



Review article

Screen time, dietary patterns and intake of potentially cariogenic food in children: A systematic review

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ABSTRACT

Objectives: To investigate the association between screen-time behavior and diet, including a potentially cariogenic diet, in children younger than 12 years old.

Sources: Four electronic databases were searched, from their earliest records up to April 2018.

Study selection: Observational studies were included, assessing time spent in sedentary behavior (viewing of TV, DVDs, computer and electronic games) and dietary intake in preschoolers and school-aged children. The quality of the studies was assessed using the Newcastle-Ottawa Scale. The strength of the evidence was evaluated by the GRADE system.

Data: Nineteen articles were included, all providing cross-sectional analysis. Sedentary behavior was assessed by parent-reported or self-reported questionnaires. In 10 studies, food frequency questionnaires were the method of dietary assessment. Most studies only assessed television viewing time (13). A significant relationship was found in all the studies, between television and/or total screen-time viewing and adverse dietary outcomes, including fewer fruits and vegetables, and greater consumption of unhealthy foods. In 15 studies, higher TV viewing and/or screen-time rates were associated with higher intake of cariogenic foods, like energy-dense snacks and sugar-sweetened beverages.

Conclusions: There may be an association between sedentary behavior, particularly television viewing, and an unhealthy diet in young people involving increased intake of cariogenic foods. However, the strength of the evidence studies was limited.

Clinical significance: Further efforts are needed to limit television viewing in young children, aimed at promoting health and preventing lifestyle-associated diseases, such as dental caries.

1. Introduction

Sedentary behavior refers to very low levels of energy expenditure by sitting and lying [1]. The modernization of society has increased the prevalence of sedentary behavior, particularly in children and adolescents [2]. This is worrisome, because excessive sedentary activities can influence young children's physical, social, emotional, and cognitive development [3–5]. Poor diet and sedentary lifestyles have been cited as two of the most significant predictors of developing and maintaining overweight and obesity [6–9].

Screen time refers to the prolonged viewing time of various types of screens, like computers, televisions, videogames and smartphones/tablets. According to the recent recommendations of the American Academy of Pediatrics, children and adolescents should spend no more than 2 h of sedentary screen time daily [5]. Currently, there is evidence

suggesting that screen-based sedentary behavior may be more important than overall sedentary time in predicting obesity in children [10,11]. Nowadays, children and adolescents watch more television than ever before, and research has revealed that detrimental changes in diet may be associated with the increase in media viewing [12]. In particular, diet quality seems to be affected by the amount of television viewing time among children [13–15]. However, it is not clear whether young people who watch more television simply eat a poorer diet overall [16], or if they eat foods during television viewing that contribute to an overall diet that is lower in quality [17].

Dental caries, considered by the World Health Organization as a major public health problem globally, and the most widespread non-communicable disease [18], share common risk factors, such as diet, with other conditions, such as obesity [19]. Thus, it is possible that excessive screen time may also be associated with cariogenic dietary

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patterns [20]. So far, only one systematic review has examined the association between eating whilst watching TV and children's food and eating intake [21]. It was found that having the TV on at mealtimes reduces diet quality with more high-fat, high-sugar foods and fewer fruits and vegetables and increased consumption of sugar sweetened beverages. No reviews have examined the relationship between screen time and cariogenic diet in children. The objectives of this review were to examine the associations between screen-time behavior and diet in children younger than 12 years old. Additionally, the association between screen time and foods and drinks designated as potentially cariogenic was investigated.

2. Review methods

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) [22] guideline, and was registered in the International Prospective Register of Systematic Reviews (PROSPERO; <http://www.crd.york.ac.uk/prospero/>, reference CRD42017068862).

2.1. Eligibility criteria

The research was limited to observational studies, and investigated the associations between any screen-time behavior (television viewing, videocassette recorders, movies, and video/computer games) and diet in children younger than 12 years old. Intervention studies, case-control studies, review articles, case reports and personal or expert opinions, as well as qualitative studies, were not included. The review did not include studies limited to the effect of advertisement on food selection, or those that did not investigate the direct association between screen time and diet consumption. Also excluded were studies investigating TV viewing during meals. No restrictions on language or publication date were established.

2.2. Information sources and search strategies

In this review, electronic databases were searched up to April 2018, and scanned reference lists of the selected articles were consulted to identify relevant studies. The databases included International Database for Medical Literature (MEDLINE)/PubMed, ISI Web of Science, Scopus, Scientific Electronic Library online (SciELO), and Latin American and Caribbean Health Sciences (LILACS). Structured search strategies were performed using Medical Subject Headings [MeSH], and the combination of keywords following the structure of each database (S1).

2.3. Study selection

The searched titles and their abstracts were reviewed independently by two authors (AQS and LAP) to identify eligible papers. In phase 1, titles and abstracts were read by the authors to eliminate clearly irrelevant reports. When the abstract was not available, or insufficient information was provided, the full text of the report was obtained. The same two authors reviewed the full text articles independently, by applying the same eligibility criteria described above. Disagreements were resolved by discussion, until a consensus was arrived at; otherwise, a third reviewer (MLG) was consulted. All the studies excluded at this or subsequent stages were recorded, and explained in the flowchart (Fig. 1).

2.4. Data collection

Data from the studies was extracted in duplicate independently, using a pre-designed and pre-tested data extraction form. The following information was collected: author's name, year of publication, country, study design, sample size, age, assessment of screen time, assessment of

dietary intake, adjustment for confounding variables, and the key finding of the association between screen time and diet. The data from multiple reports of the same study were identified to avoid double counting. The classification of groups of a potential cariogenic effect was based on their densities of refined sugar or other simple carbohydrates, and/or previously reported associations with caries in the literature. The items categorized as more cariogenic were: added sugar, candy, chips, chocolate, chocolate milk, coffee (sugar added), cookies, fruit-flavored drinks, gelatin, honey, ice cream, Petit Suisse cheese, soft drinks, sweet biscuits, and tea [23]. Fast foods were classified as potentially cariogenic, given that they are usually accompanied by cariogenic items, such as soft drinks and condiments containing sugar.

2.5. Quality assessment

An adapted version of the Newcastle-Ottawa Quality Assessment Scale for cross-sectional studies was used by two independent reviewers [24,25]. The assessment of bias included the following items: (i) selection of the study population, (ii) comparability of subjects, and (iii) assessment of exposure or outcome, according to the study design. Based on these criteria, study quality was rated on a scale from 1 (very poor) to 10 (high). The following point distribution criteria were adopted: (i) selection of the study population (0–5 stars), (ii) comparability of subjects (0–2 stars), and (iii) outcome for cohort and cross-sectional studies (0–3 stars). A study is classified as being a high-quality study if the total score obtained is seven or higher [26]. Disagreements were resolved by consensus.

2.6. Synthesis of results

If data were homogeneous for pooling, a meta-analysis would be considered. If data were heterogeneous and inappropriate for a meta-analysis, a qualitative summary of the findings would be carried out. Heterogeneity was assessed by comparing the differences in participant characteristics and outcome assessment across the included studies.

2.7. Certainty of evidence rating and strength of recommendations grading

The certainty of evidence regarding the association of TV viewing and cariogenic diet was assessed through GRADE (Grading of Recommendations, Assessment, Development and Evaluation) approach for narrative summary of different effects across studies [27]. The assessment with GRADE was carried out by two independent researchers (A.Q.S and V.P.P) and disagreements were resolved by consensus. We rated down certainty of evidence if there were problems in risk of bias, inconsistency, indirectness, imprecision and publication bias [27].

3. Results

3.1. Identification of included studies

A total of 10,868 titles were found during the first scanning of key words. After duplicate removal (1488), 9380 articles were included for title and abstract scanning. After double searching for title and abstract, 171 eligible articles were selected for full text scanning, and their reference lists were screened for further relevant publications. A total of 45 eligible articles were included in this phase, although 26 articles were excluded during data extraction. A final total of 19 articles were included in this systematic review (Fig. 1).

3.2. Description of included studies

A meta-analysis was not performed, because the study designs were too different, and the outcomes measured were not sufficiently similar. Thus, we reported a qualitative synthesis of the results. Table 1 shows

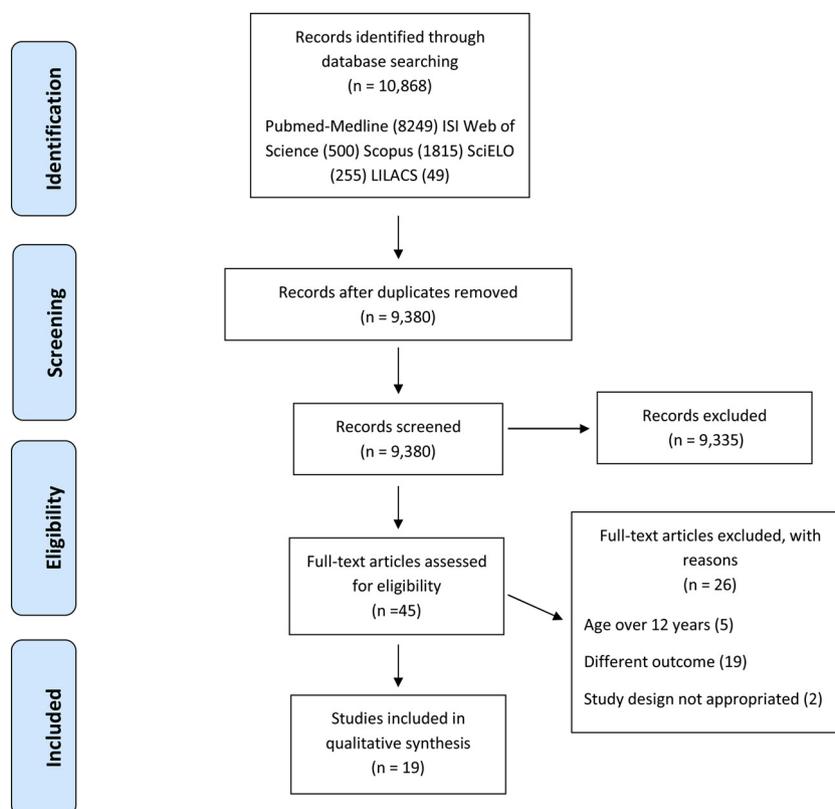


Fig. 1. Flow diagram for study selection.

the characteristics of the included articles and a description of the effect of different screen types on food choices among children.

Of the 19 studies included, all had a cross-sectional design or performed cross-sectional analyses. One was prospective, but only the baseline data was used in this review [13]. Publication year ranged from 2003 to 2017. All the studies were published in the English language, except one Spanish article [28].

Screen time assessment was self-reported or parent-reported for children younger than eight years old. In most of the studies, only television viewing was assessed [10,13,35–37,14,28–34]. In the others, total screen time was considered [38–40], or both total screen time and TV viewing were used as exposures [41–43]. Similarly, diet assessment for the included studies was either self- or parent-reported, depending on the child's age. The food frequency questionnaire (FFQ) was used in 10 studies; 24 h recall questionnaires were used in six studies; two studies used food diaries; and one study used the Children's Eating and Physical Activity Questionnaire (EPAQ) and a visual food servings guide [30].

The viewing cut-point varied among the studies. Nine studies adopted the recommendation of the AAP as a cut-off point [10,14,29,32,33,35,39–41]. Regardless of the cut-point adopted, higher TV viewing time and/or total screen time was associated with a poor quality diet. A decline in fruit, vegetables, meat, and other healthy foods, and an increase in the consumption of fatty, high-sugar foods, like candy, chocolate, chips, and other high caloric foods, was observed in all the studies investigated.

3.3. Association between potentially cariogenic diet and screen time

Table 2 shows the results of studies which assessed foods considered potentially cariogenic. In 15 studies, an association could be made between the intake of cariogenic foods and screen time.

A study with 10,453 6-to-9-year-old children, from five European countries that participated in the World Health Organization European

Childhood Obesity Surveillance Initiative, showed that one additional hour of screen time was associated with the higher consumption of a series of cariogenic foods, including 'soft drinks containing sugar' (1.28 [1.19;1.39]), 'diet/light soft drinks' (1.21 [1.14;1.29]), 'flavored milk' (1.18 [1.08;1.28]), 'potato chips (crisps), corn chips, popcorn or peanuts' (1.32 [1.20;1.45]), 'candy bars or chocolate' (1.31 [1.22;1.40]), and 'biscuits, cakes, doughnuts or pies' (1.22 [1.14;1.30]) [41].

The findings of all the studies included showed that the consumption of a potentially cariogenic diet may have an inverse relationship on the time spent watching television, playing videogames or using the computer. In 2006, Utter et al. [35] explored how time spent watching television is associated with the dietary behavior of New Zealand children between 5–10 years old. The results showed that children watching two or more hours of TV per day were more than twice as likely to be high consumers of soft drinks than children watching less than an hour of TV daily. Recently, this association was confirmed in Spain [40], where screen-time duration was associated with the higher frequency of consumption of energy-dense, micronutrient-poor products (such as sugar-sweetened soft drinks, snacks and chocolates). Moreover, Kelishadi et al. [38] confirmed these associations among Iranian children. Students subjected to prolonged screen time (more than 4 h/d), had higher odds of daily consumption of sweets (odds ratio [OR] 1.25; 95% confidence interval [CI] 1.14–1.4), soft drinks (OR 1.52; 95% CI 1.4–1.7), canned fruit juice (OR 1.3; 95% CI 1.2–1.4), and fast food (OR 1.53; 95% CI 1.4–1.7), showing that prolonged time spent watching TV, and using a computer during leisure time could be associated with unhealthy dietary habits.

3.4. Quality assessment

Regarding the quality of the studies, the assessment results (Table 1) indicate 14 high-quality and only 2 low-quality studies. The lower scores were mainly related to not calculating the minimum sample size, the lack of a multivariate analysis, and a non-response rate. Both high-

Table 1
Study characteristics included in the systematic review of the effect of different types of screens on food choices among children.

Author, Year, Country, Study type	Sample characteristics	Assessment of Screen Time	Assessment of Dietary intake	Adjustment for confounding variables	Key finding	Study quality
Arançeta et al., 2003, Spain [29] Cross-sectional	N = 1,375 Age = 2–13 years	- Interview with participants and their mothers or guardians responsible for feeding the child, when under 8 y. - Time spent watching TV categorized as: < 1, 1–2, > 2.	- 24-h recall and food frequency questionnaire	Age, gender, mother's level of education	- TV viewing time showed a positive association with a "snacky" pattern and a negative association with the 'healthy' pattern. - The highest proportion of inadequate intake for vegetables was observed among 10–13 years old boys and 6–9 years old girls. - The youngest age group (2–5 years) showed the lowest proportions of inadequacy for the dairy group. - TV viewing time was positively associated with unhealthy foods (sweets, soft drinks, pastries, diet soft drinks, potato chips, French fries, fruit juices, ice cream, fried foods, and fast food), and negatively associated with fruits, vegetables, and green vegetables.	High (7)
Borghese et al., 2014, Bulgaria, Czech Republic, Lithuania, Portugal, and Sweden [10] Cross-sectional	N = 523 Age = 9–11 years	- Self-reported - Time spent watching TV (on school day and weekends), categorized as: > 2 h/ ≤ 2.	- Food frequency questionnaire (FFQ).	Age, gender, ethnicity, maturity offset, fat mass, income, parental education, moderate-to-vigorous physical activity (MVPA), total sleep period, moderate-to vigorous physical activity/sedentary time.	- Screen time was positively associated with consumption of high-fat foods, free sugar or salt, like soft drinks containing sugar, flavoured milk, candy bars or chocolate, biscuits, cakes, doughnuts or pies, potato chips, corn chips, popcorn or peanuts, pizza, French fries (chips), and hamburgers, and negatively associated with the consumption of vegetables. - Each additional hour of TV viewing was associated negatively with fruit and vegetable consumption.	High (7)
Börnhorst et al., 2015, (Bulgaria, Czech Republic, Lithuania, Portugal, and Sweden) [41] Cross-sectional	N = 10,453 Age = 6–9 years	- Parent-reported - Sum of TV and PC time/day (weekday and weekend). - Total screen time categorized as: < 2 h/ ≥ 2.	- Short food-frequency questionnaire (FFQ) – 16 items.	Age, sex, outdoor play time, maximum educational level of parents, sleep duration, and body mass index z-scores.	- Screen time was positively associated with consumption of high-fat foods, free sugar or salt, like soft drinks containing sugar, flavoured milk, candy bars or chocolate, biscuits, cakes, doughnuts or pies, potato chips, corn chips, popcorn or peanuts, pizza, French fries (chips), and hamburgers, and negatively associated with the consumption of vegetables. - Each additional hour of TV viewing was associated negatively with fruit and vegetable consumption.	High (7)
Boynton-Jarrett et al., 2003 USA [13] Prospective study	N = 548 Mean age 11.7 years at baseline and 13.3 at follow-up. N = 135 Age = 2–6 years	- Self-reported - Hours/days of television viewing. - Parent-reported - TV, DVD and video viewing on three consecutive days (two weekdays and one weekend day).	- Youth Food-Frequency Questionnaire	Baseline fruit and vegetable intake, age, sex, ethnicity, school, total energy intake (by energy-adjusting baseline and follow-up fruit and vegetable servings) and BMI. None related	- Each additional hour of TV viewing was associated negatively with fruit and vegetable consumption.	Medium (6)
Cox et al., 2012 Australia [30] Cross-sectional	N = 1540 Age = 4–5 years	- Parent-reported - TV viewing questionnaire categorized as: < 3 h, or ≥ 3.	- Child consumption of food or drinks during screen time. - Children's Eating and Physical Activity Questionnaire (EPAQ). - Visual 'food servings' guide, child's intake of ten food and beverage categories on the previous day. - 24 h recall questionnaires.	Maternal characteristics (age, immigrant status, education, working status and self-perceived health). Mother and father's smoking status, and number of smoking parents in the household, family type, annual household income, socio-economic status, day care attendance and child sex.	- TV viewing was positively associated with energy-dense nutrient-poor foods and with frequency of consuming fast foods, and negatively associated with vegetable consumption.	Low (3)
Dubois et al., 2008 Canada [31] Cross-sectional analysis in a cohort study	N = 1540 Age = 4–5 years	- Parent-reported - TV viewing questionnaire categorized as: < 3 h, or ≥ 3.	- 24 h recall questionnaires.	Maternal characteristics (age, immigrant status, education, working status and self-perceived health). Mother and father's smoking status, and number of smoking parents in the household, family type, annual household income, socio-economic status, day care attendance and child sex.	- TV viewing time was positively associated with consumption of carbohydrates and soft drinks, and negatively associated with a lower daily consumption of fruits and vegetables.	High (8)

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Table 1 (continued)

Author, Year, Country, Study type	Sample characteristics	Assessment of Screen Time	Assessment of Dietary intake	Adjustment for confounding variables	Key finding	Study quality
Hare-Bruun et al., 2011 Denmark [32] Prospective cohort study with cross-sectional analysis	N = 697 Age = 8-10 years	- Self-reported - TV viewing (times/week and hours/day), categorized as: < 1, 1-2, > 2	- single 24 h recall - Sum of healthy food preferences using a computer-based questionnaire.	BMI z-score, physical activity (mean counts per minute), maternal BMI, paternal BMI, SES and the baseline value of the outcome variable of Healthy Food Patterns and Healthy Food Habits.	- More TV viewing time was associated with lower healthy food patterns and healthy food habits.	High (8)
Kelishadi et al., 2017, Iran [38] Cross-sectional multicenter	N = 13,486 Age = 6–18 years	- Self-reported. - (WHO-GSHS questionnaire. Time spent watching TV or working with computers (hours/ day on weekends/weekdays) categorized as: (screen time, > 4 or ≤4), (computer, > 1 h or ≤1). (TV, > 3 h, or ≤3)	- Frequency of 'sweets, salty snacks, soft drinks, fresh fruit, dried fruit, vegetables, canned fruit juice, milk, and fast food consumption.'	Age, sex, living area (urban, rural), physical activity, BMI z-scores, socio-economic status, and sleep duration	- Screen time was positively associated with consumption of sweets, fresh fruit, dried fruit, and canned fruit juice. - Computer use was positively associated with sweets, fresh fruit, dried fruit, canned fruit juice, and vegetable consumption. - TV viewing time was positively associated with sweets, salty snacks, soft drinks, and fast food consumption. - No significant association was observed between screen time, TV viewing time, and time spent working with computers and consuming fresh fruit and vegetables. - Significant relationship between the time spent watching TV and screen time and reduced consumption of milk.	High (8)
Lipsky and Iannotti, 2012, USA [42] Cross-sectional	N = 5152 Age < 13 years	- Self-reported - Time spent watching TV (including videos and DVDs) hours/ day on weekends/ weekdays and computer use for play games or internet use. - Parent-reported - Time spent watching TV in the last week categorized as: > 1-3 h, or ≥4 h.	- Frequency of eating fruit, vegetables, sweets, and sugary soft drinks; eating at a fast food restaurant (≥ 1 day/week); and skipping breakfast (≥ 1 day/week).	Computer use, physical activity, age, sex, race/ethnicity, and family affluence	- TV viewing time and computer use were positively related to sweets and soda intake and fast food intake and inversely related to fruit and vegetable intake. - TV viewing time was positively associated with sugar ingestion. No association with cereals, fruits, dairy products, meat, fish and oils consumption was found.	High (7)
Lopez et al., 2012 Chile [28] Cross-sectional	N = 45 Age = 3-6 years	- Parent-reported - TV viewing time, on weekday and weekend. Categorized as: < 2 h, or ≥2 h.	- Quantitative consumption trend survey (ETCC)	None related	- TV viewing time was positively associated with sugar ingestion. No association with cereals, fruits, dairy products, meat, fish and oils consumption was found.	Medium (5)
Manios et al., 2009 Greece [33] Cross-sectional	N = 2,242 Age = 1-5 years	- Parent-reported - TV viewing time, on weekday and weekend. Categorized as: < 2 h, or ≥2 h.	- Weighed food records (during nursery hours) - 24-h recall or food diaries under parent's/ guardian's supervision in (two consecutive weekdays and one weekend day).	Age, sex, birth rank, the presence of brothers/sisters, location of residence, maternal educational status, maternal employment status and time spent by mothers with their children.	- TV viewing time was positively related to the ingestion of high total energy intake of monosaturated and polyunsaturated fat, consumption of bread, meat, total fat, and other carbohydrates (i.e., sweets, chocolates, soft drinks), and negatively associated with fruit and vegetable consumption.	High (7)

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Table 1 (continued)

Author, Year, Country, Study type	Sample characteristics	Assessment of Screen Time	Assessment of Dietary intake	Adjustment for confounding variables	Key finding	Study quality
Miguel-Berges et al., 2017 Belgium, Bulgaria, Germany, Greece, Poland and Spain [43] Cross-sectional	N = 6431 Age = 3.5–5.5 years	- Parents/caregivers reported watching TV and DVDs, playing computer/video games, on weekday and weekend. Categorized as: (watching TV or total screen time) > 1, or ≤ 1 h.	- 37-item semi-quantitative food frequency questionnaire FFQ.	Sex, maternal education, body mass index and centre.	- Both TV viewing time and total screen time had a positive association with consumption of fizzy drinks, juices, sweetened milk, cakes and biscuits, chocolate, sugar-based desserts and pastries, salty snacks and potatoes, and a negative association with vegetables, fruits and fish intake. - TV viewing time was positively associated with sugar-sweetened beverages, fruit juice, whole or 2% milk, fast food, snack food, and red and processed meat consumption. Negative association was found with fruit and vegetables, dietary fiber, and calcium consumption.	Medium (6)
Miller et al., 2008 USA [14] Cross-sectional	N = 1203 Age = 3 years	- Parents/caregivers reported TV viewing time, on weekday/weekend in the past month categorized as: 0- ½ h/d, > ½- < 2 h/d, 2 h/d, and > 2 h/d.	- Semi- quantitative food frequency questionnaire	Mother's age, household income, education, marital status, and smoking; pre-pregnancy maternal and paternal BMI; and child's race/ethnicity, BMI z-score, sleep duration at 3 years, and breast feeding duration, child's age and sex.	- TV viewing time and consumption of sweetened beverages increased in a dose-response fashion. - After the age of 3 years, an increase by age group in the consumption of sweetened beverages, TV viewing time and exposure to commercial TV was observed.	High (7)
Olaśdotir et al., 2014, Sweden [39] Cross-sectional	N = 1,733 Age = 2 – 9 years	- Parent-reported Hours/day watching TV, videos or DVD sitting at the computer or playing computer games (weekdays and weekends) categorized as: ≤30 min, 31-60 min, 61-90 min, 91-120 min, > 2 h.	- Food frequency questionnaire (FFQ).	Age, sex, having older siblings, child's weight status, parental education, income, and parental norms on sweetened beverages.	- TV viewing time and consumption of sweetened beverages increased in a dose-response fashion. - After the age of 3 years, an increase by age group in the consumption of sweetened beverages, TV viewing time and exposure to commercial TV was observed.	High (7)
Pérez-Farinós et al., 2017 Spain [40] Cross-sectional	(2011) 6287 children, aged 6 to 9 years (2013) 2806 children, aged 7 to 8 years	- Parent-reported Hours/ days watching TV (including videos), and/or playing PC or video games, (weekdays/weekends). - Screen time categorized as: < 2 h, ≥2 h.	- Short food frequency questionnaire (FFQ).	Age (years), sex, outdoor playtime (hours/day), maximum parental educational level, BMI categories, and presence of a computer, television or game console in the child's bedroom.	- Screen time was associated with higher frequency of consumption of energy-dense, micronutrient-poor products (such as sugar-sweetened soft drinks, snacks and chocolates), and lower frequencies of consumption of fruit and vegetables. - Less TV viewing time was positively associated with favorable dietary quality in preschool (2-5 years), and school aged children (6-11 years).	High (7)
Sisson et al., 2012 USA [34] Cross-sectional	N = 1423 Age = 2–5 years N = 1749 Age = 6–11 years N = 1878	- Self- or parent-reported according to the age. - Hours/days watching TV or videos (over the past 30 days) categorized as: < 4 h, or ≥ 4 h. - Parent-reported - Time spent watching TV or videos over the previous week categorized as: < 1 h, 1- < 2 h, or ≥ 2 h.	- Healthy Eating Index–2005(calculated from two 24-h recalls). - Food frequency questionnaire (FFQ)	Age, BMI, race/ethnicity, physical activity, and total energy intake (i.e., nutrient density method). Age, sex, ethnicity physical activity and socioeconomic status.	- TV viewing time was associated with higher consumption of soft drinks, hamburgers and French fries, and all of the commonly advertised foods, except for chocolate sweets and fried chicken. - Children who watched two or more hours of - TV per day were less likely to be high consumers of fruits and vegetables; the relationship with milk consumption was not statistically significant.	High (7)

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Table 1 (continued)

Author, Year, Country, Study type	Sample characteristics	Assessment of Screen Time	Assessment of Dietary intake	Adjustment for confounding variables	Key finding	Study quality
Wiecha et al., 2006 USA [37] Longitudinal study	N = 548 Age = mean age at baseline, 11.70 years N = 4211	- Self reported - Time spent watching television and videos during each day of the week.	- Youth food frequency questionnaire (FFQ).	Baseline BMI, physical activity, age, total energy intake, sex, race/ethnicity, and school indicator variables. None related	- TV viewing time was positively associated with the consumption of calorie-dense low-nutrient foods frequently advertised on television. - TV viewing time was positively associated with the consumption of sodas, crisps, cakes and pastries, and sweets and chocolates at least once a day, and negatively associated with the consumption of fruits.	High (8) Low (4)
Yannakoulia et al., 2004 Greece [36] Cross-sectional	Age = 11.5 years	- Self reported - Time spent in watching TV and playing video/computer games categorized as: Never, < 0.5h, < 1 h, 2-3 h, 4 h, > 4.	- Mini food frequency questionnaire. - Unhealthy Food Choices Score (UFCS).			

Table 2

Association between greater screen time and intake of potentially cariogenic foods.

Study	Cariogenic foods included in the studies	Association
Aranceta et al., 2003 [29]	Snacky pattern (buns, cakes, biscuits, sweets, salted snacks and soft drinks)	+
Borghese et al., 2014 [10]	Sweets	+
	Soft drinks	+
	Pastries	+
	Potato chips	+
	Ice cream	+
	Fast food	+
	Sports drinks	+
Börnhorst et al., 2015 [41]	Soft drinks containing sugar	+
	Flavoured milk	+
	Potato chips (crisps), corn chips	+
	Candy bars or chocolate	+
	Biscuits, cakes, doughnuts or pies	+
Hare-Bruun et al., 2011 [32]	Unhealthy items (French fries, carbonated drinks, pizza, crisps, burgers, and sweets/chocolate).	+
Kelishadi et al., 2017 [38]	Sweets	+
	Soft drinks	+
	Canned fruit juice	+
	Fast food	+
Lipsky and Iannotti, 2012 [42]	Sweets (candy or chocolate)	+
	Coke or other soft drinks that contain sugar (soda)	+
	Eating at a fast food restaurant (McDonald's, KFC, Pizza Hut, and Taco Bell).	+
Lopez et al., 2012 [28]	Sugar	+
Manios et al., 2009 [33]	Carbohydrates (i.e., sweets, chocolates, soft drinks, etc.)	+
Miguel-Berges et al., 2017 [43]	Fizzy drinks (soft drinks and light drinks)	+
	Packed juices	+
	Sweetened milk	+
	Cakes and biscuits	+
	Chocolate and chocolate spreads	+
	Sugar-based desserts and pastries	+
Miller et al., 2008 [14]	Sugar-sweetened beverages	+
	Fruit juice	+
	Fast food intake	+
	Snack food intake	+
Olafsdottir et al., 2014 [39]	Sugar-sweetened drinks including sports drinks, (syrup-based drinks)	+
Pérez-Farinós et al., 2017 [40]	Milkshakes	+
	Potato chips and other salty snacks	+
	Candy bars or chocolate	+
	Biscuits and cakes	+
	Soft drinks containing sugar	+
Utter et al., 2006 [35]	Potato crisps	+
	Chocolate sweets	-
	Biscuits	+
	Soft drinks	+
Wiecha et al., 2006 [37]	Sugar-sweetened beverages	+
	Salty snacks	+
	Sweet baked snacks	+
	Candy	+
	Fast food type main courses	+
Yannakoulia et al., 2004 [36]	Sodas	+
	Potato crisps, chips	+
	Cakes and pastries	+
	Sweets and chocolates	+

+ Positive association; – Negative association; 0 No association.

and low-quality studies showed a positive association between television viewing and/or screen time and the consumption of a poor-quality diet (Appendix 1).

3.5. Certainty of evidence rating and strength of recommendations grading

In general, time spent by children watching TV is associated with intake of potentially cariogenic diet with moderate certainty of evidence (Appendix 2). Major concerns were regarding: risk of bias (not serious), inconsistency (not serious), indirectness (not serious) and imprecision (not serious).

4. Discussion

Information concerning the influence of sedentary behavior on health, including diet quality, is essential for pediatric health care providers to identify parental practices and reinforce active media mediation strategies. To the best of our knowledge, this is the first systematic review to investigate the effect of screen time on diet in preschool and school-aged children. The primary outcome of this review addresses the associations observed between time spent on screen viewing and diet quality, and the secondary outcome considers the consumption of a potentially cariogenic diet and screen-time. This systematic review involved searching multiple electronic databases; in addition, reference lists of literature reviews were searched to obtain other studies that could also be included.

Depending on the child's age, parent-reported methods were used to assess child TV viewing and diet consumption, a method that may be subject to bias [44]. All dietary intake methodologies, such as the use of food frequency questionnaires or dietary recall, have their limitations, and may lead to either incomplete or inaccurate reporting. Although the quality assessment did consider the use of validated tools, the limitations regarding the accuracy of dietary intake data may also exist in high quality studies. In addition, an important limitation common to all studies is their cross-sectional design or data analysis. Longitudinal studies are important to confirm causality rather than associations. Although much research has already been carried out to confirm that the relationship between TV and diet exists, this review, to the best of our knowledge, is the first to collate evidence on the impact of watching TV or other screen-time activity on children's diet quality. Moreover, its findings clearly show that there is indeed an impact on general and oral health, especially in regard to obesity and dental caries, respectively. It should be underscored that further studies are needed in this field, given the ever-increasing number of "screens" being used by children, to determine the impact of different types of screen time on diet quality and preference.

This review found evidence that the time spent watching television, playing on the computer and total screen time were inversely related to diet quality among children. In addition, the higher consumption of a potentially cariogenic diet was found among children with excessive screen time, with moderate level of certainty. Previous studies have shown that children who watched television advertisements for cariogenic foods, such as chocolate, fast food, soft drinks, biscuits, and energy drinks, are more prone to developing dental caries [45,46]. This may be explained by the effect of food advertisements, which may divert a child's preference over healthy food choices, even if only on the short term. This diversion could lead to changes in the child's eating habits, and put the child at greater risk not only for general diseases, but also for dental diseases [47]. Strategies must be adopted to promote a healthy diet for children, and thus prevent chronic diseases like obesity and dental caries. Policies aiming to reduce the exposure of children to TV marketing messages promoting unhealthy foods, and to introduce more messages for nutritional foods must be encouraged.

As a limitation, different cutoff points to determine excessive screen time were adopted in the studies, ranging from < 1 to < 4 h. This limits the validity of the exposure tested. However, regardless of the cutoff

adopted, association between excessive screen time and diet was confirmed. Another limitation was the difficulty to summarize results considering age groups, due to the fact that age of participants varied among studies.

Based on the findings of this review, it may be plausible to suggest that excessive screen time might be associated with caries resulting from the adoption of poor dietary habits. So far, the underlying mechanisms of the association between TV viewing and dental caries are not fully understood, especially in children. Studies among adolescents have shown that a longer duration of television viewing time was associated significantly and confirmedly with a greater number of decayed teeth and a higher DMFT index [20,48]. Within the multifactorial context of dental caries, the importance of one's diet, especially regarding the control of sucrose and fermentable carbohydrate consumption, has been evidenced in the literature. Therefore, it is believed that sugar consumption is clearly the key to the large differences in caries prevalence observed worldwide, since caries serve as a substrate for cariogenic microorganisms [49–51]. In this same respect, it has been reported that watching TV is also associated with increased meal frequency and food consumption [12,52–54], regardless of appetite sensations [55]. Parents must be made more aware of the harmful effects of excessive screen time regarding sedentary behavior, thus reinforcing the importance of parental regulations to limit their child's screen time.

Health professionals, including dentists, should spread their knowledge regarding the importance of limiting screen time, according to the recommendations of the American Academy of Pediatrics (AAP). It is also important that parents of younger children choose high-quality programming, and watch it with their children to help them understand what they are seeing and how it can be applied to the world around them. Regarding older children, parents should place regular limits on the time spent using different media and on the types of media used, and also make sure that media-related activities do not replace adequate sleep, physical activity and other behaviors essential to promoting good health [5].

5. Conclusions

Based on the present systematic review an association was found between the time spent by preschool and school-aged children watching TV and poor diet quality, characterized by higher fat and sugar consumption with fewer fruits and vegetables, and increased intake of sugar-sweetened beverages, therefore representing a potentially cariogenic diet. More longitudinal studies with a long follow-up, combined with clinical examinations, are important to establish the relationship between dental caries and screen time. Findings reinforce the importance of adopting different initiatives aimed at health promotion and prevention of lifestyle-associated diseases.

Author contributions

A.Q.S and L.A.P revised the literature, extracted the data and supervised the drafting of the manuscript. V.P.C, M.C and M.L.G conceived the ideas, acquired the data, and critically revised the final manuscript.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.jdent.2019.06.004>.

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