

Association Between Screen Media Use and Academic Performance Among Children and Adolescents

A Systematic Review and Meta-analysis

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IMPORTANCE The health consequences of excessive screen media use in children and adolescents are increasingly being recognized; however, the association between screen media use and academic performance remains to be elucidated.

OBJECTIVES To estimate the association of time spent on screen-based activities with specific academic performance areas in children and adolescents and to examine this association separately in these populations.

DATA SOURCES MEDLINE, Scopus, Web of Science, Cochrane Database of Systematic Reviews, and ERIC were searched from database inception through September 2018.

STUDY SELECTION Cross-sectional studies of the association between time or frequency of screen media use and academic performance in children and adolescents were independently screened by 2 researchers. A total of 5599 studies, published between 1958 and 2018 from 23 countries, were identified.

DATA EXTRACTION AND SYNTHESIS Data were processed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Random-effects models were used to estimate the pooled effect size (ES).

MAIN OUTCOMES AND MEASURES Academic performance areas included composite scores, language, and mathematics. Screen media measurements included time or frequency of computer, internet, mobile phone, television, video game, and overall screen media use.

RESULTS In total, 58 cross-sectional studies (1.0%) of 5599 articles were included in the systematic review, of which 30 (52%) were included in the meta-analysis. The systematic review studies involved 480 479 participants aged 4 to 18 years, ranging from 30 to 192 000 people per study, and the meta-analysis studies involved 106 653 total participants, ranging from 70 to 42 041 people per study. Across studies, the amount of time spent on overall screen media use was not associated with academic performance (ES = -0.29 ; 95% CI, -0.65 to 0.08). Individually, television viewing was inversely associated with composite academic performance scores (ES = -0.19 ; 95% CI, -0.29 to -0.09), language (ES = -0.18 ; 95% CI, -0.36 to -0.01), and mathematics (ES = -0.25 ; 95% CI, -0.33 to -0.16). Video game playing was inversely associated with composite scores (ES = -0.15 ; 95% CI, -0.22 to -0.08). Subgroup analyses found that television viewing was inversely associated with language only in children (ES = -0.20 ; 95% CI, -0.26 to -0.15), whereas both television viewing (ES = -0.19 ; 95% CI, -0.30 to -0.07) and video game playing (ES = -0.16 ; 95% CI, -0.24 to -0.09) were inversely associated with composite scores only in adolescents.

CONCLUSIONS AND RELEVANCE Findings from this study suggest that each screen-based activity should be analyzed individually for its association with academic performance, particularly television viewing and video game playing, which appeared to be the activities most negatively associated with academic outcomes. Education and public health professionals should consider supervision and reduction to improve the academic performance of children and adolescents exposed to these activities.

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+ Editorial

+ Supplemental content

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Sedentary behaviors, defined as sitting or lying-down activities involving an energy expenditure of 1.0 to 1.5 basal metabolic equivalents,¹ are considered the fourth greatest risk factor of mortality worldwide.² Specifically, screen media use is the most popular leisure-time sedentary behavior among children and adolescents. Screen media use includes screen-based activities such as internet surfing, computer use, mobile phone use, television viewing, and video game playing.³ On average, during their free time, children and adolescents watch television between 1.8 and 2.8 hours, play video games for 40 minutes, and use a computer 34 minutes per day.³ Overall, 28% of children and adolescents are engaged in these screen-based activities more than 4 hours per day, with higher prevalence among boys than girls (30% vs 25%).³ Along with screen media's advantages of access to a wide variety of resources and fast communication, use of screen media has been associated with adverse physical, psychological, and social health consequences.^{4,5}

A growing body of evidence suggests that screen media use could play a key role in cognition (ie, brain processes involved in knowledge, intellect, and action) and academic performance (ie, academic achievement and abilities) in children and adolescents.^{6,7} For instance, recent empirical research has reported that screen media use may reduce functional connectivity between cognitive areas.⁷ However, studies into the association between screen media use and academic performance have shown controversial results, reporting not only negative⁶⁻⁹ but also positive^{10,11} and null associations.^{12,13}

Previous systematic reviews in children and adolescents have focused on the association of television viewing and video game playing with academic performance, showing a negative association.^{14,15} More than 2 hours per day of television viewing has been associated with lower academic performance in children and adolescents.¹⁴ However, to our knowledge, no previous systematic review and meta-analysis has examined the association of several screen-based activities with different academic performance areas in these age populations.

Given the increasing time spent on screen-based activities among children and adolescents, elucidating the association between sedentary behaviors and academic performance, which has been shown as a factor in future health¹⁶ and work opportunities, is important.¹⁷ Thus, the aim of this systematic review and meta-analysis was 2-fold: (1) to estimate the association of time spent on screen-based activities with specific academic performance areas in children and adolescents and (2) to examine this association separately in children and adolescents.

Methods

This systematic review and meta-analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)¹⁸ and the Cochrane handbook.¹⁹ The study protocol was registered on the International Prospective Register of Systematic Reviews (PROSPERO reference number CRD42018090388).

Key Points

Question What is the association between screen-based activities and academic performance areas among children and adolescents?

Findings In this systematic review and meta-analysis of 58 cross-sectional studies, television viewing and video game playing (but not overall screen media) were inversely associated with the academic performance of children and adolescents. In addition, the negative association between these screen-based activities and academic performance seemed greater for adolescents than for children.

Meaning This study suggests that education and public health professionals should consider screen media use supervision and reduction as strategies to improve the academic success of children and adolescents.

Search Strategy and Inclusion Criteria

We systematically searched MEDLINE (via PubMed), Scopus, Web of Science, Cochrane Database of Systematic Reviews, and ERIC databases from their inception through September 2018. The search strategy included the following relevant terms: *screen time, screen media, electronic media, internet use, computer use, mobile phone use, television watching, TV watching, television viewing, TV viewing, television programs, video game, and video viewing; scholastic, academic performance, academic achievement, school grades, mathematics, language, reading, and writing; and children, childhood, preschooler, schoolchildren, preadolescent, adolescent, and youth*. In addition, the reference lists of the articles included in this review and the references from previous systematic reviews and meta-analyses were reviewed to identify other relevant studies.

Primary source articles published in peer-reviewed journals were eligible for inclusion if the data were in regard to the association between screen media use time or frequency and academic performance in children and adolescents. Specific inclusion criteria were as follows: (1) participants: children and adolescents aged 4 to 18 years or primary, elementary, and secondary school students; (2) exposure: usage time or frequency of screen-based activities; (3) outcomes analyzed: academic performance assessed by school grades, standardized tests, or other measurements, such as school performance or academic failure; (4) study design: cross-sectional studies; and (5) language: articles published in English or Spanish.

Studies were excluded if they did not meet the inclusion criteria or did not report findings concerning the association between time or frequency of screen media use and academic performance (ie, measurements of screen media use time or frequency and academic performance were included, but their association was not analyzed). Inclusion of toddlers or participants with disorders that could limit the generalization of the data was also a reason for exclusion.

Data Extraction and Quality Assessment

Two of us (M.A.-R., C.A.-B.) independently screened the full texts of selected studies. One of us (M.A.-R.) extracted data from

the selected studies, and another (C.A-B.) checked the data for accuracy. A standardized data extraction table was created (eTable 1 in the Supplement) and included the following data from all eligible articles: author, year of publication, country of the study, sample size (with percentage of girls), age of participants, main exposures (screen-based activities), main outcomes (academic performance indicators), and control variables.

After concealing information about authors, affiliations, date, and source of each article included in the review, 2 of us (M.A-R., C.A-B.) independently evaluated their methodological quality. Discrepancies were settled by consensus.

The Quality Assessment Tool for Observational Cohort and Cross-sectional Studies was used to evaluate the risk of bias.²⁰ The checklist comprised 14 items for longitudinal research, of which only 11 could be applied to cross-sectional studies. Each item of methodological quality was classified as yes, no, or not reported.

Statistical Analysis

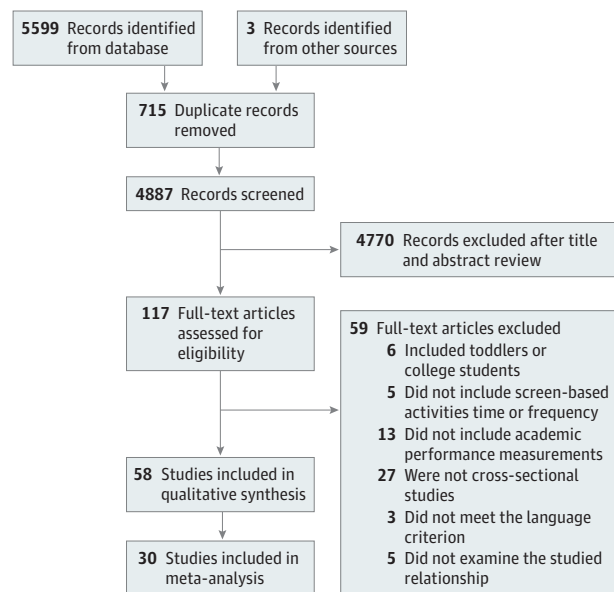
Detailed statistical procedures used in this meta-analysis followed the recommendations of previous protocols.²¹ Academic performance indicators were classified according to 3 main areas: composite scores, language, and mathematics. In addition, screen-based activities were classified as computer use, internet surfing, mobile phone use, television viewing, video game playing, and overall screen media (a composite measure of 2 or more screen-based activities). At least 3 observations in each academic performance area or in each screen-based activity were requested for conducting the meta-analysis, and only unadjusted correlations and regression coefficients were considered for these analyses.

The effect size was calculated with Cohen *d* index²² by using random-effects models based on the Der Simonian and Laird method, considering each screen-based activity and academic performance area. Heterogeneity was assessed with the *I*² statistic, and its values were classified as not important (0%-40%), moderate (30%-60%), substantial (50%-90%), or considerable (75%-100%)²³; the corresponding *P* values were also considered. When studies included 2 or more cohorts or groups, their data were analyzed as independent samples.

Analyses of the association between screen-based activities and academic performance areas were performed by subgroups of age: children were between 4 and 11.9 years of age, and adolescents were between 12 and 18 years of age. In addition, random-effects meta-regression analyses were conducted to examine whether age (in years) was a factor in these associations. At least 10 observations for each association were required to conduct random-effects meta-regression analyses. Sensitivity analyses were performed to estimate the association of each study with the pooled effect size. The Egger regression asymmetry test was conducted to assess publication bias, considering *P* < .10 to be statistically significant.²⁴

Statistical analyses used StataSE software, version 14 (StataCorp LLC). A 2-sided *P* < .05 indicated statistical significance.

Figure 1. Flow Diagram



Results

A total of 5599 records were identified after literature search (Figure 1). Fifty-eight cross-sectional studies (1%)^{8-13,25-76} were selected from these records for inclusion in this systematic review, of which 30 (52%) were included in the meta-analysis.

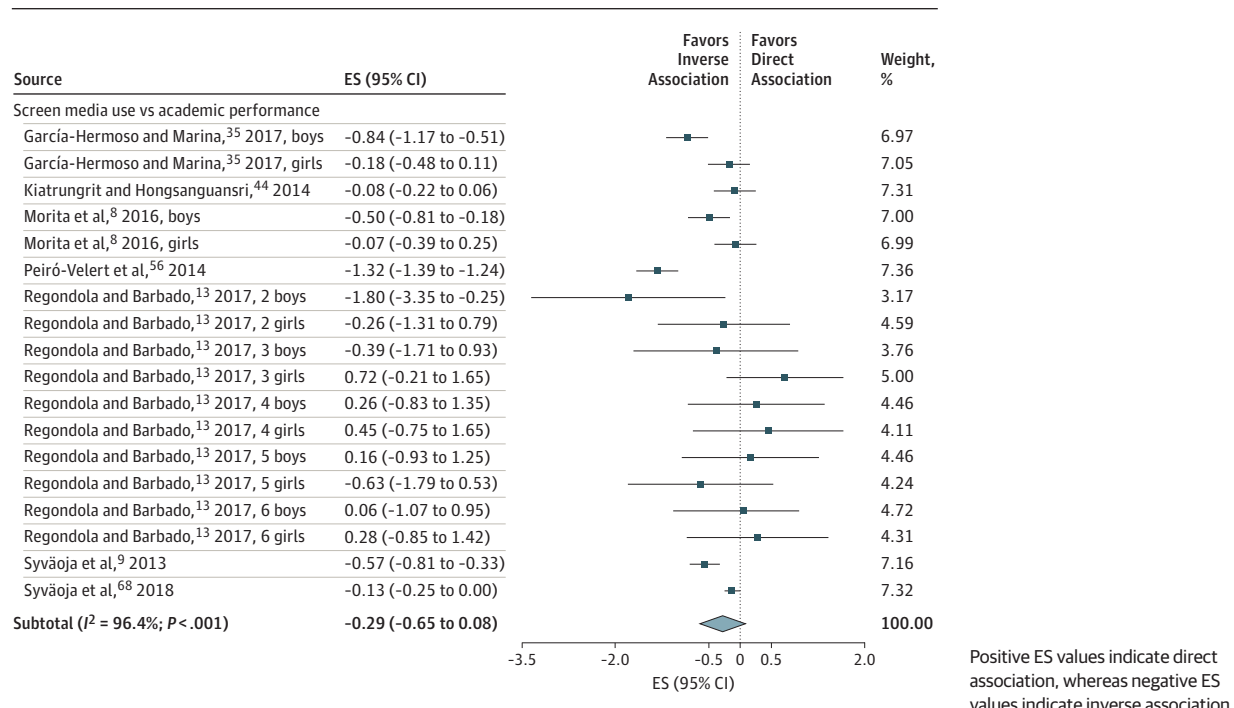
A summary of the cross-sectional studies included in this review is provided in eTable 1 in the Supplement. Articles were published between 1958 and 2018, and the studies involved participants aged 4 to 18 years from 23 countries. Eighteen studies originated from 10 European countries, 14 from 8 Asian countries, 23 from 2 North American countries, 2 from 2 South American countries, and 1 from a country in Oceania. Studies included in the systematic review involved a total of 480 479 participants, ranging from 30 to 192 000 people per study, whereas the studies included in the meta-analysis involved 106 653 total participants, ranging from 70 to 42 041 people per study.

Of the 58 studies in the systematic review, 4 studies (7%) reported data on computer use, 9 (15.5%) on internet surfing, 5 (9%) on mobile phone use, 36 (62%) on television viewing, 23 (40%) on video game playing, and 10 (17%) on overall screen media time or frequency. Regarding the outcomes analyzed, most studies used school grades (*n* = 25 [43%]) or standardized academic achievement tests (*n* = 21 [36%]), whereas other studies reported academic failure data (*n* = 4 [7%]) or self-reported academic achievement (*n* = 6 [10%]) or school performance (*n* = 6 [10%]).

Study Quality

Studies met from 27.3% to 81.8% of the quality criteria, with 36 studies (62%) meeting more than 50% of the quality criteria as assessed by the Quality Assessment Tool for Observational Cohort and Cross-sectional Studies²⁰ (eTable 3 in the

Figure 2. Pooled Estimated Effect Size (ES) of the Association Between Overall Screen Media Time or Frequency and Composite Scores of Academic Performance



Supplement). Most studies clearly stated the main aim and plainly defined the exposure variables. However, 23 studies (40%) did not include objectively measured outcomes, and 23 (39%) did not use key potential confounders in the analyses. For instance, 30 (52%) of the 58 included studies did not consider potential confounders associated with home environment and parental characteristics.

Systematic Review

Among the 58 included studies, 47 (81%) examined the linear associations or mean differences between time spent on screen-based activities and academic performance in children and adolescents (eTable 2 in the Supplement). Cross-sectional data from these studies showed that time spent on overall screen media, specifically television viewing, was inversely associated with academic performance in most unadjusted and adjusted analyses.

Regarding video game playing, results were controversial because studies mainly reported an inverse association or a lack of association with composite scores. Lack of association also predominated in those studies analyzing the association of video game playing with language and mathematics.

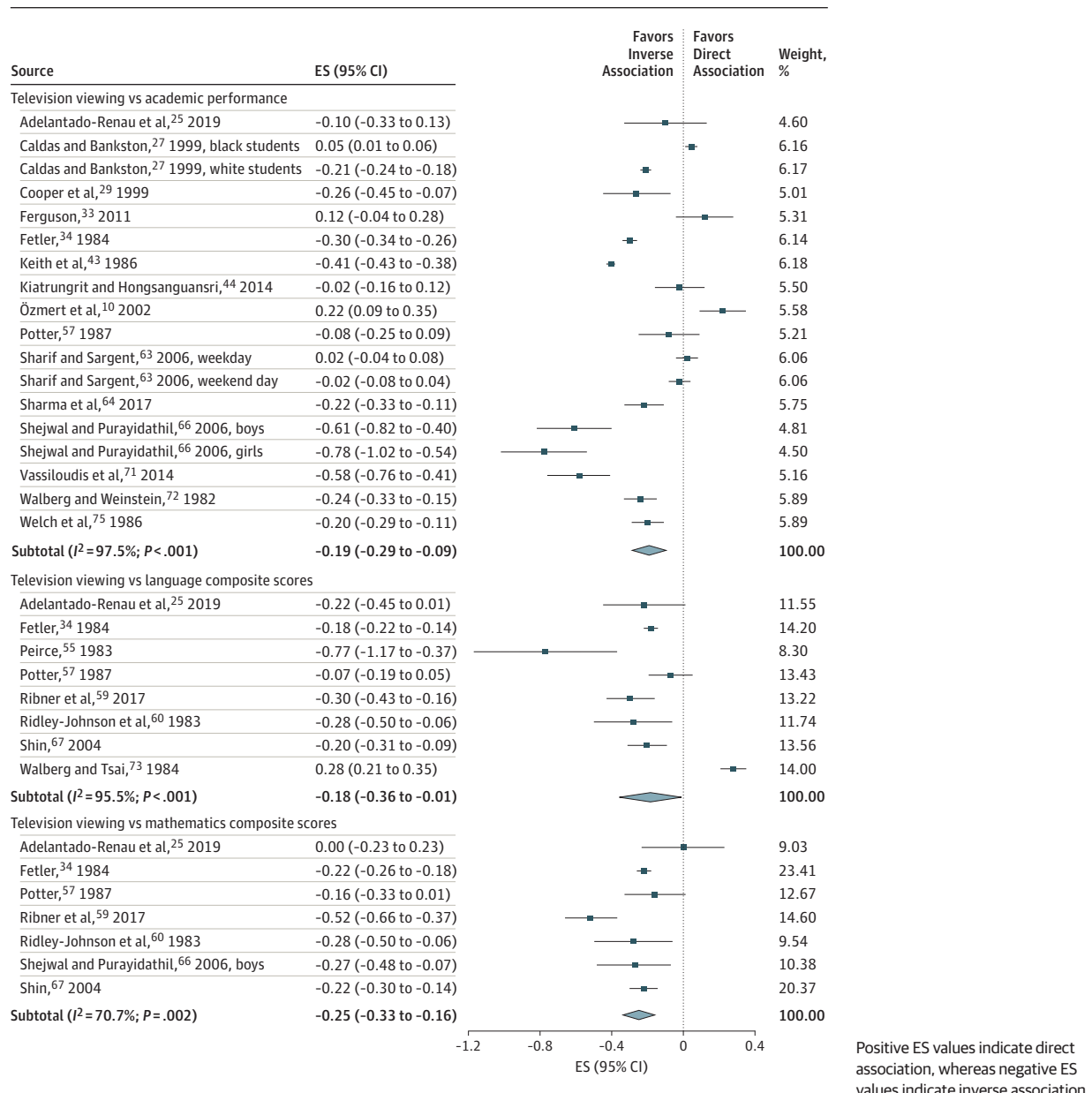
Studies of the association between internet surfing and academic performance reported an inverse association with composite scores and mathematics and divergent results regarding language. Regarding computer use, only 2 studies analyzed this screen-based activity and showed divergent results: no association⁴⁴ and positive association.⁵⁶ Overall, mobile phone use was not associated with academic performance indicators.^{40,44}

In addition, other studies included in this systematic review reported odds ratios (n = 8) and difference of proportions (n = 3). Among these studies, 2 assessed the association between time spent on overall screen media and academic performance.^{32,74} Wang et al⁷⁴ showed an inverse association, whereas Faught et al³² reported a positive association of screen media with academic performance when adolescents spent from 2 to 4 hours on screen-based activities, but a negative association was found when they spent 7 or more hours per day. Four studies investigating whether time or frequency of television viewing was associated with academic performance showed divergent results: a lack of association^{52,65} or a negative association.^{69,76} Three studies analyzed the association between video game playing and academic performance^{41,47,53}; Jaruratanasirikul et al⁴¹ and Muñoz-Miralles et al⁵³ reported an inverse association, whereas Kovess-Masfety et al⁴⁷ found that high use was associated with 1.88 times the odds of high overall school competence. Two studies examined the association between internet use time and academic performance.^{45,61} Kim et al⁴⁵ found a negative association between internet surfing for entertainment purposes and academic performance, but a positive association was found when the internet was used for educational activities. Sánchez-Martínez and Otero Puime⁶¹ showed that high internet surfing frequency and no internet use were both associated with academic failure.

Meta-analysis

The pooled effect size estimation for the association between overall screen media time or frequency and composite scores

Figure 3. Pooled Estimated Effect Size (ES) of the Association Between Television Viewing Time or Frequency and Composite Scores, Language, and Mathematics



was -0.29 (95% CI, -0.65 to 0.08). This estimate showed a considerable heterogeneity among studies ($I^2 = 96.4\%$; $P < .001$) (Figure 2).

In the analysis of the association between duration of television viewing and academic performance areas, the pooled effect sizes were -0.19 (95% CI, -0.29 to -0.09) for composite scores, -0.18 (95% CI, -0.36 to -0.01) for language, and -0.25 (95% CI, -0.33 to -0.16) for mathematics (Figure 3). Considerable heterogeneity was found among the included studies for the association of duration of television viewing with composite scores ($I^2 = 97.5\%$; $P < .001$) and language ($I^2 = 95.5\%$; $P < .001$), whereas substantial heterogeneity was observed for mathematics ($I^2 = 70.7\%$; $P = .002$).

Data for the association between duration of video game playing and composite scores showed a pooled effect size of -0.15 (95% CI, -0.22 to -0.08). A large heterogeneity was found among studies ($I^2 = 63.0\%$; $P = .004$) (Figure 4).

Subgroup analyses conducted separately in children and adolescents (Table) showed that, in children, the duration of television viewing was inversely associated with language (effect size = -0.20 ; 95% CI, -0.26 to -0.15) and mathematics (effect size = -0.36 ; 95% CI, -0.66 to -0.07). However, in adolescents, the duration of television viewing was inversely associated with composite scores (effect size = -0.19 ; 95% CI, -0.30 to -0.07) and mathematics (effect size = -0.21 ; 95% CI, -0.26 to -0.15). In addition, the duration of video game play-

Figure 4. Pooled Estimated Effect Size (ES) of the Association Between Video Game Playing Time or Frequency and Composite Scores of Academic Performance

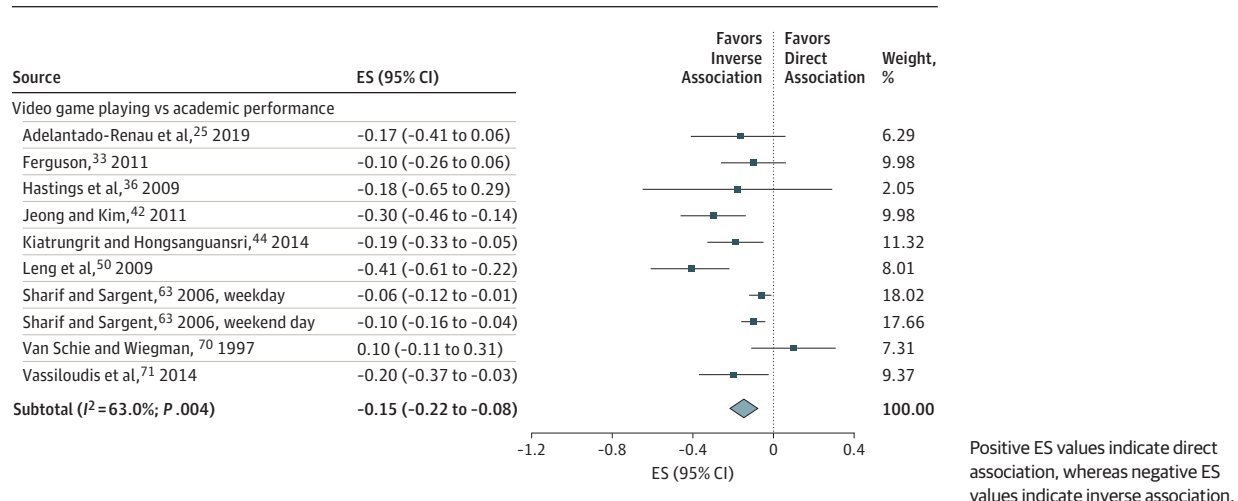


Table. Subgroup Analysis of the Association Between Duration of Screen-Based Activities and Academic Performance Areas in Children and Adolescents

Activity	No. of Studies Included in Subgroup Analysis	Effect Size (95% CI)	Heterogeneity, I^2
Children, 4-11.9 y			
Screen media ^a			
Composite scores	11	-0.15 (-0.52 to 0.23)	42.4
Television viewing			
Composite scores	3	-0.22 (-0.59 to 0.16)	97.1
Language	3	-0.20 (-0.26 to -0.15) ^b	29.1
Mathematics	2	-0.36 (-0.66 to -0.07) ^b	92.1
Video game playing			
Composite scores	2	0.04 (-0.18 to 0.26)	12.0
Adolescents, 12-18 y			
Screen media ^a			
Composite scores	6	-0.50 (-1.11 to 0.10)	98.4
Television viewing			
Composite scores	14	-0.19 (-0.30 to -0.07) ^b	97.8
Language	5	-0.18 (-0.47 to 0.12)	94.3
Mathematics	5	-0.21 (-0.26 to -0.15) ^b	9.7
Video game playing			
Composite scores	7	-0.16 (-0.24 to -0.09) ^b	68.9

Positive ES values indicate direct association, whereas negative ES values indicate inverse association.

^a Screen media indicates a composite measure of 2 or more screen-based activities.

^b Statistically significant values.

ing was inversely associated with the composite scores of adolescents (effect size = -0.16; 95% CI, -0.24 to -0.09).

The random-effects meta-regression model showed that the associations of overall screen media (β , -0.0005; 95% CI, -0.131 to 0.130; $P > .99$), television viewing (β , -0.056; 95% CI, -0.117 to 0.006; $P = .07$), and video game playing (β , -0.009; 95% CI, -0.121 to 0.104; $P = .82$) with composite scores were not associated with the age of children and adolescents (as a continuous variable) (eTable 4 in the Supplement).

Sensitivity analyses suggested that the pooled effect size estimation for the association between television viewing and language was slightly modified when data from several studies were removed, with effect size ranging from -0.21 to

-0.13.^{25,34,55,57,59,60,67} The pooled effect sizes for the remaining associations were not modified by the one-by-one removal of the included cohorts (eTable 5 in the Supplement).

Funnel plots and the Egger asymmetry test indicated statistically significant publication bias only for the pooled subgroup analyses of the association between overall screen media and composite scores (effect size = 0.80; 95% CI, 0.16-1.43; $P = .02$; eFigure in the Supplement).

Discussion

To our knowledge, this systematic review and meta-analysis is the first to synthesize the evidence on the cross-sectional

associations between time spent on overall screen media, different screen-based activities, and specific academic performance areas in children and adolescents. The meta-analysis indicates a lack of association between the amount of time spent on overall screen media use and the academic performance of children and adolescents. However, when the association between each screen-based activity and academic performance was analyzed, television viewing was inversely associated with composite scores, language, and mathematics, whereas video game playing was inversely associated with composite scores. In addition, subgroup analyses conducted separately in children and adolescents showed that the duration of these screen-based activities may have a greater association with the academic performance of adolescents than children.

The lack of association between the overall time spent on screen-based activities and academic performance does not concur with previous research reporting a negative association between overall screen media time and academic performance.^{7-9,30,56} One study found that adolescents who spent more than 7 hours per day on overall screen media were 40% less likely to achieve high academic performance, whereas those who spent 2 to 4 hours per day had 1.23 times the odds of achieving excellent grades compared with those who spent fewer than 2 hours per day.³² We speculate that the lack of association between overall screen media use and academic performance found in this meta-analysis as well as the lack of agreement among studies could be partially the result of several aspects of the overall screen media time measure that are not captured, such as the specific device used, the purpose of the task, the content, and the context in which children and adolescents use screen media.

Regarding the association between the duration of individual screen-based activities and academic performance, our results concur with previous research showing an inverse association of television viewing with composite scores,^{29,64,66,71} language,^{59,67} and mathematics.^{59,77} Previous research has suggested that television viewing replaces other activities such as physical activity, verbal interaction, studying, or sleeping (ie, the time-displacement hypothesis)⁶ and reduces mental effort (ie, the passivity hypothesis), which might affect school performance.⁶⁷ In addition, excessive television viewing time among children has been shown to decrease attention and cognitive functioning⁷⁸ and to increase behavioral problems and unhealthy eating habits,⁶⁷ which may also impair academic outcomes.

The analysis of video game revealed an inverse association between the duration of video game playing and composite scores, in consonance with previous research.^{42,44,50,63} Previous studies have shown that playing video games is inversely associated with emotional and social health, triggering psychological and behavioral problems^{15,79} that may have implications for overall academic outcomes. Conversely, because playing video games requires interaction with the task, it could also be positively associated with academic outcomes depending on the game content. Evidence has indicated that playing video games requires players to successfully understand the language⁷⁰ and might increase their engagement with text online.⁸⁰

Regarding internet surfing, few studies have analyzed its association with academic performance in children and adolescents. Most studies showed an inverse association between internet overuse and academic performance, although they did not consider the device used (ie, computer, smartphone, or tablet) or the purpose of internet use.^{25,26,31,61} Kim et al⁴⁵ showed that internet use time was inversely associated with academic performance when used for leisure activities but was positively associated when used for educational purposes. With regard to the device used, the association between time of computer use and academic performance in children and adolescents remains equivocal, with both negative⁵³ and positive³⁹ associations found, whereas the duration of mobile phone use has been poorly investigated, suggesting a lack of association with academic performance.^{39,40,44} Overall, this systematic review and meta-analysis highlights the need for further research into individual types of screen-based activities given their varying associations with the academic performance of children and adolescents.

Subgroup analyses conducted separately in children and adolescents indicated an inverse association between the duration of television viewing and language only in children, showing that time spent on screen-based activities was mostly associated with negative implications for academic performance in adolescents. These findings agree with those in previous studies, suggesting that only young children (aged 2-3 years) may gain an advantage from watching educational programs because they learn from repetitions.⁶ However, this method is not efficient for developing more complex academic abilities during late childhood, when high exposure to television viewing has been shown to increase the risk of language-derived problems.⁸¹ Among adolescents, the facilitated and simultaneous access to different screen-based activities for different purposes (eg, social communication, online networking, and playing games), which is a signature of contemporary society, could explain the greater negative association of these activities with academic performance.

Although the data show that the association between screen media use and academic performance seems to depend on the age of children and adolescents and the type of device they used, the exact nature of these associations still needs a more nuanced consideration. In addition to these 2 factors, screen media use content, context, and task should be analyzed given that each sedentary screen-based activity (eg, talking to someone, looking at magazines, or playing) might have a different implication for academic performance.^{82,83} Moreover, previous studies have suggested that the home environment and parental characteristics (eg, socioeconomic status and parental support) may be stronger factors in academic performance compared with the amount of screen media use per se.²⁸ A restricted budget likely does not allow children and adolescents to buy books or to participate in out-of-school educational activities. At the same time, parents with high educational level and knowledge of pediatric media guidelines as well as parents who support and have high expectations for their children's future might discourage activities with low educational value,⁶ such as television viewing or video game playing. However, these factors were considered in only 48% of in-

cluded studies in the present systematic review. Thus, further investigations of these potential aspects are needed to clarify the association between screen media use and academic performance in children and adolescents.

These findings have public health implications for the prevention of academic failure in children and adolescents as well as support the need for designing interventions to reduce screen media use beginning in early childhood. Given that previous systematic reviews and meta-analyses have shown that the effectiveness of interventions to reduce screen time is higher when including health promotion curricula or counseling,⁸⁴ teachers and public health professionals should collaborate to achieve better results. Thus, in addition to controlling access to screen media and reducing the exposure to screen-based activities, particularly to television and video games, interventions should include the promotion of active and healthy lifestyles. More in-depth studies of the consequences of excessive screen media use and its association with health and cognition are warranted, which will inform the advice provided to families, educators, and health policymakers.

Limitations and Strengths

This systematic review and meta-analysis have some limitations. First, the cross-sectional design of the included studies prevents causal inferences. Second, the questionnaires to assess screen media use and the variety of tools to measure academic performance, as well as the inclusion of articles published only in English or Spanish, could have altered the results. Third, subgroup analyses could not be conducted for some of the screen-based activities and/or academic performance areas.

Fourth, the purpose, content, and context of screen media use; socioeconomic status; and/or parental support were not taken into account in the analyses.

Nonetheless, this systematic review and meta-analysis have several strengths, including the inclusion of a wide range of screen-based activities and different academic performance areas. In addition, only 22 studies met less than 50% of quality criteria, and subgroup analyses were conducted to examine the implication of age for the studied associations.

Conclusions

The findings from this systematic review and meta-analysis suggest that each screen-based activity should be analyzed individually because of its specific association with academic performance. Television viewing and video game playing seem to be the activities most negatively associated with academic performance, particularly among adolescents. Moreover, this study highlights the need for further research into the association of internet, computer, and mobile phone use with academic performance in children and adolescents. These associations seem to be complex and may be moderated and/or mediated by potential factors, such as purpose, content, and context of screen media use. Given that both academic performance and sedentary behaviors can be factors in future health, education and public health professionals should consider supervision and reduction as strategies for television viewing and video game playing to improve both the health status and academic performance of children and adolescents exposed to these activities.

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