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Review article

The Health Indicators Associated With Screen-Based Sedentary Behavior Among Adolescent Girls: A Systematic Review

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A B S T R A C T

Purpose: Evidence suggests sitting time is independently associated with a range of health issues in adults, yet the relationship between sedentary behavior and health indicators in young people is less clear. Age-related increases in sedentary behavior are well-documented; the behavioral patterns of adolescent girls are of particular concern. More than one third of adolescent girls' sedentary behavior time is accumulated through use of recreational screen-based behaviors. The objective of this review was to investigate the association between recreational screen-based sedentary behavior and the physical, behavioral, and psychosocial health indicators for adolescent girls. A secondary objective was to identify studies that have adjusted sedentary behavior indicators for physical activity.

Methods: A structured electronic search of all publication years (through December 2011) was conducted to identify studies in: CINAHL, Communications and Mass Media Complete, ERIC, MEDLINE with Full Text, PsycINFO, and SPORTDiscus with Full Text. Included publications were observational and interventional studies involving adolescent girls (12–18 years) that examined associations between screen-based, sedentary behavior and health indicators (physical, psychosocial, and/or behavioral). The search identified 33 studies that evaluated health indicators of screen-based sedentary behaviors among adolescent girls.

Results: Strong evidence for a positive association between screen-based sedentary behavior and weight status was found. A positive association was observed between screen-time and sleep problems, musculoskeletal pain and depression. Negative associations were identified between screen time and physical activity/fitness, screen time and psychological well-being, and screen time and social support. The relationship between screen-based sedentary behavior and diet quality was inconclusive. Less than half of the studies adjusted sedentary behavior indicators for physical activity.

Conclusions: Screen-based sedentary behavior is associated with a range of adverse health consequences, but additional longitudinal studies are needed to better understand the health impacts. In addition, screen-time guidelines for youth should be regularly revised and updated to reflect rapid technological changes.

IMPLICATIONS AND CONTRIBUTION

Screen-based sedentary behavior was associated with numerous health consequences and some social benefits for adolescent girls. More time spent engaging in screen-based activities resulted in greater health consequences. Four hours of daily screen time had the most harmful effects. Interestingly, adverse health outcomes persist even when participating in sufficient physical activity.

Conflict of Interest: The authors declare that there are no conflicts of interest.

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Sedentary behavior refers to activities that require minimal body movement [1]. The term "physical inactivity" is often used interchangeably with "sedentary behavior," implying it is the absence of "physical activity" [2]; rather, sedentary behavior

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refers to activities that result in levels of energy expenditure similar to resting level (1.0 to 1.5 metabolic equivalent) [3]. Sedentary behaviors include sitting for a range of purposes (e.g., work, travel) and screen-based activities such as computer/internet use, nonactive electronic gaming, and television viewing. Time spent being sedentary has emerged as an important indicator of health in adult populations [2]. In adults, strong evidence exists linking sedentary behavior to overweight and obesity [4], cardiovascular disease [5], adverse metabolic profiles [6], poor fitness [7], osteoporosis [8], diabetes [4], breast cancer [9], and reduced psychosocial functioning [10].

Although previous studies have explored the mechanisms through which sedentary behavior adversely influences health in adults, the evidence in adolescents is less clear. For example, a number of studies have found that time spent in sedentary activities displaces time available for engaging in sport and active recreation [11,12], but others have found that individuals can be both highly active and highly sedentary [13,14]. Alternatively, evidence indicates that specific sedentary activities, such as television and DVD viewing, are associated with poor dietary behaviors (e.g., unhealthy snacking/overconsumption of food and high-energy drinks). It has also been suggested that the cardiometabolic processes associated with prolonged sitting, which have been found in adults [15], may also apply to youth.

An age-related increase in sedentary behavior has been well-documented, with greatest increases observed during early adolescence [16,17]. Sedentary behavior during adolescence has generally been associated with increased body weight [7,8,18], which is concerning because sedentary habits established during adolescence are likely to track into adulthood [19]. Recreational screen-based sedentary behavior is an important focus area because screen-based behaviors such as television viewing results in lower energy expenditure compared with other sedentary activities such as playing board games, writing, and reading [4]. Screen-time guidelines for youth have emerged that recommend young people participation in screen-based sedentary behaviors should not exceed 120 minutes per day [20–23].

Improving our understanding of the health indicators associated with screen-time in adolescent girls is important for a number of reasons. Activity levels are consistently lower among girls [24] and the physical activity decline associated with adolescence is more pronounced in adolescent girls [25,26]. There is evidence suggesting that adolescent girls spend more time in sedentary pursuits, such as watching television, compared with boys [27]. Considering the potential adverse outcomes associated with excessive screen time and decreased physical activity, there is a need to examine the health indicators associated with screen time in this target population. In addition, the prevalence of internalizing mental health disorders such as depression, anxiety, and low self-esteem is higher among girls [28,29]. In summary, unbiased synthesis of existing research focusing on the association between health outcomes and screen time may assist in providing evidence to guide targeted programs and health guidelines and recommendations for girls.

Recent reviews [30,31] in children and adolescents have primarily focused on sedentary behavior and the associated physical health outcomes. Less is known regarding behavioral and psychosocial outcomes associated with screen-based sedentary behavior in youth [11]. To present a broad overview of various health indicators related to screen time, the primary aim of this systematic review is therefore to investigate the association between time spent engaging in recreational screen-based sedentary behavior (specifically television viewing, computer/internet use, and/or electronic gaming) and the physical, behavioral and psychosocial health indicators in adolescent girls.

In addition, sedentary behavior has been reported as a health risk factor in adults for obesity, elevated metabolic risk profiles, and poor cardiorespiratory fitness, independent of achieving sufficient physical activity [32–34], but evidence for this relationship in adolescents is inconsistent. Although Tremblay and colleagues [31] did not consider physical activity as a potential confounder of the relationship between sedentary behavior and health outcomes in their meta-analyses, a more recent high-quality study found that sedentary behavior was not associated with cardiometabolic risk factors in youth after adjusting for physical activity. Therefore a secondary objective of our review was to identify studies examining adolescent girls that have specifically adjusted for physical activity participation in order to further understand this relationship.

Methods

Search strategy

A structured electronic search employing PRISMA reporting guidelines [35] of all publication years (through December 2011) using CINAHL, Communications and Mass Media Complete, ERIC, MEDLINE with Full Text, PsycINFO, and SPORTDiscus with Full Text was conducted. The following search strings were used: (adolesce* or youth* or teen* or young person) AND (girl* or female*) AND (sedentary behavio* or screen time or television or TV or computer or internet or video game* or electronic game*). These strings were further limited to subjects aged 12 to 18 years and published in English language. Published articles in peer-reviewed journals were considered for the review. First, titles and abstracts of articles identified in the search process were assessed for suitability and additional articles known to the author were assessed for possible inclusion. Second, full-text articles were retrieved and assessed for inclusion. Third, reference lists from retrieved full-text articles were searched. Finally, reference lists from relevant papers (e.g., previous reviews) were examined for additional studies.

Study selection criteria

Studies were consider eligible if they: (1) examined adolescent girls aged 12–18 years; (2) examined the health impacts of screen-based sedentary behavior for either adolescent girls or separately by gender; (3) involved a cross-sectional, longitudinal, or experimental study design; (4) assessed leisure-time screen-based sedentary behavior; (5) assessed at least one health indicator; and (6) assessed the relationship between screen time and health. Conference abstracts, dissertations, theses and articles published in non–peer-reviewed journals were not included for review.

Studies that examined screen-based activities required specifically for educational purposes (e.g., homework, classroom activities) or considered the content viewed (e.g., advertising, violence) rather than health associations of the screen-based activity, were not included. Studies which focused on or measured active electronic gaming (as opposed to sedentary gaming) were also not included, because active gaming has been shown to involve light to moderate physical activity [36,37].

Data extraction

Key study characteristics of the identified studies were extracted including: the country of origin, size/source of study population, study-design, details of the intervention or observations, sedentary behaviors examined, health domain, and study results in terms of the health-related indicators. Studies identified in this review that specifically adjusted for physical activity participation were also identified.

Risk of bias

Two reviewers (S.A.C., N.K.) independently assessed the risk of bias of studies meeting the inclusion criteria. Scoring discrepancies were resolved via consensus and inter-rater reliability was calculated using percentage agreement. Risk of bias for the 33 studies was assessed using a checklist tool adapted from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [38] and the Consolidated Standards of Reporting Trials (CONSORT) guidelines [39], and included the following six questions: (1) Did the study describe the participant eligibility criteria? (2) Were the participants randomly selected? (3) Did the study report the sources and details of sedentary behavior assessment and did the instruments have acceptable reliability for the specific age group (an intra-class correlation coefficient $\geq$.70 or Pearson correlation $\geq$.80 was considered acceptable) [40]? (4) Did the study report the sources and details of assessment of physical, psychosocial, or behavioral health indicators and did all of the methods have acceptable reliability? (5) Did the study report a power calculation and was the study adequately powered to detect the hypothesized relationships (if the study did not report adequate power, a score of 0 was assigned)? and (6) Did the study report the numbers of individuals who completed each of the different measures and did participants complete at least 80% of measures? A risk of bias score was awarded to each study by assigning 0 (absent or insufficiently reported) or 1 (present or clearly described) for each of the six questions. Low risk of bias studies was regarded as those with a score of five or six, a moderate risk of bias presented scores of three to four, high risk of bias scored two or below; this scoring scale was based on a previous review [41].

Level of evidence

Health impacts of various screen-based sedentary behaviors were categorized as follows: Physical (e.g., weight status, musculoskeletal pain), psychosocial (e.g., depression, perceived self-rated health, psychological well-being, socializing/social support), and behavioral (e.g., diet quality, physical activity/fitness, sleep problems).

Evidence ratings (i.e., +, −, ?, ++, −) were coded based on previously reported methods conducted in numerous reviews [24,41–43]. The relationship between screen-based sedentary behaviors and health indicators was determined by examining the percentage of studies that reported an association (e.g., between screen time and weight status). If 0% to 33% of the included studies reported a positive or a negative association between screen time and the health indicator, the result was categorized as no association (0). If 34% to 59% of the studies reported positive association, or a negative association between screen time and health impacts, the result was categorized as inconsistent/uncertain (?). If 60% to 100% of studies reported a positive association between screen time and the health indicator, the result was coded as a positive association n (+). Likewise, if 60% to 100% of studies reported a negative association between screen time and the health indicator, the result was coded as a negative association (−).

To incorporate risk of bias assessment, if there were more than four low risk of bias* studies (* denotes studies considered to be low risk of bias, scoring $\geq$4 in the risk of bias assessment as conducted in previous reviews were identified for a health indicator), additional coding was conducted [24,41–43]. For example, if 60% to 100% of low-risk of bias* studies found a positive relationship between screen time and the health indicator, the result was coded as having strong evidence for a positive association (++).

Results

Overview of studies

Electronic literature searching yielded 492 studies (Figure 1). Of these, 33 studies met the inclusion criteria. The search identified 33 studies that evaluated the physical and/or psychosocial and/or behavioral health indicators associated with screen-based sedentary behaviors among adolescent girls (Table 1). Of these, 16 evaluated physical health associations, 6 evaluated the psychosocial health associations, 5 evaluated the behavioral health associations, and 6 studies evaluated a combination of health indicators (e.g., physical and psychosocial, physical and behavioral) of screen-based sedentary behavior.

Most studies (25/33, 76%) employed a cross-sectional study design, whereas eight were longitudinal. All studies were observational, with the exception of two that implemented school-based interventions [9,44]. Samples sizes ranged from 72 [45] to 31,022 [46]. Descriptive characteristics of the 33 studies are outlined in Table 1.

Measures of sedentary behavior

Of the 33 identified studies, the majority (22, 67%) examined the combined or overall associations of television, video, sedentary electronic gaming, and computer and internet usage, whereas a further eight studies examined television viewing exclusively [19,47–53], two examined computer/internet usage [54,55], and one examined electronic gaming [56].

Data were collected using a variety of methods; most used self-report questionnaires/surveys, whereas the remaining studies employed physical activity/sedentary behavior recall (e.g., of the previous 3–7 days) [19,46,56,57], interviews/focus groups [48,58], and objective measurement such as accelerometry and observation [59,60].

Risk of bias

Results from the study risk of bias assessment are reported in Table 2. Seven studies were identified as low risk of bias [46,47,49,59–62], 16 studies were rated as moderate risk of bias, and 10 studies were classified as high risk of bias. Only 14 studies report acceptable reliability for their sedentary behavior measure (item 3). Only six studies reported power calculations (item 5), and only seven studies reported the numbers of individuals who completed each of the different measures (item 6). Risk of bias was used to guide the level of evidence of available studies. Inter-rater reliability between the two reviewers was high

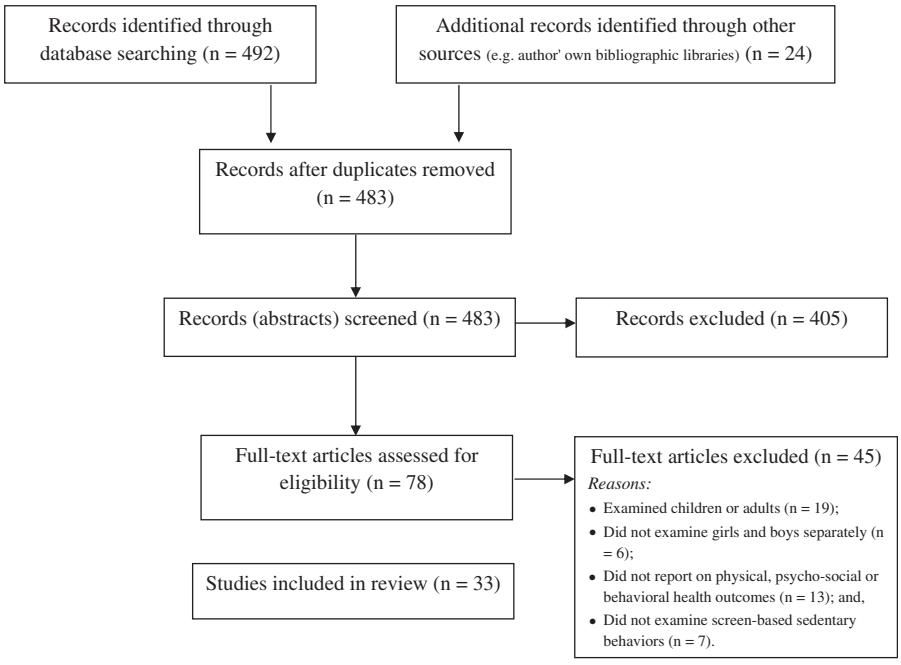

Figure 1. Flow of study selection through the phases of the review.

(97% agreement) and all discrepancies between the reviewers with regard to extracted data were discussed until consensus reached.

Physical health indicators

Most of the studies (19/33, 58%) examined the association between screen-based sedentary behavior and weight status. Indicators of screen-based sedentary behavior included increased body mass index (BMI)/body fatness [9,44,45,49,50,57–61,63–66], increased risk of overweight/obesity [47,52,67,68], and increased odds of obesity [69]. These have all been grouped as weight status. Only one of these studies reported no association between screen-based sedentary behavior and weight status [64]. When additional summary coding was completed for low risk of bias studies only (e.g., eight studies gained a risk of bias score $\geq$4) a strong association was found for weight status (i.e., 88% of low risk of bias studies [n = 7/8] reported a positive association between screen-based sedentary behavior and increasing weight status).

The association between screen-based sedentary behavior and musculoskeletal pain was examined in two studies (Table 3). One study found combined sources of screen time to be associated with increased neck, shoulder, and lower back pain [70], whereas an additional study reported television and computer use to be associated with increased backache and headache [46]. The association between screen-based sedentary behavior and musculoskeletal pain was therefore rated as positive (i.e., all studies reported increased musculoskeletal pain).

Behavioral health indicators

The association between screen-based sedentary behavior and diet quality was examined in five studies. Screen time was associated with increased energy intake in two studies [48,58] and insufficient consumption of fruit and vegetables in one study [52] (Table 3). In addition, one study reported no association between screen time and consumption of soft drinks [47], whereas screen time was associated with decreased snacking in one study [53]. The association between screen-based sedentary behavior and healthy dietary behavior was therefore rated as negative (i.e., 60% of studies reported a reduction in healthy dietary behaviors).

The association between screen time and physical activity/fitness was examined in five studies (Table 3). Television viewing was associated with lower fitness in one study [47], and a negative association between television viewing and physical activity was reported by two studies [19,53]. An additional two studies reported computer use and overall screen time to be associated with increased physical activity [58,71]. The association between screen-based sedentary behavior and physical activity/fitness was therefore rated as negative (i.e., 60% of studies reported less physical activity/fitness).

The association between screen-based sedentary behavior and sleep problems was examined in two studies (Table 3). One study reported internet use to be associated with sleep problems [54], and an additional study reported combined sources of screen time were associated with sleep problems including daytime fatigue [62]. Thus the association between screen-based sedentary behavior and sleep problems was rated as positive (i.e., all studies reported more sleep problems).

Although the majority of studies reported various forms of screen-based sedentary behavior were associated with poor health indicators (e.g., weight gain, unhealthy dietary behaviors, low fitness/physical activity levels, sleep problems, musculoskeletal pain), some studies reported health benefits associated with screen-based sedentary behavior (e.g., four studies found screen time to be associated with health benefits such as increased physical activity levels [58,71], reduced prevalence of

Table 1
Characteristics of studies included in this review

Number as indicated in reference list	Author, date	Study design	N	Age group (year)	Country	Was physical activity participation used as an adjusting variable for sedentary behavior?	Sedentary behavior examined	Health domain	Health indicators
63	Barnett et al, 2009	Longitudinal	744 adolescents	12–13 years	Canada	✓	*Overall	Physical	• BMI
54	Bélanger et al, 2011	Cross-sectional	7,548 adolescents	16–20 years	Switzerland	×	Int	Behavioral Psycho-social	• Sleep Problems • Depression
69	Boone et al, 2007	Longitudinal	9,155 adolescents	Mean age 1995: 15.9; 2001: 21.4.	USA	×	*Overall	Physical	• Obesity
72	Brodersen et al, 2005	Cross-sectional	4,320 adolescents	Mean age 11.8 years	UK	×	*Overall	Psychosocial	• Self-perceived health • Emotional symptoms
47	Burke et al, 2006	Cross-sectional	602 adolescents	Mean age 12.0 years	Australia	✓	TV	Physical Behavioral	• Overweight/obesity • Fitness • Soft drink consumption
48	Crespo et al, 2001	Cross-sectional	4,069 adolescents	8–16 years	USA	✓	TV	Behavioral	• Energy intake
56	Cummings & Vandewater, 2007	Cross-sectional	1,491 adolescents	10–19 years	USA	×	EG	Psychosocial	• Socializing with peers • Socializing with parents
49	Eisenmann et al, 2008	Cross-sectional	12,464 adolescents	14–18 years	USA	✓	TV	Physical	• BMI
50	Forshee et al, 2009	Longitudinal	2,216 adolescents	Mean age 14 at baseline	USA	×	TV	Physical	• BMI
70	Hakala et al, 2006	Cross-sectional	6,003 adolescents	14–18 years	Finland	✓	Comp, Int, EG	Physical	• Neck-shoulder and lower back pain
19	Hardy et al, 2007	Cross-Sectional	2,750 adolescents	Grade 6–10	Australia	✓	TV	Behavioral	• Physical Activity
51	Hume et al, 2011	Longitudinal	155 adolescents	Mean age 14.5 to 16.3 years	Australia	✓	TV	Psychosocial	• Depression
44	Hume et al, 2009	Longitudinal	580 adolescents	Mean age 12.7 years	Holland	✓	TV, Comp	Physical	• Weight status (waist circumference)
73	Jackson et al, 2010	Cross-sectional	500 adolescents	Mean age 12.19 years	USA	×	EG, Int	Psychosocial	• Self-concept • Self-esteem
67	Kautiainen et al, 2005	Cross-sectional	6,515 adolescents	Mean age 14.6–18.6 years	Finland	✓	TV, EG, Comp	Physical	• Overweight
45	Lown et al, 2008	Cross-sectional	72 girls	Mean age 10.5 years	USA	×	*Overall	Physical Psychosocial	• BMI • Social support
52	Lowry et al, 2002	Cross-sectional	15,349 adolescents	9th–12th grade	USA	×	TV	Physical Behavioral	• Overweight • Fruit and vegetable intake
64	Nogueira et al, 2009	Cross-sectional	326 adolescents	11–15 years	Brazil	×	*Overall	Physical	• Body composition
59	Pratt et al, 2008	Cross-sectional	1,458 girls	12 years	USA	✓	*Overall	Physical	• Body composition
55	Punamaki, 2007	Cross-sectional	7,297 adolescents	12–18 years	Finland	×	Comp	Psycho-social	• Perceived health
57	Schneider et al, 2007	Cross-sectional	194 girls	Mean age 15.2 years	USA	✓	*Overall	Physical	• BMI
71	Sharif et al, 2006	Cross-sectional	4,508 adolescents	Grades 5–8	USA	✓	*Overall	Behavioral	• Physical activity
53	Snoek et al, 2006	Cross-sectional	10,087 adolescents	Mean age 13.0 years	Netherlands	✓	TV	Behavioral	• Snacking • Physical activity
65	Springer et al, 2006	Cross-sectional	718 girls	Mean age 11.6 years	USA	✓	TV, EG, Comp	Physical Psychosocial	• BMI • Social support
9	Spruijt-Metz et al, 2008	Longitudinal	459 girls	Mean age 12.5 years at baseline	USA	✓	*Overall	Physical	• Body fat
66	Sun et al, 2009	Cross-sectional	5,753 adolescents	12–13 years	Japan	×	TV, EG	Physical	• BMI
46	Torsheim et al, 2010	Cross-sectional	31,022 adolescents	11–15 year olds	Nordic countries	✓	TV, Comp	Physical	• Backache and headache
60	Treuth et al, 2009	Longitudinal	984 adolescents	Mean age 13.9 years at baseline	USA	×	*Overall	Physical	• Body Fat

Table 1
Continued

Number as indicated in reference list	Author, date	Study design	N	Age group (year)	Country	Was physical activity participation used as an adjusting variable for sedentary behavior?	Sedentary behavior examined	Health domain	Health indicators
10	Ussher et al, 2007	Cross sectional	2,623 adolescents	13–16 years	UK	✗	TV, Vid, Comp	Psychosocial	• Psychological wellbeing
58	Utter et al, 2003	Cross-sectional	4,480 adolescents	Mean age 14.9 years	USA	✗	TV, Comp	Physical Behavioral	• BMI • Dietary intake • Physical activity
61	Velde et al, 2007	Cross-sectional	12,538 adolescents	8.8–13.8 years	Europe	✗	TV, Comp	Physical	• BMI
68	Vicente-Rodríguez et al, 2008	Cross-sectional	1960 adolescents	13–18.5 years	Spain	✗	TV, Vid, Comp	Physical	• Overweight
62	Viner et al, 2006	Longitudinal	1,880 adolescents	11–14 years	UK	✗	TV, Vid, Comp	Behavioral	• Sleep Problems (including day time fatigue)

Comp = computer use; EG = electronic gaming; Int = internet use; *Overall = combined use of various forms of screen-based sedentary behavior; TV = television; vid = video; ✓ = yes; ✗ = no.

overweight and obesity [47], less snacking [53], increased consumption of fruit and vegetables [58]). In addition, two studies reported no relationship between screen time and physical health (e.g., one study found no association between screen time and body composition [64], whereas another study reported no association between screen time and soft drink consumption [47]).

Psychosocial health indicators

Six studies examined the relationship between screen-based sedentary behavior and psychosocial health (Table 3). A positive association between screen-based sedentary behavior and depressive symptoms was reported in three studies [51,54,72]. Four studies reported a negative association between screen-time activities and perceived health [10,55,72,73], and one study reported a negative association between screen time and psychological wellbeing [10]. The association between screen-based sedentary behavior and depression was therefore rated as positive (i.e., all studies reported increased prevalence of depression), whereas the association between screen-based sedentary behavior and perceived health was rated as negative (i.e., all studies reported poorer perceived health).

The association between screen-based sedentary behavior and social support/socializing was reported in four studies (Table 3). Screen-based sedentary behavior was associated with reduced social support in three studies (45,56,65) and one study reported electronic gaming was associated with a decrease in time spent with friends [56]. The same study also reported screen time significantly increased time spent with parents [56]. The association between screen-based sedentary behavior and social health was therefore rated as negative (i.e., 75% of studies reported reduced social health).

Further, sedentary behavior has been reported as a health risk, independent of engaging in physical activity by 16 of the 33 studies examined in this review (Table 1). Of these 16 studies, 88% reported health associations with sedentary behavior that were detrimental (i.e., increased BMI, decreased physical activity, musculoskeletal pain, and depression).

Discussion

The primary objective of this review was to investigate the health indicators associated with screen-based sedentary behavior in adolescent girls; a secondary objective to examine the impact of sedentary behavior in studies that have specifically adjusted for physical activity participation. The majority of studies reported screen-based activities were associated with poor health. In addition, less than half of included studies have adjusted sedentary behavior for physical activity participation. Even when participation in physical activity was accounted for, an inverse relationship between screen-based sedentary behavior and various health outcomes persisted.

Of the studies accounting for physical activity participation, 88% (14/16) reported adverse health outcomes associated with screen-based recreation. Consistent with emerging literature in adults, evidence examined in this review indicates screen time in adolescent girls is associated with weight status, energy intake, depression, and musculoskeletal pain independent of physical activity levels. Furthermore, we identified a consistent inverse association between screen time and physical activity.

Table 2
Risk of bias of studies included in this review

Reference number	Study	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Total (risk of bias)
63	Barnett et al, 2009	1	0	0	1	0	0	**2**
54	Bélanger et al, 2011	1	1	0	1	0	1	**4**
69	Boone et al, 2007	1	1	1	1	0	0	**4**
72	Brodersen et al, 2005	1	1	1	1	0	0	**4**
47	Burke et al, 2006	1	1	1	1	1	1	**6**
48	Crespo et al, 2001	1	1	0	1	0	0	**3**
56	Cummings & Vandewater, 2007	1	1	1	1	0	0	**4**
49	Eisenmann et al, 2008	1	1	1	1	1	0	**5**
50	Forshee et al, 2009	1	1	0	1	0	0	**3**
70	Hakala et al, 2006	1	1	0	0	0	0	**2**
19	Hardy et al, 2007	1	1	1	1	0	0	**4**
51	Hume et al, 2011	1	1	1	1	0	0	**4**
44	Hume et al, 2009	1	1	0	1	0	0	**3**
73	Jackson et al, 2010	1	0	0	1	0	0	**2**
67	Kautiainen et al, 2005	1	0	0	1	0	0	**2**
45	Lown et al, 2008	1	0	1	1	0	0	**3**
52	Lowry et al, 2002	1	1	0	1	0	0	**3**
64	Nogueira et al, 2009	1	1	0	1	0	0	**3**
59	Pratt et al, 2008	1	1	1	1	1	1	**6**
55	Punamaki, 2007	1	1	0	0	0	0	**2**
57	Schneider et al, 2007	1	0	0	1	0	0	**2**
71	Sharif et al, 2006	1	0	0	1	0	1	**4**
53	Snoek et al, 2006	1	1	1	1	0	0	**4**
65	Springer et al, 2006	1	0	0	1	0	0	**2**
9	Spruijt-Metz et al, 2008	1	0	1	1	0	0	**3**
66	Sun et al, 2009	1	0	0	0	0	0	**1**
46	Torsheim et al, 2010	1	1	1	1	1	0	**5**
60	Treuth et al, 2009	1	1	1	1	0	1	**5**
10	Ussher et al, 2007	1	0	0	1	0	0	**2**
58	Utter et al, 2003	1	0	0	1	0	0	**2**
61	Velde et al, 2007	1	1	1	1	0	1	**5**
68	Vicente-Rodríguez et al, 2008	1	1	0	1	1	0	**4**
62	Viner et al, 2006	1	1	1	1	1	1	**6**

Note: (1) Did the study describe the participant eligibility criteria? (2) Were the participants randomly selected? (3) Did the study report the sources and details of sedentary behavior assessment and did the instruments have acceptable reliability for the specific age group? (4) Did the study report the sources and details of assessment of physical, social, or mental outcomes and did all of the methods have acceptable reliability? (5) Did the study report a power calculation and was the study adequately powered to detect hypothesized relationships? (6) Did the study report the numbers of individuals who completed each of the different measures and did participants complete at least 80% of physical activity measures?

Physical and behavioral health

Strong evidence for a positive relationship between screen-based sedentary behavior and weight was identified with all longitudinal and all but one cross-sectional study reporting a positive association, particularly when screen time exceeded 2 hours. Although small amounts of screen time may not be problematic, there appears to be a dose-response relationship between screen time and health indicators. For instance, a longitudinal study [50] found each additional hour of television viewing was associated with a BMI increase of .22 kg/m^2. Similarly, Torsheim et al [46] found that the prevalence of backache increased by 10% for every hour of computer use, electronic gaming, and television viewing. Alternatively, there may be a threshold for screen-based recreation, after which individuals may experience poor health. For example, the risk of sleep problems increased two-fold in adolescent girls engaging in screen-based activities for 4 or more hours per day [62]. Although the majority of adolescents are exceeding the minimal screen-time recommendation (<2 hours per day), only a small proportion of this population experience adverse health outcomes. As further studies emerge, it may be possible to confidently identify the screen-based recreation threshold in this population.

Both dietary behavior and physical activity influence weight status and have an association with sedentary behavior. As such, two cross-sectional studies presented a positive relationship between screen-time activities and dietary behavior, specifically reporting increased energy intake [48,58]. Interestingly, Utter et al [58] found a positive relationship between computer use and consumption of fruit/vegetables among adolescent girls, whereas a cross-sectional investigation of more than 4,000 adolescents found "high" computer users engaged in significantly greater amounts of physical activity in comparison to "average"/"low" users [58]. This may suggest different forms of screen time are associated with distinct behaviors (i.e., time spent using a computer allows control over content accessed); therefore, users may actively seek out health-related information that is not available via other forms of screen time (e.g., electronic gaming). This may highlight the potential for using computers to promote healthy lifestyle messages within adolescent populations.

Screen-time activities were also associated with physical activity participation and fitness levels. This is consistent with a number of studies that have hypothesized time spent engaging in sedentary behavior displaces time available to be active [61,65]. One study [57] reported adolescent girls who spent more time participating in non–screen-based sedentary activities, compared with screen-based, were significantly more likely to engage in vigorous physical activities and have higher cardiovascular fitness. This may suggest the association is unrelated to

Table 3
Summary of studies examining the association between screen-based sedentary behavior and health outcomes

Health indicator	Association		No association	Summary coding		Additional coding for high-quality studies
	Association	Reference numbers	Study numbers	n/N for health outcome (%)	Overall association	
Physical health						
Weight status[a]	+	63*, 69*, 49*, 50, 44, 67, 45, 52, 59*, 57, 65, 9, 66, 60*, 58, 61*, 68*	18	17/19 (89%)	+	7/8 (88/%)
	−	47*		1/19 (5%)		++
Musculoskeletal pain	+	70, 46*		2/2 (100%)	+	
Behavioral health						
Healthy dietary behavior	+	53*	5*	1/5 (20%)	−	
quality	−	48, 52, 58		3/5 (60%)		
Physical activity/fitness	+	71*, 58		2/5 (40%)	−	
	−	47*, 19*, 53*		3/5 (60%)		
Sleep problems	+	54, 62*		2/2 (100%)	+	
Psychosocial health						
Depression	+	54*, 72*, 51*		3/3 (100%)	+	
Perceived health	−	72*, 73, 55, 10		4/4 (100%)	−	
Psychological wellbeing	−	10		1/1 (100%)	−	
Socializing/social support	+	56*		1/4 (25%)	−	
	−	56*, 45, 65		3/4 (75%)		

* Denotes studies considered to be low risk of bias, scoring ≥ 4 in the risk of bias assessment as conducted in previous reviews [35–38].
[a] Weight status refers to body mass index, body fatness, increased risk of overweight or obesity.

the duration of the sedentary behavior, but rather the type of sedentary activity (screen-based vs. other sedentary behaviors) participated in.

Our review also suggests screen time has implications for sleep patterns. Although only two studies were identified, both had a low risk of bias and suggest a positive relationship exists. These findings are consistent with a study examining the sleep patterns of children (5–12 years), which concluded electronic media use had a negative effect on children's sleep patterns, duration of sleep, and the prevalence of sleep disorders [74]. Because of very limited research available, further longitudinal studies are needed to investigate this relationship.

Limited cross-sectional evidence concerning the association between screen-based activities and musculoskeletal pain exists with only two studies of varying levels of bias identified in this review [46,70]; however, both studies identified a positive association. Similar findings have been reported in a cross-sectional mixed gender sample of US/Canadian youth, which found screen time to be positively associated with various muscular complaints [11]. This may suggest for adolescent girls the association between screen time and musculoskeletal pain is related more to the duration of the activity and may reflect an increase in time spent using the internet and electronic gaming for social interaction purposes.

Psychosocial health

Few studies examining adolescent girls have investigated the psychosocial impacts of screen-time activities, excluding the impact of content viewed. The available evidence suggests a positive association between screen time and depression, whereas a negative relationship has been identified between screen time and psychological well-being. Low risk of bias studies has reported internet use [54] and television viewing [51] were associated with higher levels of depression in adolescent girls. However, as these studies employed cross-sectional and longitudinal designs the evidence cannot be considered strong. Other cross-sectional studies examining screen time found associations with psychosocial health indicators including reduced psychological well-being [10], poor self-perceived health [55,72], and increased frequency of emotional symptoms (e.g., stress) [72].

Cross-sectional evidence suggests screen-based activities can also impact socializing and social support. An overall negative association was identified between screen time and social health. Two studies with a high risk of bias reported overall screen-based sedentary activities were associated with a reduction in social support for physical activity [45,65]. A low risk of bias cross-sectional study [56] reported noninteractive sedentary electronic-games (e.g., single-player games) were associated with less time spent socializing with peers. Interestingly, the same study reported shared use of sedentary electronic-games (e.g., multiplayer games) resulted in increased time engaging in leisure time activities with parents and peers [56]. This may indicate that screen-based recreation with a more socially interactive format (e.g., multiplayer electronic games or social networking games) may be more effective in producing social health gains for adolescent girls compared with electronic games played in isolation. For example, a study conducted by Brox et al [75] reported interactive multiplayer games produced positive social effects such as enhancing perceptions of connectedness.

Several studies propose modest reductions in screen time can lessen the impact of poor physical and psychosocial health indicators. For instance, two longitudinal studies reported reducing overall screen-based sedentary behavior to be associated with decreased weight [9,69]. Specifically, Boone et al [69] found low levels of weekly screen time (less than 4 hours) reduced the risk of obesity by almost 40%.

The findings from this review confirm screen-based sedentary behavior is associated with numerous health consequences for adolescent girls including weight gain, reduced fitness, poor diet, musculoskeletal pain, sleep problems, and depression. Additionally, some social health benefits have been observed.

The dose-response relationship between screen-based sedentary behaviors and health suggests that the more time adolescent girls spend engaging in screen-based activities the greater the physical, behavioral, and psychosocial health consequences. Findings of this review suggest that engaging in more than 4 hours of daily screen time has the most harmful health effects. Therefore to reduce the risk of poor health, adolescent girls should be encouraged to reduce daily screen time to less than 2 hours per day. This is of particular importance considering adverse health outcomes associated with sedentary behavior persisted even when adolescent girls participated in physical activity.

Study strengths and limitations

This review has several strengths, including the use of criteria for assessing study risk of bias adapted from the STROBE [38] and CONSORT [39] statements. This review also used a comprehensive search strategy that was applied to several databases. However, several limitations should be acknowledged. First, this review reported on various types of screen-based sedentary behavior (television, computer, internet, electronic gaming); however, it did not consider the simultaneous use of screen-based activities (i.e., using the internet while also watching television) or the use of mobile phones for small-screen recreation. Second, health indicators have not been equally represented in the literature (i.e., 18 studies examined the association between screen-based sedentary behavior and weight, whereas only 1 study examined psychological well-being) which may limit the interpretations made in relation to their contribution to adolescent girls' health.

Implications and recommendations

To reduce risk of poor physical, behavioral, and psychosocial health, adolescent girls should be encouraged to comply with screen time recommendations for use of "electronic media for entertainment." As technology changes rapidly, up-to-date guidelines that encompass all forms of screen-based sedentary behavior, in particular new forms of recreational "electronic media" (e.g., in-car television/DVDs, hand held consoles, mobile phones) are necessary.

At present, evidence surrounding health impacts of screen-based sedentary behavior for adolescent girls is hampered in terms of risk of bias and study quantity. This review included only eight longitudinal studies and two interventional studies; the majority of studies examined had a moderate to high risk of bias. More studies, employing low-risk of bias methodology, to explore the relationship between screen-based sedentary behavior and adolescent health are therefore necessary to investigate the causal nature of such relationships. This review guides the potential for future studies to conduct a meta-analysis of the relationship between screen time and girls' body weight. In addition, future research should further explore biological mechanisms through which sedentary behavior and physical activity might independently influence health outcomes. Finally, many studies relied on self-reported activity data gathered via surveys, questionnaires, logs, and activity recall. Such instruments are potentially limited by errors in recall and provision of socially desirable responses. A recent systematic review of sedentary behavior measures used in this population identified a number of limitations with existing measures [76]. There is a need for greater precision in measurement of sitting time to accurately capture sedentary behavior; the use of objectively measured activity (e.g., Actical and Actiwatch accelerometers) has been validated in adolescents and reported to produce sound classification accuracy [76].

Considering the distinct screen time and physical activity patterns evident among adolescent girls and boys, future sedentary behavior interventions should employ strategies reflecting these differences. For example, evidence suggests that adolescent boys spend large amounts of time engaged in computer gaming. Indeed, a review focusing on adolescent boys is also warranted considering these distinct behavioral patterns. In conclusion, because of the large number of cross-sectional studies and the high risk of bias in the studies reviewed, our findings should be interpreted with caution. Low risk of bias longitudinal and experimental studies will help to improve our understanding of the health consequences of sedentary behavior.

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