective in promoting young people's mental health outcomes (Cilar et al., 2020; Paulus et al., 2016), this study shows how school-based interventions directed to change digital habits impact adolescent positive and negative wellbeing. The findings globally indicate that, when adolescents are subject to school-based programs intending to produce more balanced and healthier digital habits, they become less prone to psychological problems like depressive symptoms and anxiety and more prone to improving their life satisfaction and flourishing. One reason for this could be that the interventions may be successfully targeting digital use, which could improve adolescents' digital maturity and, in turn, may help them to benefit from their digital use, rather than being harmed by it (Celik et al., 2025; Laaber et al., 2023). Future studies should address the reasons and potential mechanisms that explain why positive and negative wellbeing are subject to improvements when adolescents participate in school-based programs oriented toward more balanced digital media engagement.

The results from our narrative synthesis showed a variety of mechanisms and frameworks used in the school-based intervention designs. One common approach in the literature, particularly in universal multi-component interventions targeting several health-related risk factors, was to measure screen time as a proxy of sedentary behavior, rather than measuring screen time separately as engagement with digital devices (e.g., Busch et al., 2013; Lubans et al., 2016; Sharma et al., 2018). Other studies narrowed their focus on problematic digital use, but many of them did not run high-quality RCTs (except for Du et al., 2010 and Manwong et al., 2018). This suggests a need for school-based interventions that target problematic digital use with more robust methodological designs. Various studies integrated digital device components into their designs, including smartphone apps (Lubans et al., 2016) and online messages (Babic et al., 2016). Although these tools could allow a more dynamic feature for the intervention designs, their effectiveness could differ based on participants' digital skills to navigate through them (Livingstone & Helsper, 2010). This area of research deserves further attention in future research.

Overall, there was a variation in the length and size of the interventions. Some studies had a small and relatively short design, and some studies invested in a long-term design covering the entire participating schools. For example, Kim et al. (2018) tested a one-month-long group-based therapy intervention on problematic digital use with only 17 students, while Busch et al. (2013) applied a health education program to 336 students that lasted three years. Also, there was not enough evidence to draw conclusions on when in time interventions were more effective, and whether and how the length of interventions matters to produce effective outcomes. Moreover, the studies also differed in design (cluster RCTs, non-randomized controlled trials, and single-arm pre-post studies), and participant selection, with some studies including universal school samples and others focusing on adolescents with excessive screen time or problematic digital use. These variations along with the differences in the operationalization of the related but non-identical constructs likely contributed to the substantial heterogeneity observed in several of the meta-analyses, meaning that the high between-study variability in effect sizes reflected genuine differences across studies rather than random error alone. However, this heterogeneity does not render the findings uninformative. Rather, it suggests that the pooled estimates should be interpreted as average effects across a diverse and still methodologically developing intervention literature. The use of random-effects models was appropriate for this purpose, as

it accounts for variation in true effects across studies. Moreover, for several outcomes, the overall direction of effects was broadly consistent, with intervention groups showing more favorable post-intervention changes than control groups. The sensitivity analyses also showed that the results were robust to different assumptions regarding the pre-post correlation coefficients. Nevertheless, we could not conduct adequately powered moderator analyses to formally test sources of heterogeneity. Future research with a larger evidence base should examine whether intervention type, duration, target group, and outcome operationalization explain variation in effectiveness.

This study had some limitations which warrant a careful interpretation of the meta-analyses' results. First, the small number of studies for some investigated outcomes reduced the power of the analysis, making it difficult to explore the true effect of interventions. To remedy this possible outcome, arm-based random-effects meta-analyses analysis strategy was conducted which increased the sample size by including pre-post studies without a control group, yet it led to lower GRADE assessments for several of the outcomes. Second, in terms of study design, many of the studies applied multi-component interventions. While this approach could be beneficial to have a more comprehensive approach for improving mental wellbeing (Busch et al., 2013), it makes unclear how much of the intervention content is specifically focused on digital use. Third, mainly due to the lack of consensus in defining and operationalizing problematic use in the literature (Almourad et al., 2020), the included studies used a variety of problematic use measurements (e.g., internet overuse, phone addiction, social media addiction). Although pooling these studies with different contexts of digital engagement may partly constrain the precision of this measurement, the analysis on problematic digital use still offers an insight into the extent of the effectiveness of school-based interventions on negative experiences that apply to various forms of digital use. Fourth, due to the limited number of studies included in the meta-analysis, publication bias assessed through Egger's test and funnel plots could be underpowered, potentially reducing the ability to detect asymmetry and small-study effects. Accordingly, the absence of clear evidence of publication bias should not be interpreted as definitive evidence that publication bias is not present. Finally, the examined data did not have enough statistical power to separate between short- and long-term effects in the interventions. Future studies will hopefully be able to separate between short-, medium-, and longer-term effects of school-level interventions on digital habits, both in terms of digital use patterns and mental wellbeing.

Taken together, despite some limitations, this study provides strong policy implications for school-based interventions. Because of the great concerns about excessive screen time and addictive components of online activities and their impacts on adolescent mental wellbeing (Santos et al., 2023), the findings contribute to the search for a successful solution to address these issues. As schools are the fundamental learning and socializing setting for young people, interventions designed to be delivered through the education systems in group formats to improve digital habits seem to be effective in addressing adolescents' digital use problems as well as their mental wellbeing. This study provides enough evidence to justify investigating alternative school-based interventions further to study the precise mechanisms by which these school-level interventions may be effective to improve adolescents' digital lives and wellbeing.

Finally, future studies should focus on preregistering theory-driven components and high-quality RCT designs. Doing so would ensure follow-up measurements for long-term results, as well as reporting evidence on implementation fidelity and cost-effectiveness. With these improvements, the effectiveness of school-based interventions in reducing adolescents' problematic digital use and improving positive mental wellbeing could be assessed more systematically.

Conclusion

There are growing societal and scientific concerns regarding the potentially negative impacts of adolescents' excessive and problematic digital use on their wellbeing. Although schools can act as key contexts for implementing interventions targeting adolescents' digital behaviors and wellbeing, previous literature has provided limited evidence on whether school-based interventions are effective in helping adolescents to reduce their digital use and improve their mental wellbeing. To address this timely research question, our study employed an innovative arm-based random-effects meta-analytic approach to investigate the effectiveness of school-based interventions, combined with a narrative synthesis to summarize studies that were not suitable for inclusion in the meta-analysis. The findings showed that school-based interventions are effective in reducing adolescents' screen use and, anxiety and depressive symptoms. These findings indicate that schools play a key role in adolescents' daily digital habits and mental wellbeing, implying that schools could be a critical context to promote behavior change and mental health support among adolescents. Yet, the available interventions remain methodologically thin for problematic digital use and for bolstering positive wellbeing, with many multicomponent programs and short-term designs obscuring strong implications. Future research should investigate school-based interventions targeting problematic digital use and positive mental wellbeing specifically and using robust RCT designs that allow to effectively tackle adolescents' digital use.

Appendices

See Tables 3, 4, 5, 6, 7, 8, 9.

Table 3 Systematic search keywords and database searching details

Search	Keywords	Results
PubMed		
#1	(((((((Adolescen*) OR (Youth)) OR (Teen*)) OR (juvenil*)) OR (student*)) OR (pupil*) OR ("Adolescent"[Mesh]) OR ("Students"[Mesh])))	2,891,986
#2	((((((((((Smartphone) OR (ICT)) OR ("Information and communication technologies")) OR (Digital technolog*)) OR (phone)) OR (tablet*)) OR (social media)) OR (social network*)) OR (social networking site*)) OR (sns)) OR (digital media)) OR (Internet)) OR (screentime) OR (screen time) OR ("Smartphone"[Mesh]) OR ("Social Media"[Mesh]) OR ("Social Networking"[Mesh]) OR ("Internet Use"[Mesh]))	570,661
#3	((((trial*) OR (experiment*)) OR (intervention*)))	6,195,748
#4	(((((((((mental health) OR (depression)) OR (anxiety)) OR (quality of life)) OR (life satisfaction)) OR (affect*)) OR (mood)) OR (loneliness)) OR ("Mental wellbeing") OR ("Mental well-being") OR ("Psychological wellbeing") OR ("psychological well-being") OR ("Mental Health"[Mesh] OR ("Depression"[Mesh]) OR ("Anxiety"[Mesh])) OR ("Psychological Well-Being"[Mesh]) OR ("Affect"[Mesh]))	3,836,895
#5	(((school-based) OR (classroom-based)))	18,972
#6	#1 AND #2 AND #3 AND #4 AND #5	258
PsycINFO		
#1	(((Adolescen*) OR (Youth)) OR (Teen*)) OR (juvenil*)) OR (student*)) OR (pupil*) OR (DE "Youth Mental Health")))	1.331.911
#2	((Smartphone) OR (ICT) OR ("Information and communication technologies") OR (Digital technolog*) OR (phone) OR (tablet*) OR (social media) OR (social network*) OR (social networking site*) OR (sns) OR (digital media) OR (Internet) OR (DE "Smartphone Use") OR (screen time) OR (screentime) OR (DE "Screen Time") OR (DE "Information and Communication Technology") OR (DE "Digital Technology") OR (DE "Social Media") OR (DE "Digital Media") OR (DE "Social Networks"))	179,009
#3	(((trial*) OR (experiment*)) OR (intervention*)))	1,385,188
#4	((mental health) OR (depression)) OR (anxiety)) OR (quality of life)) OR (life satisfaction)) OR (affect*)) OR (mood)) OR (loneliness) OR ("Mental wellbeing") OR ("Mental well-being") OR ("Psychological wellbeing") OR OR ("psychological well-being") OR (DE "Mental Health") OR (DE "Depression (Emotion)") OR (DE "Anxiety") OR (DE "Quality of Life") OR (DE "Life Satisfaction") OR (DE "Loneliness"))	1,751,911
#5	((school-based) OR (classroom-based))	39,196
#6	#1 AND #2 AND #3 AND #4 AND #5	336
CINAHL		
#1	(((Adolescen*) OR (Youth)) OR (Teen*)) OR (juvenil*)) OR (student*)) OR (pupil*) OR (DE "Youth Mental Health")))	909,770
#2	((Smartphone) OR (ICT) OR ("Information and communication technologies") OR (Digital technolog*) OR (phone) OR (tablet*) OR (social media) OR (social network*) OR (social networking site*) OR (sns) OR (digital media) OR (Internet) OR (DE "Smartphone Use") OR (screen time) OR (screentime) OR (DE "Screen Time") OR (DE "Information and Communication Technology") OR (DE "Digital Technology") OR (DE "Social Media") OR (DE "Digital Media") OR (DE "Social Networks"))	182,709
#3	(((trial*) OR (experiment*)) OR (intervention*)))	1,182,644
#4	((mental health) OR (depression)) OR (anxiety)) OR (quality of life)) OR (life satisfaction)) OR (affect*)) OR (mood)) OR (loneliness) OR ("Mental wellbeing") OR ("Mental well-being") OR ("Psychological wellbeing") OR OR ("psychological well-being") OR (DE "Mental Health") OR (DE "Depression (Emotion)") OR (DE "Anxiety") OR (DE "Quality of Life") OR (DE "Life Satisfaction") OR (DE "Loneliness"))	1,015,425
#5	((school-based) OR (classroom-based))	12,627
#6	#1 AND #2 AND #3 AND #4 AND #5	91
ERIC		
#1	(Adolescen*) OR (Youth) OR (Teen*) OR (juvenil*) OR (student*) OR (pupil*) OR (MJMAINSUBJECT.EXACT.EXPLODE("Youth"))	1,029,827
#2	(Smartphone) OR (ICT) OR ("Information and communication technologies") OR (Digital technolog*) OR (phone) OR (tablet*) OR (social media) OR (social network*) OR (social networking site*) OR (sns) OR (digital media) OR (Internet) OR (screen time) OR (screentime) OR (MJMAINSUBJECT.EXACT.EXPLODE("Social Media")) OR (MJMAINSUBJECT.EXACT.EXPLODE("Social Networks")) OR (MJMAINSUBJECT.EXACT.EXPLODE("Internet"))	92,419
#3	(trial*) OR (experiment*) OR (intervention*)	218,810
#4	(mental health) OR (depression) OR (anxiety) OR (quality of life) OR (life satisfaction) OR (affect*) OR (mood) OR (loneliness) OR ("Mental wellbeing") OR ("Mental well-being") OR ("Psychological wellbeing") OR ("Psychological well-being") OR (MJMAINSUBJECT.EXACT.EXPLODE("Mental Health")) OR (MJMAINSUBJECT.EXACT.EXPLODE("Depression (Psychology)")) OR (MJMAINSUBJECT.EXACT.EXPLODE("Anxiety")) OR (MJMAINSUBJECT.EXACT.EXPLODE("Quality of Life")) OR (MJMAINSUBJECT.EXACT.EXPLODE("Life Satisfaction"))	191,452
#5	((school-based) OR (classroom-based))	17,943

Table 3 (continued)

Search	Keywords	Results
#6	#1 AND #2 AND #3 AND #4 AND #5	50
EMBASE		
#1	(Adolescen*) OR (Youth) OR (Teen*) OR (juvenil*) OR (student*) OR (pupil*) OR ('adolescent'/syn) OR ('juvenile'/syn) OR ('student'/syn) OR ('pupil'/syn)	5,265,053
#2	(Smartphone) OR (ICT) OR ("Information and communication technologies") OR (Digital technolog*) OR (phone) OR (tablet*) OR (social media) OR (social network*) OR (social networking site*) OR (sns) OR (digital media) OR (Internet) OR (screen time) OR (screentime) OR ('smartphone'/syn) OR ('digital technology'/syn) OR ('tablet'/syn) OR ('social media'/syn) OR ('social network'/syn) OR ('internet'/syn)	755,470
#3	(((trial*) OR (experiment*)) OR (intervention*)))	11,211,792
#4	(mental health) OR (depression) OR (anxiet) OR (quality of life) OR (life satisfaction) OR (affect*) OR (mood) OR (loneliness) OR ("Mental wellbeing") OR ("Mental well-being") OR ("Psychological wellbeing") OR ("psychological well-being") OR ('mental health'/syn) OR ('depression'/syn) OR ('anxiety'/syn) OR ('quality of life'/syn) OR ('life satisfaction'/syn) OR ('affect'/syn) OR ('mood'/syn) OR ('loneliness'/syn) OR ('psychological well-being'/syn)	5,360,997
#5	((school-based) OR (classroom-based))	21,748
#6	#1 AND #2 AND #3 AND #4 AND #5	406
Web Of Science		
#1	(((Adolescen*) OR (Youth)) OR (Teen*)) OR (juvenil*)) OR (student*)) OR (pupil*)	2,754,010
#2	((Smartphone) OR (ICT) OR ("Information and communication technologies") OR (Digital technolog*) OR (phone) OR (tablet*) OR (social media) OR (social network*) OR (social networking site*) OR (sns) OR (digital media) OR (Internet) OR (screen time) OR (screentime)	1,315,889
#3	(((trial*) OR (experiment*)) OR (intervention*)))	11,487,394
#4	((mental health) OR (depression)) OR (anxiety)) OR (quality of life)) OR (life satisfaction)) OR (affect*)) OR (mood)) OR (loneliness) OR ("Mental wellbeing") OR ("Mental well-being") OR ("Psychological wellbeing") OR ("psychological well-being")	5,801,044
#5	((school based) OR (classroom based))	28,409
#6	#1 AND #2 AND #3 AND #4 AND #5	123

Table 4 Thresholds for interpreting the meta-analysis results

Interpretation	Negative	Positive
Screen time (hours/day)		
Trivial	>-17.4	<17.4
Small	-17.5 to -38.8	17.5 to 38.8
Moderate	-38.9 to -56.5	38.9 to 56.5
Large	-56.6 to -76.0	56.7 to 76.0
Very Large	<-76.0	>76.0
Problematic use		
Trivial	>-4.0	<4.0
Small	-4.1 to -10.0	4.1 to 10.0
Moderate	-10.1 to -16.0	10.1 to 16.0
Large	-16.1 to -23.9	16.1 to 23.9
Very Large	<-23.9	>23.9
Anxiety		
Trivial	>-3.9	<3.9
Small	-4.0 to -9.8	4.0 to 9.8
Moderate	-9.9 to -15.7	9.9 to 15.7
Large	-15.8 to -23.5	15.8 to 23.5
Very Large	<-23.5	>23.5
Depressive symptoms		
Trivial	>-3.3	<3.3
Small	-3.4 to -8.3	3.4 to 8.3
Moderate	-8.4 to -13.3	8.4 to 13.3
Large	-13.4 to -20.0	13.4 to 20.0
Very Large	<-20.0	>20.0
Life satisfaction and Flourishing		
Trivial	>-4.5	<4.5
Small	-4.6 to -11.2	4.6 to 11.2
Moderate	-11.3 to -17.9	11.3 to 17.9
Large	-18.0 to -26.8	18.0 to 26.8
Very Large	<-26.8	>26.8
SDQ—Psychological difficulties		
Trivial	>-2.7	<2.7
Small	-2.8 to -6.7	2.8 to 6.7
Moderate	-6.8 to -10.7	6.8 to 10.7
Large	-10.8 to -16.0	10.8 to 16.0
Very Large	<-16.0	>16.0

SDQ: Strengths and Difficulties Questionnaire. The extent of overlap was estimated as the areas of the sampling distribution falling in substantial and trivial magnitudes. These areas represent the probabilities that the true effect has those positive magnitudes

Table 5 Interpretations of sampling uncertainty in the 95% CI limits

Probability	Interpretation of sampling uncertainty	Conclusion[a]
≤0.005	Most likely substantial effect	Strong conclusive evidence for effect
0.005 – 0.05	Very likely substantial effect	Very good conclusive evidence for effect
0.05 – 0.25	Likely substantial effect	Weak conclusive evidence for effect
0.25 – 0.75	Possible substantial effect	Some conclusive evidence for effect
0.75 – 0.95	Unlikely substantial effect	Good conclusive evidence against effect
0.95 – 0.995	Very unlikely substantial effect	Very good conclusive evidence against effect
≥0.995	Most unlikely substantial effect	Strong conclusive evidence against effect

[a]In cases where there was some conclusive evidence (i.e., a probability of 0.25 to 0.75) for both a substantial negative and substantial positive magnitude, the effect in question was deemed to be inconclusive

The probability represents the area of the sampling distribution falling between trivial or substantial (i.e., small, moderate, and large) values on the right side of zero

Table 6 Meta-analyses of Percentage Changes in Outcome Variables from Baseline to Post Intervention, using a correlation coefficient of 0.5

Group	Estimate	SE	Lower 95% CI	Upper 95% CI	p value	Interpretation
Model: Screen time (hrs/day)						
Control	9.071	3.287	2.629	15.512	0.006	Strong conclusive evidence against intervention effect
Intervention	-3.673	3.250	-10.043	2.698	0.259	Weak conclusive evidence for intervention effect
Contrast						
Intervention—Control	-12.743	1.754	-16.180	-9.306	<.0001	Strong conclusive evidence for intervention effect
Intervention—Control[a]	-11.964					
Model: Problematic use						
Control	-4.688	5.475	-15.419	6.044	0.392	Inconclusive evidence
Intervention	-6.156	5.320	-16.582	4.270	0.247	Inconclusive evidence
Contrast						
Intervention—Control	-1.468	2.023	-5.433	2.496	0.468	Weak conclusive evidence for effect
Model: Anxiety						
Control	-3.174	2.180	-7.447	1.099	0.145	Weak conclusive evidence for intervention effect
Intervention	-4.832	2.171	-9.088	-0.577	0.026	Very good conclusive evidence for intervention effect
Contrast						
Intervention—Control	-1.658	0.344	-2.333	-0.983	<.0001	Strong conclusive evidence for intervention effect
Model: Depressive symptoms						
Control	1.138	2.030	-2.841	5.116	0.575	Some conclusive evidence for intervention effect
Intervention	-2.287	2.011	-6.228	1.653	0.255	Weak conclusive evidence for intervention effect
Contrast						
Intervention—Control	-3.425	0.476	-4.358	-2.492	<0.0001	Strong conclusive evidence for intervention effect
Model: Life satisfaction and Flourishing						
Control	-2.779	1.065	-4.866	-0.691	0.009	Strong conclusive evidence against intervention effect
Intervention	1.967	1.052	-0.094	4.029	0.061	Very good conclusive evidence for intervention effect
Contrast						
Intervention—Control	4.746	0.751	3.274	6.218	<.0001	Strong conclusive evidence for intervention effect
Model: SDQ—Psychological difficulties						
Control	-0.475	1.580	-3.570	2.621	0.764	Some conclusive evidence for intervention effect
Intervention	-3.028	1.578	-6.120	0.065	0.055	Very good conclusive evidence for intervention effect
Contrast						
Intervention—Control	-2.553	1.132	-4.772	-0.335	0.024	Very good conclusive evidence for intervention effect

SDQ: Strengths and Difficulties Questionnaire. [a]: Back-transformed contrast

Table 7 Sensitivity Analyses Using Correlation Coefficients of 0.2, 0.5, and 0.8

Corr Coeff	Group	Estimate	Lower 95% CI	Upper 95% CI
Model: Screen time (hrs/day)				
0.2	Control	9.292	2.767	15.816
	Intervention	-3.452	-9.874	2.969
0.5	Control	9.070	2.629	15.512
	Intervention	-3.673	-10.043	2.698
0.8	Control	8.213	1.130	15.296
	Intervention	-4.541	-11.595	2.513
Model: Problematic use				
0.2	Control	-4.635	-15.627	6.357
	Intervention	-6.066	-16.573	4.442
0.5	Control	-4.688	-15.419	6.044
	Intervention	-6.156	-16.582	4.270
0.8	Control	-4.706	-14.991	5.579
	Intervention	-6.083	-16.249	4.082
Model: Anxiety				
0.2	Control	-3.012	-7.319	1.294
	Intervention	-4.690	-8.971	-0.410
0.5	Control	-3.174	-7.447	1.099
	Intervention	-4.832	-9.088	-0.576
0.8	Control	-3.316	-7.464	0.832
	Intervention	-4.917	-9.058	-0.776
Model: Depression				
0.2	Control	1.323	-2.392	5.038
	Intervention	-2.157	-5.816	1.503
0.5	Control	1.138	-2.841	5.116
	Intervention	-2.287	-6.228	1.653
0.8	Control	0.907	-3.264	5.078
	Intervention	-2.384	-6.538	1.770
Model: Life satisfaction and Flourishing				
0.2	Control	-2.831	-5.090	-0.572
	Intervention	1.899	-0.319	4.118
0.5	Control	-2.778	-4.866	-0.691
	Intervention	1.967	-0.094	4.029
0.8	Control	-2.734	-4.577	-0.890
	Intervention	2.078	0.246	3.910
Model: SDQ—Psychological difficulties				
0.2	Control	-0.371	-3.502	2.759
	Intervention	-2.949	-6.077	0.179
0.5	Control	-0.474	-3.570	2.621
	Intervention	-3.028	-6.120	0.065
0.8	Control	-0.588	-3.647	2.471
	Intervention	-3.093	-6.150	-0.036

SDQ: Strengths and Difficulties Questionnaire

Table 8 Egger Test Results for the meta-analyses

Group	*k*	I^2 percent	*z* score	*p* value	limit *b*	95% CI
Model: Screen time (hrs/day)						
Control	5	83.75	-0.744	0.457	13.94	-0.630, 28.502
Intervention	5	61.69	-0.533	0.594	-1.796	-10.94, 7.34
Model: Problematic use						
Control	3	81.53	-1.867	0.062	8.45	-5.86, 22.75
Intervention	5	96.43	-4.109	<0.001	23.23	8.31, 38.15
Model: Anxiety						
Control	6	95.63	0.0838	0.933	1.0506	-3.46, 5.56
Intervention	9	98.97	-2.4600	0.014	1.2058	-6.15, 8.56
Model: Depressive symptoms						
Control	3	96.87	0.4433	0.658	0.4171	-15.04, 15.87
Intervention	5	95.78	-0.7502	0.453	-0.2939	-8.50, 7.91
Model: Life satisfaction and Flourishing						
Control	3	88.61	0.8416	0.4000	4.51	-12.85, 3.83
Intervention	3	0.00	-0.7886	0.4304	2.16	-0.04, 4.36
Model: SDQ- Psychological difficulties						
Control	3	0.00	0.2798	0.780	-1.07	-9.76, 7.63
Intervention	3	93.44	-4.8371	<.0001	21.74	11.79, 31.70

SDQ: Strengths and Difficulties Questionnaire

Table 9 GRADE Assessment

	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Quality
Outcome: Screen Time (h/day)							
5 studies, 9,238 participants	RCT	Non-serious	Non-serious	Non-serious	Non-serious	Non-serious	**High**
The overall quality was not downgraded							
Outcome: Screen Time (Problematic Use)							
5 studies, 412 participants	RCT, non-RCT, and pre-post	Non-serious	Serious	Serious	Serious	Serious	**Very Low**
Inconsistency was downgraded because the model reported substantial unexplained I^2 and significant QE test Indirectness was downgraded due to the different designs included in the meta-analytic model Publication bias was downgraded due to the potential publication bias in the intervention arms The overall quality was downgraded from High to Moderate, from Moderate to Low, and from Low to Very Low							
Outcome: Anxiety							
7 studies, 8,799 participants	RCT, non-RCT, and pre-post	Non-serious	Serious	Serious	Non-serious	Serious	**Very Low**
Inconsistency was downgraded because the model reported substantial unexplained I^2 and significant QE test Indirectness was downgraded due to the different designs included in the meta-analytic model Publication bias was downgraded due to the potential publication bias in the intervention arms The overall quality was downgraded from High to Moderate, from Moderate to Low, and from Low to Very Low							
Outcome: Depressive Symptoms							
5 studies, 8,617 participants	RCT, and pre-post	Non-serious	Serious	Serious	Non-serious	Non-serious	**Low**
Inconsistency was downgraded because the model reported substantial unexplained I^2 and significant QE test Indirectness was downgraded due to the different designs included in the meta-analytic model The overall quality was downgraded from High to Moderate, and from Moderate to Low							
Outcome: Life Satisfaction							
3 studies, 2,353 participants	RCT	Non-serious	Non-serious	Non-serious	Non-serious	Non-serious	**High**
The overall quality was not downgraded							
Outcome: Strengths and Difficulties Questionnaire							
3 studies, 623 participants	RCT	Non-serious	Non-serious	Non-serious	Non-serious	Serious	**Moderate**
Publication bias was downgraded due to the potential publication bias in the intervention arms The overall quality was downgraded from High to Moderate							

Justification of magnitude of thresholds

The extent of overlap of the 95% CI with trivial or substantial (i.e., small, moderate, and large) values was used to assess sampling uncertainty. The extent of overlap was estimated as the areas of the sampling distribution falling in substantial (i.e., small, moderate, and large) and trivial magnitudes. These areas represent the probabilities that the true effect (i.e., very large sample effect) has those positive magnitudes. Thresholds for interpreting the probabilities for a given magnitude are provided in the table below. We interpreted the area of the sampling uncertainty below the normal distribution curve *on the right side of zero (positive magnitude)*

See Figs. 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

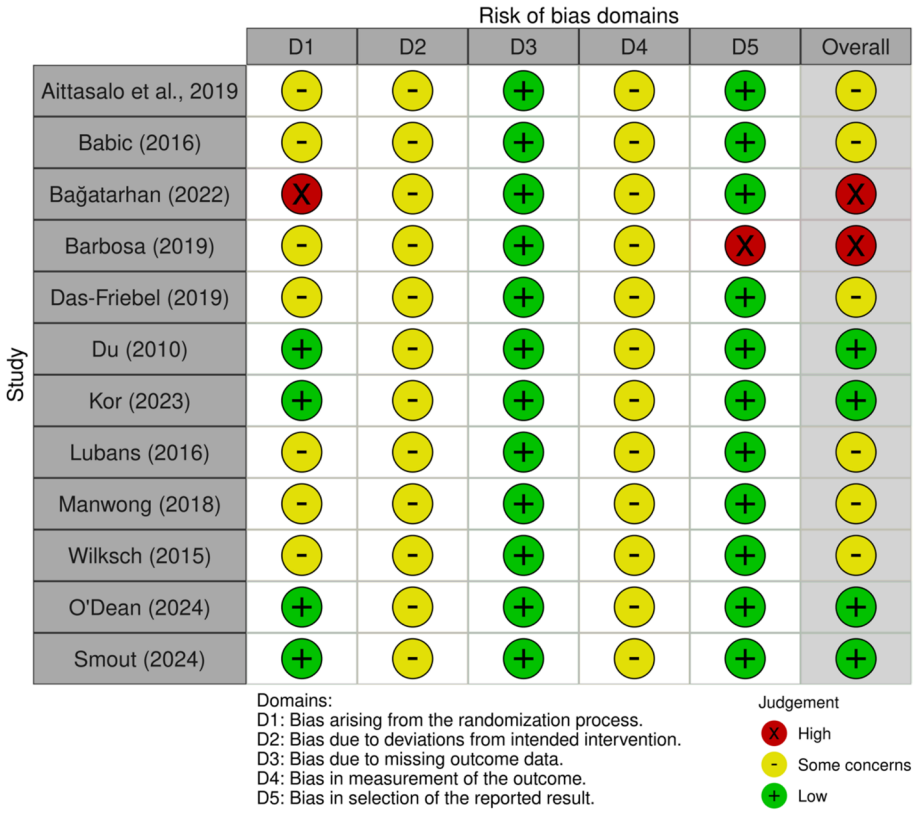


Fig. 8. Traffic-light Plot of the Risk of Bias for Rach Included Study (RoB2)

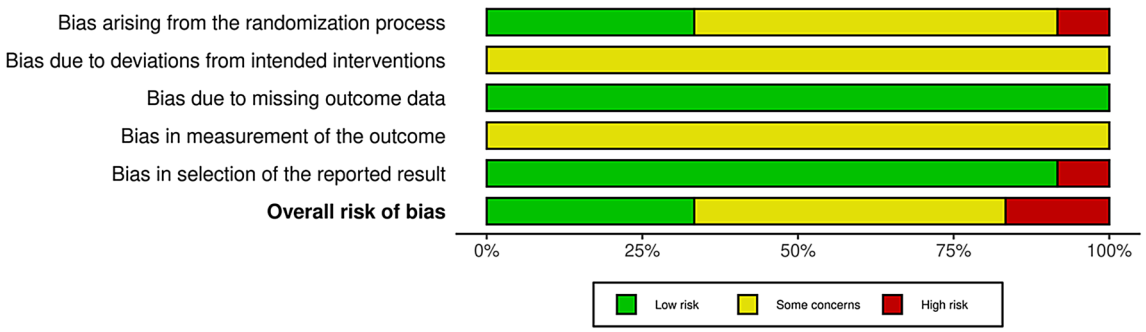


Fig. 9. Summary Plot of the Risk of Bias for Each RoB2 Domain

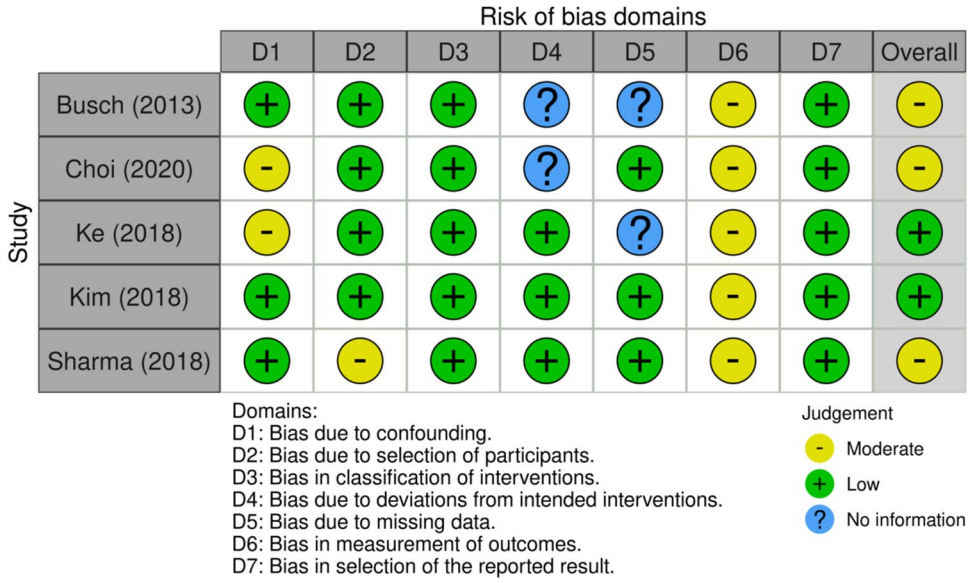


Fig. 10. Traffic-light Plot of the Risk of Bias for Rach Included Study (ROBINS-I)

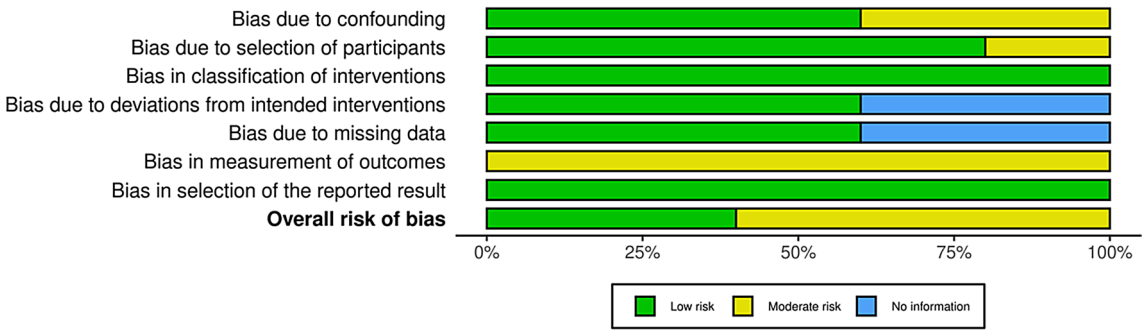


Fig. 11. Summary Plot of the Risk of Bias for Each ROBINS-I Domain

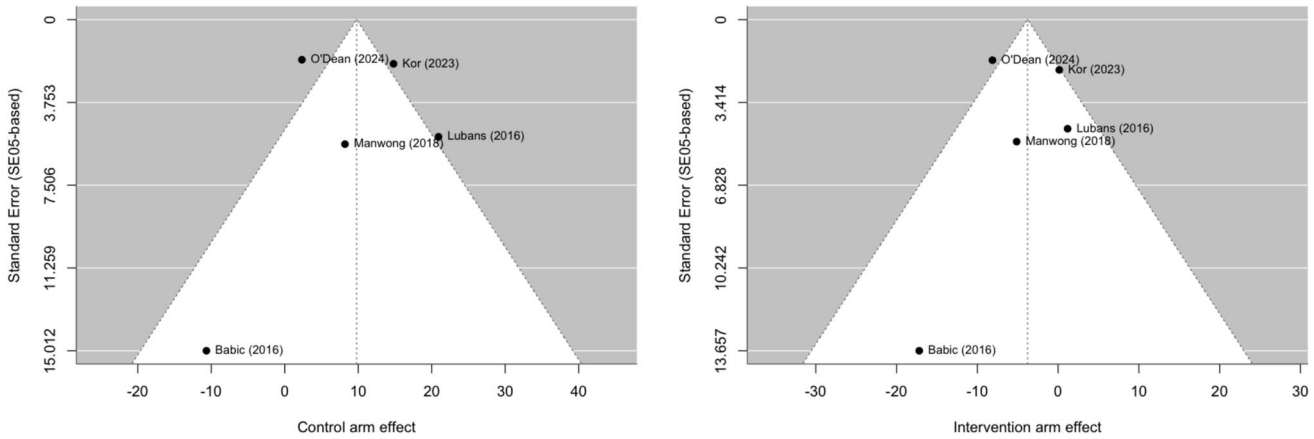


Fig. 12. Funnel Plots of the Meta-analysis of the Screen Time (hours/day)

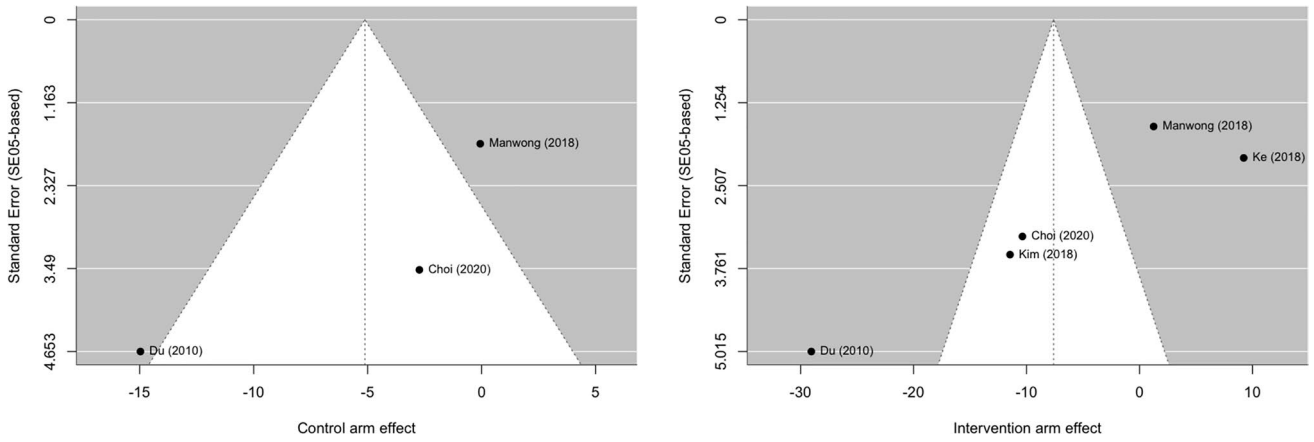


Fig. 13. Funnel Plots of the Meta-analysis of the Problematic Use

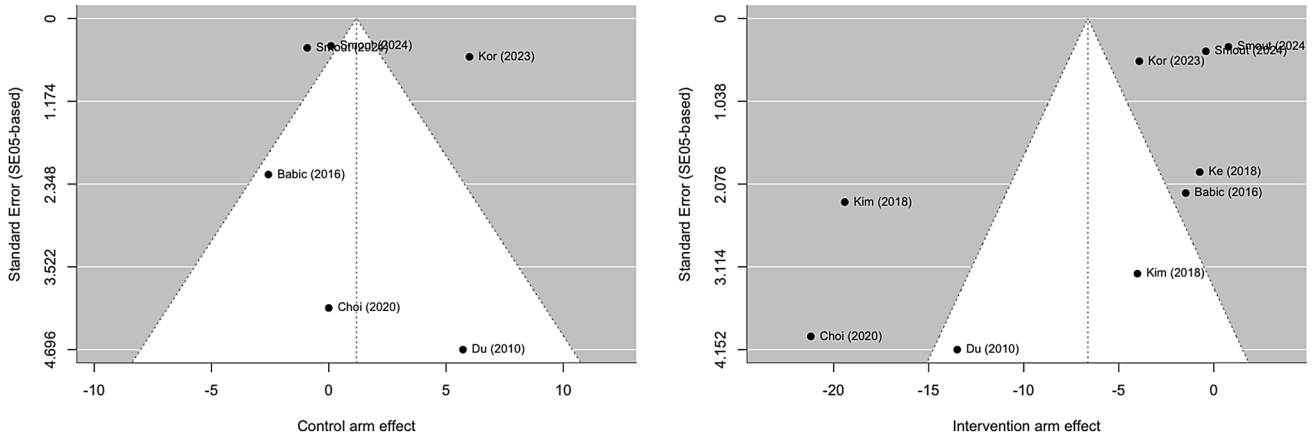


Fig. 14. Funnel Plots of the Meta-analysis of the Anxiety Scores

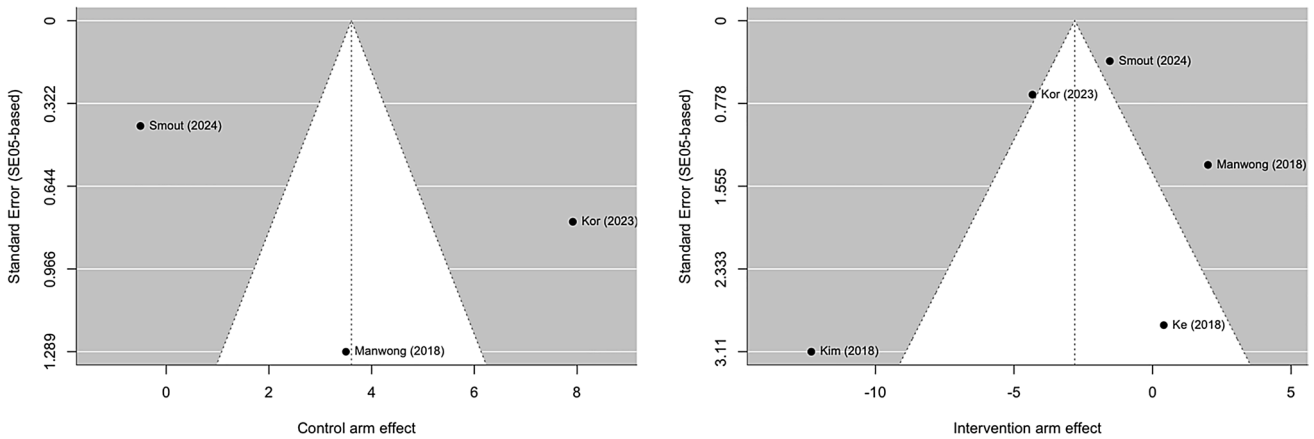


Fig. 15. Funnel plots of the meta-analyses of the Depressive Symptoms scores

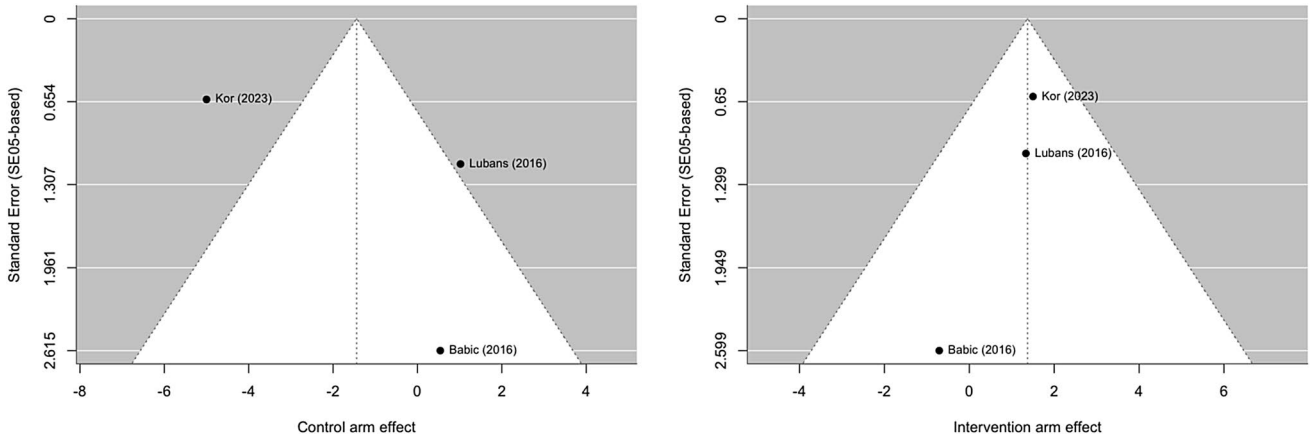


Fig. 16. Funnel Plots of the Meta-analysis of the Life Satisfaction and Flourishing Scale scores

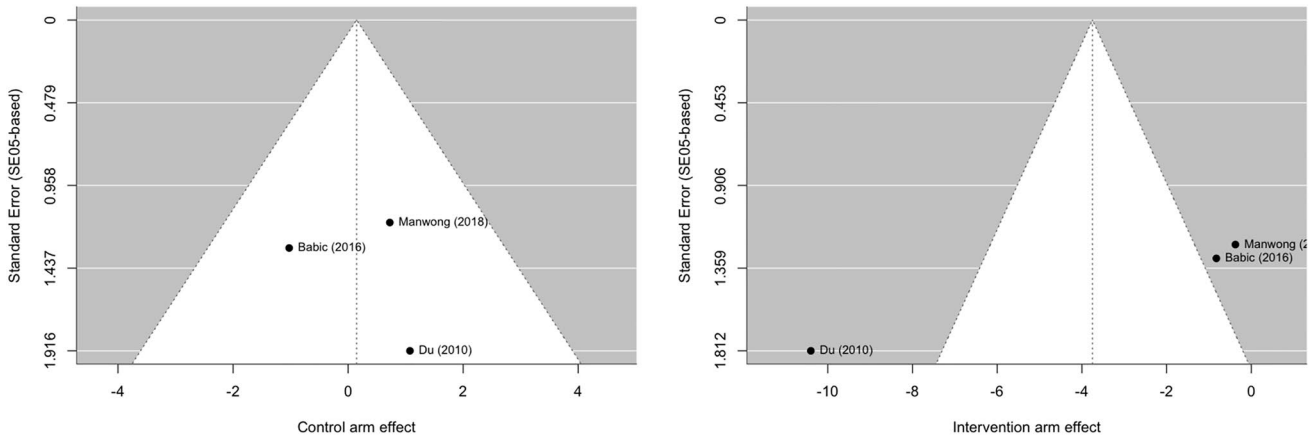


Fig. 17. Funnel Plots of the Meta-analysis of the Strengths and Difficulties Questionnaire—Psychological difficulties scores

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Authors' contributions SC participated in conceptualizing the study, protocol design, searching, screening, data synthesis, data analyses, and drafting of manuscript; PG participated in conceptualizing coordinating the study, drafting and revision of manuscript; PGV participated in screening, data synthesis, and revision of manuscript; GT participated in conceptualizing the study, protocol design, searching, screening, data analyses, and revision of manuscript. All authors listed have read and approved the final manuscript for publication.

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Data Availability The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Conflict of interests The authors have no conflicts of interest to declare that are relevant to the content of this article.

Generative AI and AI-assisted technologies in the writing process The authors declare that no generative AI were used in the data production, analysis, and writing processes of this manuscript.

Pre-registration The protocol for this systematic review and meta-analysis was registered both at the Open Science Framework (https://doi.org/10.17605/OSF.IO/CZGKX) and PROSPERO international prospective register of systematic reviews (CRD420250648902). Pre-registration included the study design, research questions, and the outcome variables of interest.

Ethical approval The study was conducted according to the guidelines of the Declaration of Helsinki. This systematic review and meta-analysis study uses data obtained from published records and do not require ethical approval.

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