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Childhood obesity risk increases with increased screen time: a systematic review and dose–response meta-analysis

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Abstract

Background The role of screen time in promoting obesity among children has been reported in previous studies. However, the effects of different screen types and the dose–response association between screen time and obesity among children is not summarized yet. In the current meta-analysis we systematically summarized the association between obesity and screen time of different screen types in a dose–response analysis.

Methods A systematic search from Scopus, PubMed and Embase electronic databases was performed. Studies that evaluated the association between screen time and obesity up to September 2021 were retrieved. We included 45 individual studies that were drawn from nine qualified studies into meta-analysis.

Results The results of the two-class meta-analysis showed that those at the highest category of screen time were 1.2 times more likely to develop obesity [odds ratio (OR) = 1.21; confidence interval (CI) = 1.113, 1.317; I^2 = 60.4%; $P < 0.001$). The results of subgrouping identified that setting, obesity status and age group were possible heterogeneity sources. No evidence of non-linear association between increased screen time and obesity risk among children was observed (P-nonlinearity = 0.310).

Conclusion In the current systematic review and meta-analysis we revealed a positive association between screen time and obesity among children without any evidence of non-linear association. Due to the cross-sectional design of included studies, we suggest further studies with longitudinal or interventional design to better elucidate the observed associations.

Keywords Screen time, Obesity, Children, Dose–response, Adiposity, Meta-analysis

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Background

Obesity is a major health problem among children and adolescents; overweight and obesity in children and adolescents increases the odds of adulthood obesity [1, 2]. Numerous factors are associated with childhood obesity including increased dietary intake of high-fat snacks and fast foods, large portion sizes, increased consumption of sugar sweetened beverages and other environmental and genetic factors [3–5]; however, lack of regular physical activity and sedentary lifestyle is one of the most important determinant of childhood obesity [6, 7]. Physical inactivity is prevalent among children; on average, children spent 41% and 51% of the after-school period in sedentary time when at after-school care and other locations (e.g. participation in afterschool programs, screen-based behaviors, homework/academics or social activities and motorized transport) respectively [8–10].

It is suggested that physical activity is one of the powerful treatments to help obesity prevention and to improve obesity-related risk factors among children; every one hour of moderate-to-vigorous physical activity is accompanied with 10% reduced risk of obesity development [11]. Although childhood obesity is a result of complex interaction between physical activity, dietary factors and metabolic and genetic factors [12, 13], the role of physical activity along with some other lifestyle modifications in reducing childhood obesity risk is further highlighted in numerous interventional studies [14–16]. Sedentary behaviors (SB) are defined as any activities that are less than or equal to 1.5 metabolic equivalents (MET); these kind of behaviors closely resemble energy expenditure of body while it is "at rest." [17]. Several studies have targeted reducing SB as a therapeutic way to decrease childhood obesity [18–21].SBs are associated with increased risk of cardiovascular diseases (CVDs), diabetes and metabolic syndrome [22, 23]. Also, SBs increase the risk of obesity among children and most of the children nowadays, engage in sedentary behaviors like television (TV) viewing [24–28]. In a population-based cross-sectional study among four thousand one hundred and ninety-seven children aged 6 to 12 years, 62% of children watched TV 1 to 3 h per day. Children who spent more than 3 h per day watching TV were 1.8 times more likely to be obese [odds ratio (OR) = 1.8 (95% confidence interval (CI) = 1.2–2.8)] [29]. Screen time (ST), as a subgroup of SBs, is a term used for activities done in front of a screen, such as watching TV, working on a computer, or playing video games. Screen time is sedentary behavior, meaning you are being physically inactive while sitting down [30]. Screen time is dramatically increased as a results of development in technology, like increased electronic media use, TV watching and computer using by children [31, 32]. American Academy of Pediatrics recommends limiting screen-time among children and adolescents to less than 2 h per day with no screens for kids under 2, and less than an hour per day for kids 2 to 5 [33].

Numerous studies have been performed that evaluated the relationship between screen time and adiposity; but the obtained results are inconsistent. While several studies reported increased obesity risk among high-screen users [34–36], some others reported increased weight only among overweight youth [1], some others reported the obesity-promoting effects of TV and failed to report this effect for personal computer (PC) or other screens [36, 37]. Several studies reported no significant association between screen use and obesity [38, 39]; while several studies reported significant increase in weight only among PC-users [40, 41]. More surprisingly, some of the studies reported lower screen time among obese youth; in the study by Christofaro et al. [42], lower obesity risk was reported among boys with the highest ST versus those with the lowest ST. According to the review of literature, it is obviously clear that numerous factors determine the effects of screen on obesity among youth; these factors are duration of screen use, screen device type, the obesity status (e.g. overweight or obesity) and geographical distribution. Moreover, numerous studies have revealed the particular importance of childhood obesity in increased likelihood of later adulthood obesity, promotion of CVD risk factors and atherosclerosis progress throughout life [43–45].

Therefore, in the current systematic review and meta-analysis, we aimed to (a) evaluate the association between screen time and obesity among children and (b) to explore the role of different factors including geographical distribution, screen type, age grouping, obesity status (e.g. overweight, obesity), setting (school, community) and sample size of different studies in the screen time-obesity associations.

Materials and methods

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used for results' presentation (Additional file 1: Table S1) [46].

Search strategy and selection of studies

The search results from the Embase, Scopus and PubMed electronic databases through September 2021 provided a total of 6291 articles (Fig. 1). Search strategy was created as a result of combination of the MeSH (Medical Subject Headings) terms from the PubMed database and free text words and was adopted for each electronic database (Additional file 1: Table S2). Duplicate removal and exclusion of articles according to title/abstarct, retrieved a total of 2156 articles. Two independent investigators

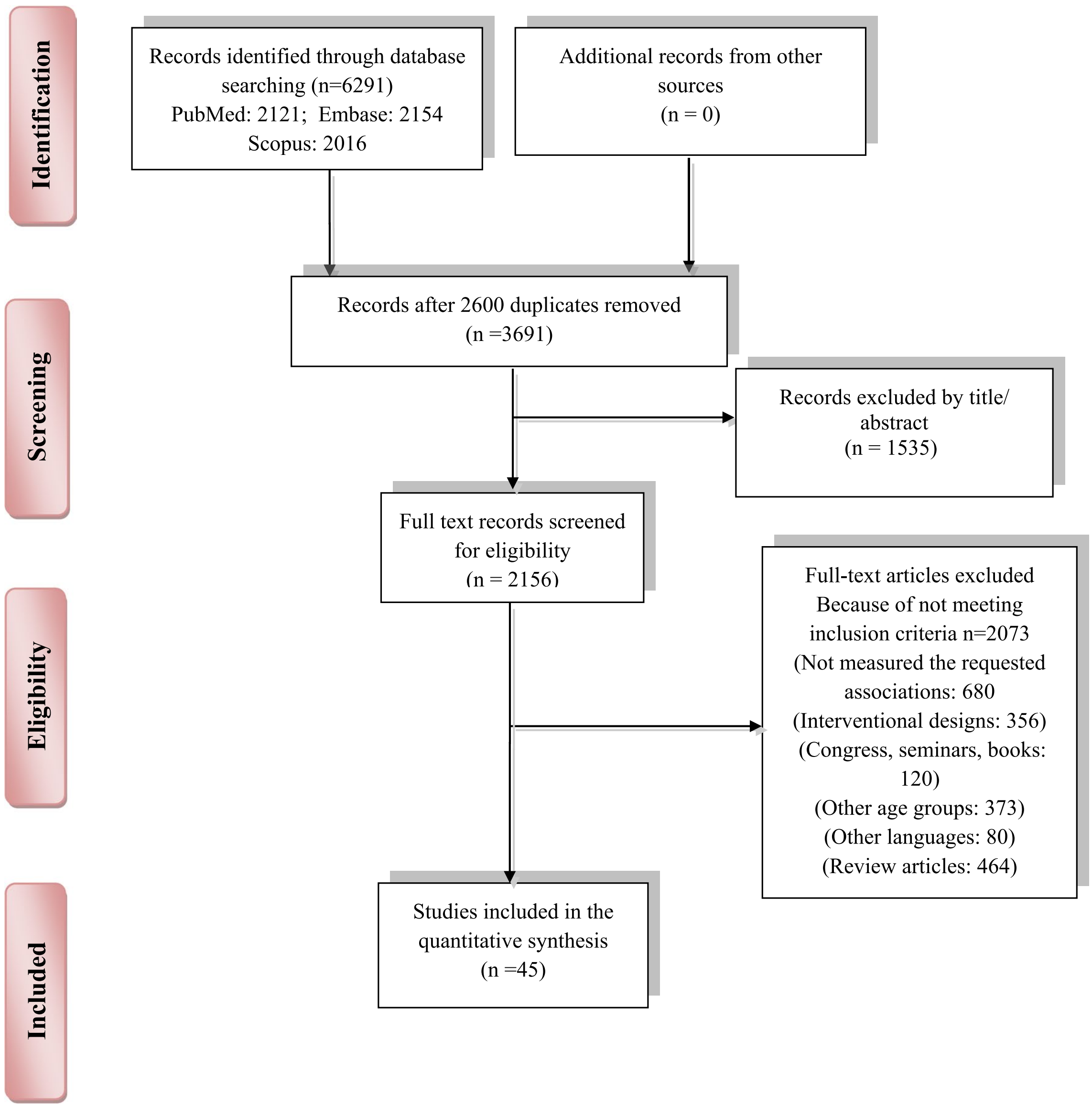

Fig. 1 Study Flowchart

cheked all of the articles. Then, 2101 manuscripts were removed because of their irrelevant subject, design, involving other age gropus, other languages, being reviews conferences and seminars, and not evaluating the association of studied parameters. Any discrepancies between reviewers were resolved by discussion. As a consequent, 45 individual studies from nine articles were included in the meta-synthesis.

Inclusion and exclusion criteria

Inclusion criteria for studies were as follows (1) studies with observational designs (case control, cross-sectional or cohort studies with the baseline measurement of study parameters); (2) studies that evaluated the relationship (OR, RR or HR) between screen time and risk of obesity (3) the studies that were conducted only among children (≤ 9 years). Clinical trials, systematic reviews, meta-analysis, case-reports and case-series, experimental studies, short communication, letter to editors, and studies that examined the relations other than the relationship between screen time and obesity were excluded from the analysis.

Data extraction and quality assessment

A standard Excel extraction datasheet (Excel 2010, Microsoft Office; Redmond, Washington, USA) was used

Table 1 Agency for Healthcare Research and Quality (AHRQ) checklist to assess quality of the cross-sectional studies

ARHQ Methodology Checklist items for Cross-Sectional study	Zulfiqar [66]	Hu [67]	Armon [68]	Tester [69]	Irish-Hauser [70]	De-Jong[71]	Veldhuis [101]	Abdelkafi Koubaa[102]	Stettler [60]
(1) Define the source of information (survey, record review)	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
(2) List inclusion and exclusion criteria for exposed and unexposed subjects (cases and controls) or refer to previous publications	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
(3) Indicate time period used for identifying patients	⊕	⊕	⊕	⊕	⊕	⊕	⊕	–	⊕
(4) Indicate whether or not subjects were consecutive if not population-based	–	–	⊕	–	–	–	–	–	–
(5) Indicate if evaluators of subjective components of study were masked to other aspects of the status of the participants	–	–	–	–	–	–	–	–	–
(6) Describe any assessments undertaken for quality assurance purposes (e.g., test/retest of primary outcome measurements)	U	U	–	U	U	U	U	U	U
(7) Explain any patient exclusions from analysis	⊕	⊕	⊕	⊕	⊕	–	⊕	⊕	⊕
(8) Describe how confounding was assessed and/or controlled	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
(9) If applicable, explain how missing data were handled in the analysis	⊕	⊕	–	⊕	⊕	–	⊕	⊕	⊕
(10) Summarize patient response rates and completeness of data collection	⊕	⊕	⊕	⊕	⊕	–	–	–	–

Table 1 (continued)

ARHQ Methodology Checklist items for Cross-Sectional study	Zulfiqar [66]	Hu [67]	Armon [68]	Tester [69]	Irish-Hauser [70]	De-Jong[71]	Veldhuis [101]	Abdelkafi Koubaa[102]	Stettler [60]
(11) Clarify what follow-up, if any, was expected and the percentage of patients for which incomplete data or follow-up was obtained	–	–	–	–	–	–	–	–	
Total score	7	7	7	7	7	4	6	5	6

The items were scored as follows: if the answer were "Yes," the score was "1" and if the answers were "No" or "Unclear", the score was "0". The final quality scores were: low quality = 0–3; moderate quality = 4–7 and high quality ≥ 8. ("⊕" shows a positive answer, "U", shows an unclear answer and "-" shows a negative answer)

for data extraction and data extraction was performed independently by two authors. The information that was included into data sheet were the name of first author and journal, year of publication, country, setting, age range and number of participants, study design, adjusted covariate, gender, obesity and screen time definition, weight, height and screen time measurement tools, and main results of the studies. Any disagreements between reviewers were resolved by discussion. The methodological quality of studies were assessed using the Agency for Healthcare Research and Quality (AHRQ) checklist [47] (Table 1).

Statistical analysis

The studies that reported the odds ratio of obesity (OR) in those with highest screen time versus lowest screen time were included in the two-class meta-analysis. When the OR was not provided, we calculated prevalence odds ratios (PORs) as suggested by Pearce et al. as the best approach for measuring effect size in prevalence studies [48]: $POR = \left[\frac{P1}{1-P1}\right] / \left[\frac{P0}{1-P0}\right]$. While P0 and P1 are the prevalence in exposed and non-exposed groups. Cochran's Q and I-squared tests were used to identify between-study heterogeneity. The possible sources of heterogeneity were identified using subgrouping and meta-regression analysis. STATA version 13 (STATA Corp LLC, College Station, TX, USA), was used for data analysis and P-values less than 0.05 were considered as statistically significant.

Only the studies that reported at least three categories for screen time and the odds or prevalence of obesity were included in the dose–response meta-analysis. Accordingly, thirteen individual studies in five articles were included [49–61]. The median point in each screen time category was identified and when medians were not reported, then approximate medians using the midpoint of the lower and upper limits were estimated. When the lowest or highest screen time categories were open-ended, the screen time was calculated by assuming the similar interval for those categories and estimating the mid-point. The reference category was the lowest one assuming OR and CIs of 1 for it. The potential non- linear associations were assessed using random-effects dose-response meta-analysis by defining the restricted cubic splines with three knots at fixed percentiles (10%, 50% and 90%) of distribution and were used to calculate study-specific odds ratios. Cochran's Q and I-squared tests were used to identify between-study heterogeneity. The possible sources of heterogeneity were identified using subgrouping approach. Begg's funnel plot was used to evaluate the publication bias followed by the Egger's regression asymmetry test and Begg's adjusted rank correlation.

Definitions

Screen time is defined according to the world health organization (WHO) definition of the time that is spent passively watching screen-based entertainment (TV, computer, mobile devices). This definition does not include some of the active games which involves physical activity or movement [62]. Thus, TV watching, usinig smart phone, internet and computer and some of the video games that are played in sedentary position are included as screen time. Child is defined as age under 10 years of as previously described by WHO [62]. In the studies that were included in the current meta-analysis, overweight and obesity were defined as folows: (1) Overweight was defined as having a Z score of BMI for age with the cut-off points of > 1 to ≤ 2 standard deviations while obesity was defined as Z score values > 2 standard

Table 2 The characteristics of studies that were included in the two-class meta-analysis of odds of obesity and increased screen time among children

Journal/ Year/ First author	Country	Setting/ num	Age (y)/ gender	Overweight/ obesity status and definition	ST definition	Main findings
J Immigrant Minor health/ 2019/ Zulfiqar [66]	Australia	Community/ 2115 + 2000	4–11	Overweight/ obesity + BMI ≥ 25 kg/m^2	TV, EG	In 4–5 years old immigrant boys and girls, video game playing of more than 1 h per day could reduce the risks of obesity but TV watching more than 3 h per day was associated with increased risk of obesity in girls of 6–7 years of age (OR = 1.5 CI = 1.0, 2.3; $P < 0.05$)
BMC Pediatrics/ 2019/ Hu [67]	China	Community/ 933	1–5	Overweight/ obesity + BMI Z score > 2	TV	Obesity was positively associated with longer TV viewing time only among 4- to 5-year-old children (OR = 1.72, CI = 1.16–2.54; $P < 0.001$)
BMC Pediatrics/ 2019/ Armoon [68]	Iran	Community/ 572	6–7	Overweight/ obesity defined as ≤ 95th and ≥ 85th percentile and ≥ 95th percentile of age respectively	TV	Watching TV and PC use of more than 2 h per day was associated with increased risk of obesity among children (for TV: OR = 3.51; CI = 1.20–8.66; $P = 0.01$ for PC: OR = 3.40 CI = 1.24–7.32; $P = 0.01$)
Pediatrics/ 2018/ Tester [69]	USA	Community/ 7028	2–5	Overweight/ obesity defined as ≤ 95th and ≥ 85th percentile and ≥ 95th percentile of age respectively	TV, PC, VG	Odds of overweight, obesity and severe obesity among children with more than 4 h per day of screen time were 1.2, 1.5 and 2.0 time greater compared with normal weight children respectively (OR = 1.2; CI = 0.9 -1.6; OR = 1.5; CI = 1.2 -1.9 and OR = 2.0; CI = 1.2 -3.3; $P < 0.05$)
BMC Pediatrics/ 2014/ Hauser [70]	USA	School/ 820	6–8	Overweight defined as ≤ 95th and ≥ 85th percentile	TV	Those with a lot of TV watching at dinner time and those with TV at bedroom has higher odds of overweight (POR = 1.07; CI = 0.81–1.42 and POR = 1.05; CI = 0.79–1.40)
Int J Obes/ 2013/ De Jong [71]	Netherland	School/ 2429 + 2004 + 2068	4–8	Overweight 25 ≤ BMI ≤ 30 kg/m^2 and obesity BMI ≥ 30 kg/m^2	TV, PC	TV viewing of more than 1.5 h was associated with increased risk of obesity (OR = 1.70; CI = 1.07–2.72; $P = 0.03$)
Int J Behav Nutr Phys Act/2012/Veldhuis [101]	Netherland	Community/ 7505	5	Overweight/ obesity defined as ≤ 95th and ≥ 85th percentile and ≥ 95th percentile of age respectively	TV	There was an increased odds of obesity with TV watching of more than 2 h per day (OR = 1.20; CI = 0.98–1.46)
Tunisie Medicale /2012/ Abdelkafi Koubaa [102]	USA	Community/ 329	2–5	Overweight/ obesity defined as ≤ 95th and ≥ 85th percentile and ≥ 95th percentile of age respectively	TV	Increased odds of obesity in high TV watchers of more than 2 h/ day (OR = 1.63; CI = 0.82–3.25)
Obes Res/ 2004/ Stettler [60]	Switzerland	Community/ 872	8	Overweight/ obesity defined as ≤ 95th and ≥ 85th percentile and ≥ 95th percentile of age respectively	TV, EG	Increased odds of obesity with increased TV watching (OR = 1.92; CI = 1.27–2.90; $P = 0.002$] and increased electronic games (OR = 2.56; CI = 1.55 to 4.23; $P < 0.001$)

ST measurement in all of the studies was performed by questionnaire. All of the included participants were apparently healthy. All of the studies had cross-sectional design. All of the studies males and females were recruited

BMI body mass index, *TV* television, *OR* odds ratio, *CI* confidence interval, *EG* electronic game, *ST* screen time, *PC* personal computer, *DVD* digital video discs, *VCDs* video compact disc digital, *POR* proportional odds ratio deviations [63]; (2) according to the international age and sex specific cut- offs of BMI [≥85th percentile and less than 95th percentile for overweight and ≥ 95th for obesity and [64] (3) as BMI cut-off of overweight $25 \leq BMI \leq 30$ kg/m^2 and obesity $BMI \geq 30$ kg/m^2 [65]. Two-class meta-analysis in the current study is a meta-analysis approach of the comparison of an outcome variable between two study groups.

Results

Study characteristics

The general characteristics of included studies are presented in Table 2. In the two-class meta-analysis, totally, 45 individual studies obtained from nine articles were included; the details of 45 individual studies are reported here: the study by Zulfiqar et al. [66], provided results for three age groups of 4–5, 6–7, 8–9 and for TV use in weekdays, electronic game playing in weekdays, TV use in weekends and electronic game playing in weekends among boys and girls separately; therefore, the results were included as 24 studies in the analysis. According to their results, electronic game playing more than one hour among 4–5 years old immigrant boys from high income countries (HICs) was associated with reduced risk of obesity (OR = 0.61; CI = 0.49–0.89), while TV watching more than 3 h per day of weekdays was associated with increased risk of obesity (OR = 1.4; CI = 1.0–1.9). Among immigrant girls from HICs in ages of 4–5 and 6–7 years old, electronic game playing of more than 1 h per day in weekdays was associated with reduced risk of obesity (OR = 0.39; CI = 0.17, 0.92), while TV watching in weekends of more than 3 h per day among age groups of 6–7, 7–8 and 9–10 years old was associated with increased risk of obesity OR = 1.6; CI = 1.2,2.1, OR = 1.4; CI = 1.1,1.8 and OR = 1.5; CI = 1.1,1.9 respectively. In the study by Hu et al. [67], was sub grouped for both 1–3 years old and 4–5 years old and higher TV watching hours was positively associated with obesity among those with 4–5 years old (OR = 1.72, 95% CI: 1.16–2.54). The results of the study by Armoon et al. [68] was reported as separate results for TV and PC users. Therefore, it was included as two separate studies and there was a positive association between odds of obesity and TV or PC use of more than 2 h per day (for TV users: OR = 3.51; CI = 1.20–8.66; P = 0.01 and PC users OR = 3.40; CI = 1.24–7.32; P = 0.01). The study by Tester et al. [69] reported the results for TV, PC, and VG among overweight, obese and severe obese children separately and therefore, the results were included as six separate studies in the analysis. According to their results, children with total screen time of more than 4 h were more likely to be overweight [OR = 1.5; CI = 1.2 to 1.9)] or obese [OR = 2.0; CI = 1.2 to 3.3]. The study by Irish-Hauser et al. [70], reported the association between overweight and TV watching during dinner with rarely/ sometimes or much users so the results were reported as three independent studies. The study by De Jong et al. [71] was reported as four studies of TV watchers of 1–1.5 and more than 1.5 h and PC users of less than 30 min/day and more than 30 min per day. In the study by Stettler [60], obesity was increased by higher TV watching hours and electronic game playing [OR = 1.92; CI = 1.27 to 2.90; P = 0.002 and OR = 2.56; CI = 1.55 to 4.23; P < 0.001 respectively]. The age range of participants was 4–11 years old. 4 studies out of 45 were school based and all of the studies were performed in combination of girls and boys.

Results of meta-analysis

The results of the two-class meta-analysis (Fig. 2) showed that being at the highest category of screen time was associated with 20% increase in obesity risk (OR = 1.21; CI = 1.113, 1.317; P < 0.001). The heterogeneity was identified as I-squared (variation in ES attributable to heterogeneity) of 60.4%. For finding the source of heterogeneity, we performed subgrouping and the results are shown in Table 3. As presented, a minimal reduction in heterogeneity was observed after subgrouping according to setting, obesity status and age group; so, these parameters might be considered as possible heterogeneity sources. The results of dose–response relationship between screen time and obesity among children is presented in Fig. 3. There was no evidence of non-linear association between increased screen time and obesity risk among children (P-nonlinearity = 0.310). The details of dose–response association is also presented in Table 4. It can be inferred from the Table that by 50, 100 and 150 min increments in screen time, there is 7%, 16% and 35% increase in the odds of obesity among children; although these values were not statistically significant (Table 4).

The results of quality assessment and publication bias

The results of the quality assessment according to AHRQ checklist (Table 1) revealed that all of the included studies had moderate quality scores. Publication bias was assessed with the funnel plot (Fig. 4). Moreover, the Begg's and the Egger's regression tests were further used to better clarify the publication bias. Accordingly, an evidence of publication bias was achieved for study parameters [OR of obesity and screen time: Egger's test (P = 0.001) and Begg's test (P = 0.001). Therefore, trim and fill analysis was performed (Fig. 5); accordingly, the obtained results were as follows: OR = 1.187; CI = 0.883, 1.491; P < 0.001).

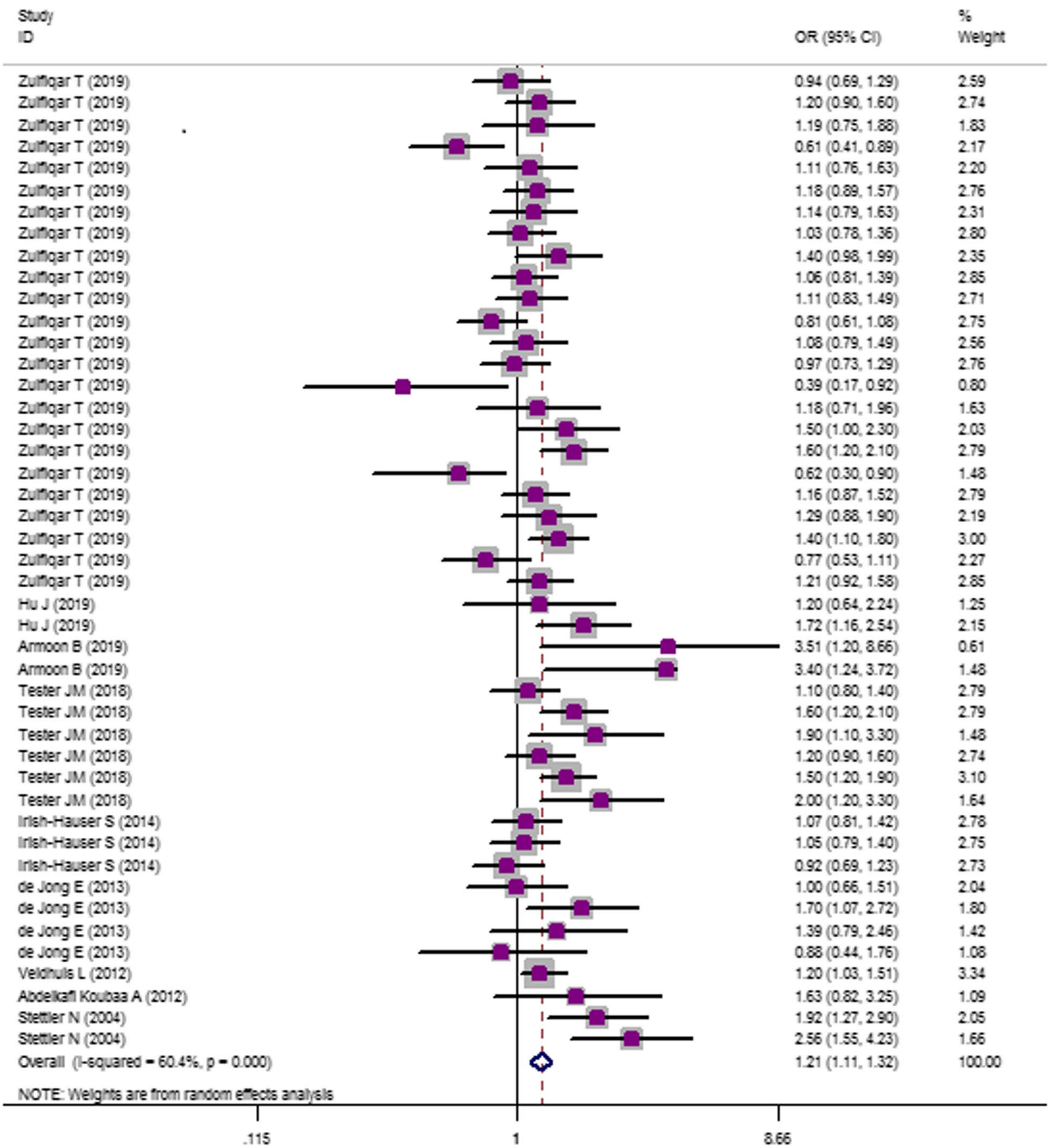

Fig. 2 Odds ratio (OR) with 95% confidence interval (CI) of obesity in highest versus lowest screen user children. I^2 represents the degree of heterogeneity

Discussion

In the current work, we identified that children at the highest category of screen time were 1.2 times more likely to develop obesity. Most of the included studies (e.g. 26 studies) used TV as the most commonly used screen and were community-based studies. The results of previous studies evaluating the association between TV viewing and childhood obesity are inconsistent; several studies reported positive association between TV viewing and obesity risk among children [67, 68, 71]; while several others reported a dose–response association between TV viewing and childhood obesity [72, 73]

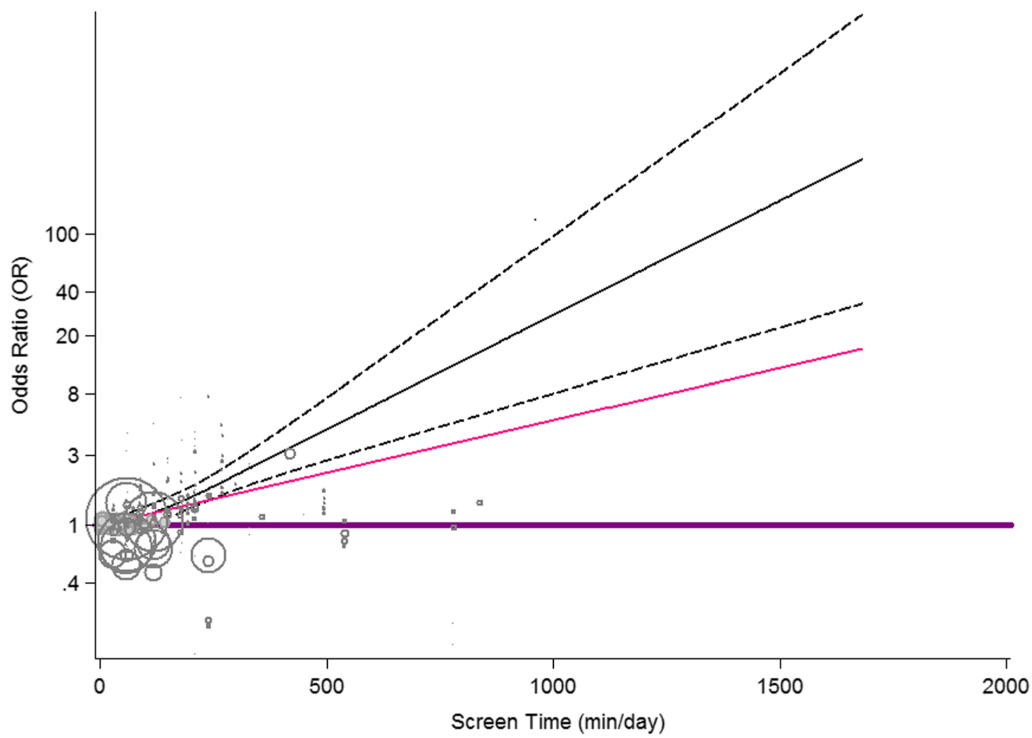

Fig. 3 Dose–response association between screen time and odds of obesity. Linear relation (solid line) and 95% CI (dashed lines) of pooled OR of obesity by 1 min/*day* increment of screen time (p- nonlinearity = 0.310) among children

and several others reported no associations between them [41, 74]. In the current meta- analysis, we summarized the results obtained from 28,675 individuals and the final result was a positive association between screen time and childhood obesity. This positive association was not observed for VG alone with a reasonably acceptable number of included studies e.g. [13]. Surprisingly, several studies have reported the negative effect of active video games on obesity. In the study by Zulfiqar et al. [66], electronic games more than 1 h in weekend was associated with reduced risk of obesity among children 4–5 years old [OR = 0.61; CI = 0.41,0.89; $P < 0.001$]. In the other study by Hernandez et al. [75] only TV viewing was associated increased obesity risk and no association was found between video games or any other types of video time with obesity risk. Several other studies also revealed the positive effects of some active video games in increasing physical activity and reducing obesity risk [76–78]. In other study by Strahan et al. [79], active video games reduced the chance of obesity among youth. The reason is that some of the video games possibly increase physical activity and physical health; in a meta-analysis by Primack et al. [80], video games were associated with 69% improve in psychological therapy outcomes and 50% improve in physical activity outcomes. In another study by Williams et al. [81], active video games were suggested as effective therapeutic tools to improve physical activity among adolescents and were considered as a more acceptable and sustainable approach than many other conventional methods.

The obesity-promoting effects of increased screen-time can be explained by this fact that increased screen activities are associated with increased food intake; numerous studies have revealed that television watching increases motivated response to food intake and snacking behavior among children and adolescents [82–86]; this is also true for video games [87–90] and personal computer use [91, 92]. More important, several food-related advertisement in television can potentially affects children's food behaviors by promoting junk food and fast food consumption and increasing obesity [93–99]. Therefore, the association between obesity and screen use is a multi-dimensional factor that all of its aspects needs to clearly studied. Several limitations of the current meta-analysis should also be addressed; first of all, the results of included studies were reported in a combination of males and females therefore, it was not possible to give gender-specific results; moreover, there are relatively low number of studies in several subgroups and their results could not be generalized. The screen time

Table 3 Subgroup analysis for the odds of obesity in highest versus lowest screen-user children

Group	No. of studies*	OR (95% CI)			$P_{within\ group}$	$P_{between\ group}$*	$P_{heterogeneity}$	I^2 (%)
Total	45	1.211	1.113	1.317	< 0.001		< 0.001	60.4
Continent						< 0.001		
America	10	1.279	1.099	1.488	0.001		0.023	53.4
Europe	7	1.435	1.114	1.847	0.005		0.021	59.8
Asia	4	2.113	1.302	3.429	0.002		0.047	62.3
Oceania	24	1.084	0.985	1.193	0.100		0.003	49.4
Screen type						< 0.001		
TV	26	1.253	1.146	1.370	< 0.001		0.009	44.3
PC	3	1.641	0.755	3.565	0.211		0.007	80
VG	13	0.991	0.838	1.173	0.920		0.001	63
TV + VG + PC	3	1.450	1.150	1.830	0.002		0.194	39.1
Age group						< 0.001		
≤ 5	18	1.200	1.051	1.369	0.007		0.001	59.6
> 5	23	1.221	1.082	1.379	0.001		< 0.001	66.2
Both	4	1.227	0.915	1.645	0.172		0.274	22.8
Setting						< 0.001		
Community	41	1.210	1.108	1.322	< 0.001		< 0.001	62.7
School	4	1.227	0.915	1.645	0.172		0.274	22.8
Obesity status						< 0.001		
Obesity	4	1.609	1.371	1.889	< 0.001		0.700	0
Overweight	5	1.065	0.938	1.209	0.333		0.789	0
Overweight/ obesity	36	1.194	1.081	1.319	< 0.001		< 0.001	61.7
Sample size						< 0.001		
1000 >	10	1.583	1.197	2.093	0.001		< 0.001	76.2
1000–5000	27	1.100	1.003	1.206	0.043		0.004	47.5
≥ 5000	8	1.351	1.170	1.560	< 0.001		0.115	39.6

TV television, *OR* odds ratio, *CI* confidence interval, *EG* electronic game, *PC* personal computer, *DVD* digital video discs, *VCDs* video compact disc digital

* All of the included studies were in moderate quality group therefore, subgrouping was not performed

Table 4 Details of non-linear association between screen time and obesity among children

Variable	Screen time increment (min/d)	OR for obesity	*P*	95% CI
Children	50	1.078	0.103	0.99, 1.10
	100	1.163		0.98, 1.21
	200	1.353		0.96, 1.55

OR odds ratio, *CI* confidence interval

was subjectively assessed by questionnaire that stems for recall bias; finally, the cross-sectional design of the included studies, make it impossible to infer the causality.

Conclusion

In the current systematic review and meta-analysis we observed increased obesity risk in those with the highest screen time versus those with the lowest screen time. This association was not non-linear and TV was the most common obesity-promoting screen in the included studies. Moreover, community based studies with greater sample size showed the strongest associations. Since the results were not separable for boys and girls, and also due to the observational design of the included studies, further studies with separate results for males and females and different screen devices with longitudinal or interventional designs are needed to better explore the obtained results.

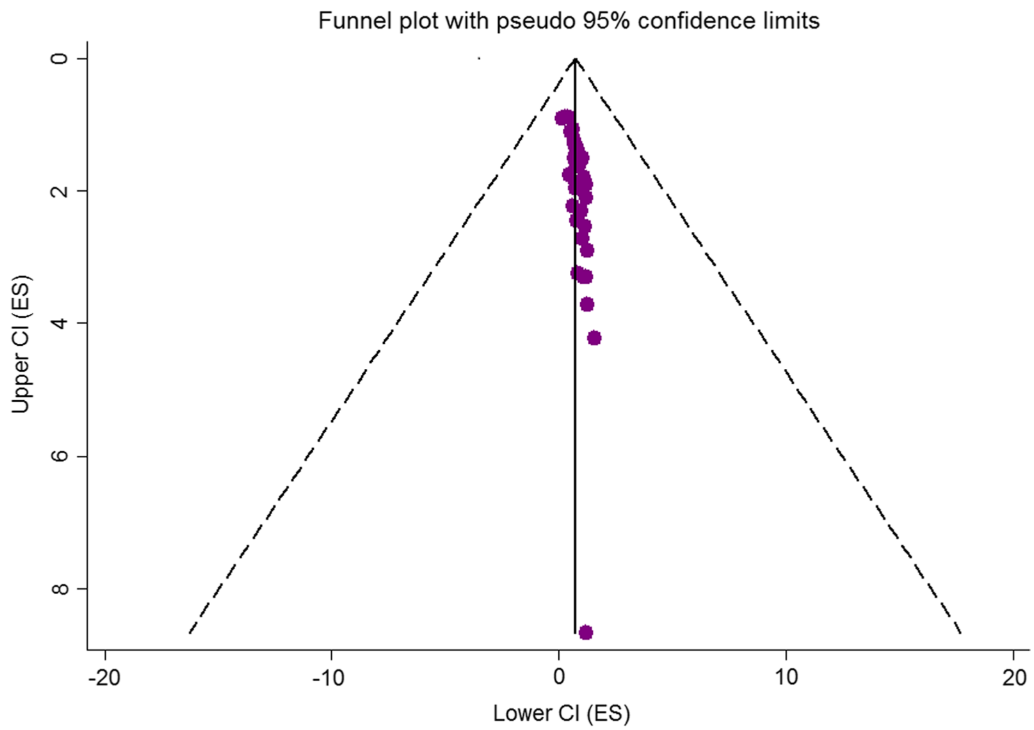

Fig. 4 Begg's funnel plot (with pseudo 95% CIs) of the odds of obesity in highest versus lowest screen time categories

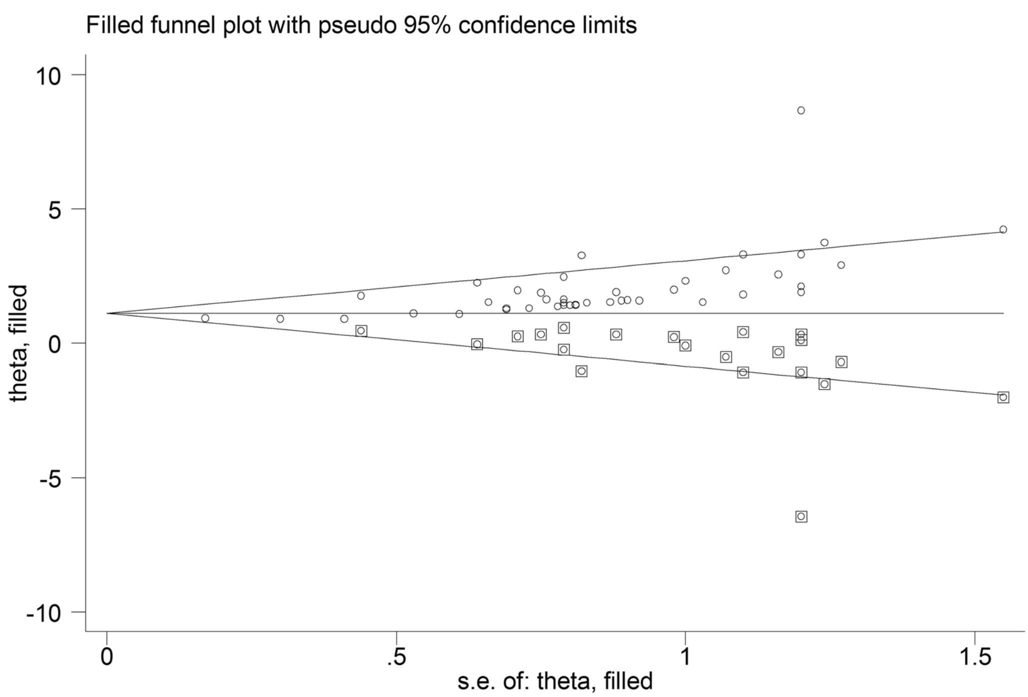

Fig. 5 Filled funnel plot with pseudo 95% confidence limits for studies evaluating the association between screen time and obesity among children (OR = 1.187; CI = 0.883, 1.49; *P* < 0.001)

Implications for practice section

In an updated systematic review and meta-analysis, we found a positive association between screen time and obesity risk among children. Therefore, this is a health alarm for families to manage their children's screen time, for policy makers to develop policies for management of media use and screen related behaviors among children [100].

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-022-00344-4.

Additional file 1. **Table S1**. PRISMA Checklist; **Table S2**. Search strategies and the number of records according to different electronic database.

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Author contributions
All authors have read and approved the manuscript; SHA, supervised the project, performed the search, extraction and wrote the first draft of the manuscript and analyzed the data. AARC and WJA were involved in search, extraction and revision of the paper. MT and ATJ were involved in data analysis. ASA and NS were involved in data extraction and data analysis. All authors read and approved the final manuscript.

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Availability of data and materials
All of the data are available with reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
The protocol of the current work has been approved by the ethics committee of Mustaqbal University College (ID: 4565/13).

Consent for publication
Not applicable.

Competing interests
The authors declare that there is no conflict of interest.

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