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Sedentary behavior and body composition in children of low-and mid-income countries: a review

Comportamento sedentário e composição corporal em crianças de países de baixa e média renda: uma revisão

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ABSTRACT

This study reviewed the relationship between sedentary behavior (SB) and body composition in children and adolescents from low-and-mid income countries (LMIC). A systematic review was developed through manual and electronic searches in eight databases. Were included observational studies conducted in LMIC, with children and adolescents from three to 19 years. As results, 39 original articles were found (37 cross-sectional, 1 case control study and 1 cohort), which in all presented 75 analyzes, most of them based on screen behaviors (n = 71; 94.7%). At all, 15 of 25 analyses showed risk associations between SB and unfavorable body composition. When focusing on the dose of sedentary behavior, risk associations were verified in distinct cutoff points: 1h/d (3 of 3 analyses); 2h/d (9 of 16); 3h/d (2 of 5); 4h/d (4 of 5) and 5h/d (3 of 6). Television time was the SB type most frequently associated as risk in all categories. In conclusion, recognition of these associations is important both to support future studies and for its dissemination in preventive messages in the population of interest. Also, further longitudinal studies are necessary for narrowing the casual relationships between the variables.

Keywords: Child; Adolescent; Sedentary lifestyle; Pediatric obesity; Review.

RESUMO

Este estudo revisou as relações entre o comportamento sedentário (CS) e composição corporal em crianças e adolescentes de países de renda baixa e média. Uma revisão sistemática foi desenvolvida por meio de buscas manuais e eletrônicas em oito bases de dados eletrônicas. Foram incluídos estudos observacionais conduzidos nos países de renda baixa e média, envolvendo crianças entre três e 19 anos de idade. Como resultados, 39 artigos originais foram encontrados (37 transversais, 1 caso-controle e 1 coorte), que, ao todo, apresentaram 75 análises, sendo a maioria delas baseadas em comportamentos de tela (n = 71; 94,7%). No geral, 15 de 25 análises apresentaram associações de risco entre o CS e composição corporal desfavorável. Quando analisadas doses de comportamento sedentário, associações de risco foram verificadas em distintos pontos de corte: 1h/d (3 de 3 análises encontradas); 2h/d (9 de 16); 3h/d (2 de 5); 4h/d (4 de 5) e 5h/d (3 de 6). O tempo de televisão foi o tipo de CS mais frequentemente associado enquanto risco em todas as categorias. Concluindo, o reconhecimento destas associações é importante tanto para o suporte de futuros estudos, assim como para sua disseminação em mensagens preventivas na população de interesse. Também, estudos longitudinais são necessários para estreitamento das relações causais entre as variáveis.

Palavras-chave: *Criança; Adolescente, Estilo de vida sedentário; Obesidade pediátrica; Revisão.*

Introduction

In the last decades, it was observed an increasing prevalence of overweight and obesity in children and adolescents from low-income and middle-income countries (LMIC)[1,2]. These data reinforce that youth obesity is a global pandemic[2], with moderate-to-high estimates of tracking[3,4], and demonstrated an eventual worsening in health conditions in children living in LMIC. Moreover, this highlight that the exposure to obesity during childhood and adolescence have been contributing to an increase of the public expending for the treatment of the related problems and an increase risk of early mortality in adulthood[5,6].

Lifestyle changes are placed as one of the determinants responsible for the rapid increase in the number of overweight children that live in LMIC[2]. As observed in high-income countries, there is an increase in the prevalence of children and adolescents with inadequate eating behaviors (i.e., higher intake in the sugar and sweets, and oils and fats groups)[7], reduced levels of moderate-vigorous physical activity[8] and, more recently, demonstrated the higher exposure to sedentary behaviors (SB)[9]. Those behaviors have been pointed as the main risk factors that contribute to the increase of the pediatric obesity prevalence.

In turn, SB is a group of behaviors that have energy expenditure similar to resting level (≤ 1.5 MET), generally happen with the body in a sitting or reclining position[10,11]. In children and adolescents, SB has as its main interlocutor the screen-based activities (i.e. use of television and computer/internet and non-active videogames)[10, 11]. There is a consensus in the literature that SB is a distinct behavior in relation to physical inactivity, being that it presents determinants and implications for the health[12–14], as well as their health consequences[15].

However, the majority of the available evidence that demonstrates risk associations between higher exposures of SB and high body composition in studies developed in high-income countries[16, 17]. Looking to expand the limits of this debate, we seek, in previous study, to raise the variables more common associated with high exposure to SB in Brazilian children and adolescents[9]. As the main findings of this study, also, was observed the existence of consistent associations between SB and unfavorable body composition[9]. This evidence was the starting point for us to hypothesize that those associations also can be observed in other countries with similar economic conditions. Thus, the purpose of this study was to review and appraise original findings that analyzed the relationship between SB and body composition in children and adolescents from LMIC.

Methods

This review is registered in the International Prospective Register of Systematic Reviews -PROSPERO (CRD42014014107). The operational process and its report were based on PRISMA statement[18].

It was previously established that the scientific articles that adequately meet the following criteria would compose the synthesis of this current review: (i) have observational design (cross-sectional, case-control or cohort); (ii) data collected in LMIC, in accordance with the classification of the World Bank (Gross National Income per capita of US$ ≤ 12.7), regardless of their representativeness (local, regional and national); (iii) report the assessment of SB for their total time, screen time or by a specific type (e.g., TV time, computer, videogame), in a certain domain (e.g., leisure time, school period) or combination (e.g., time sitting at school and at leisure), regardless if assessed in an objective way (i.e. accelerometer, ACTIVPal®) or by questionnaire, or both, as an exposure or an outcome variable; (iv) involve sample of children and/or adolescents in the range of three to 19 years of age, or with mean age in this interval, and (v) have its report in English, Italian, Portuguese or Spanish. Were not included studies that used the term "sedentary" as synonymous of the absence of physical activity (or insufficient physical activity) or studies aimed to clinical groups (e.g. with type II diabetes or hypertensive), with exception for those that presented samples with children and/or adolescents with overweight and/or obesity.

The relevant articles were searched in eight electronic databases: CINAHL, Physical Education Index, PsycINFO, PubMed, SciELO, SCOPUS, SPORTDiscus e Web of Science, with reference to the initial search realized in PubMed: ((((((((((((sedentary behavior[Text Word]) OR sitting time[Text Word]) OR sitting activit*[Text Word]) OR television [Text Word]) OR computer [Text Word]) OR videogame[Text Word]) OR screen time[Text Word]) OR screen activit*[Text Word])) AND (((((((((normal weight[Text Word]) OR overweight[Text Word]) OR obese[Text Word]) OR obesity[Text Word]) OR body mass index[Text Word]) OR bmi[Text Word]) OR anthropometr*[Text Word]) OR waist circumference[Text Word]) OR skinfold thickness[Text Word])) AND ((((correlate*[Text Word]) OR predictor*[Text Word]) OR associated factor[Text Word]) OR determinant*[Text Word]))). Were included the references available in the literature until 25th December 2015. Also, manual searches for potential studies were conduced in reference lists of assessed papers.

Risk of bias was assessed by an adapted 17-point version of Quality Assessment Tool for Quantitative Studies of Effective Public Health Practice Project (EPHPP)[19]. Original papers were assessed by seven methodological domains: (a) selection bias (characteristics of samples in relation to the review target population); (b) study design (information about study representativeness; sampling methods); (c) confounders (control of relevant confounders in analyses); (d) blinding (of outcome assessor and participants); (e) information about tools that evaluated the SB (report of its previous validation and Information that would make it possible to reproduce the SB assessment); (f) Flow of people throughout the study (report in terms of numbers and/or reasons and percentage of participants completing the study) and (g) analyses (the use of appropriate methods for analyses). The risk classification (low, moderate and high risk of bias) was done based on the distribution of studies.

Data extraction was realized in an electronic spreadsheet, in which the information was clustered in three domains: (a) descriptive data (name of study, local of realization, year of data collection, sample method, sample size, percentage of girls in the sample and age group); (b) methods (type of study, dependent variable of the research, type of SB assessed, cutoff to the risk exposure, tool used to assess the sedentary behavior, obesity preditor measures, method used to analyzed the associations and the effect measured employed), and (c) description of the results (e.g. cutoff point used, and its magnitude). The procedures of the assessments articles (titles, abstracts and full texts), data extraction and syntheses elaboration were realized by two researchers, in an independently way (ER, PG), with permanent consultation of a third reviewer in the case of doubts and disagreement (AF).

Results

The searches in eight databases identified 2,547 potential references (Figure 1). After identification and exclusion of duplicates, reviews and studies with adult samples (n = 832), 1,715 were assessed by its titles and abstracts. As a result of this evaluation, 207 studies remained in the review, which were added to the five studies identified by the manual searches in reference lists.

At the end of full text assessment, 173 references were not eligible, with the main reasons: studies developed in high-income countries (n = 83; 48%) and studies that did not assess associations between sedentary behaviors and body composition (n = 28; 16.2%). Therefore, a total of 39 original studies met the inclusion criteria and composed the descriptive synthesis[20–58] (Figure 1).

Included studies were conducted in eighteen countries of four continents (Africa, Americas, Asia and Europe). By time, were aggregated data collected among 1999 and 2013. Thirty-seven studies used across-sectional design (94.9%), one used a case-control design[52] and one used a cohort design[54] (Table 1).

Random methods were employed in sampling processes of 24 articles (61.5%). By sample sizes, there was variation among 60[26] and 18,784[45] participants. By sex, the majority of the studies have larger percentage of girls compared to boys (n = 21; 53.9%). One study had

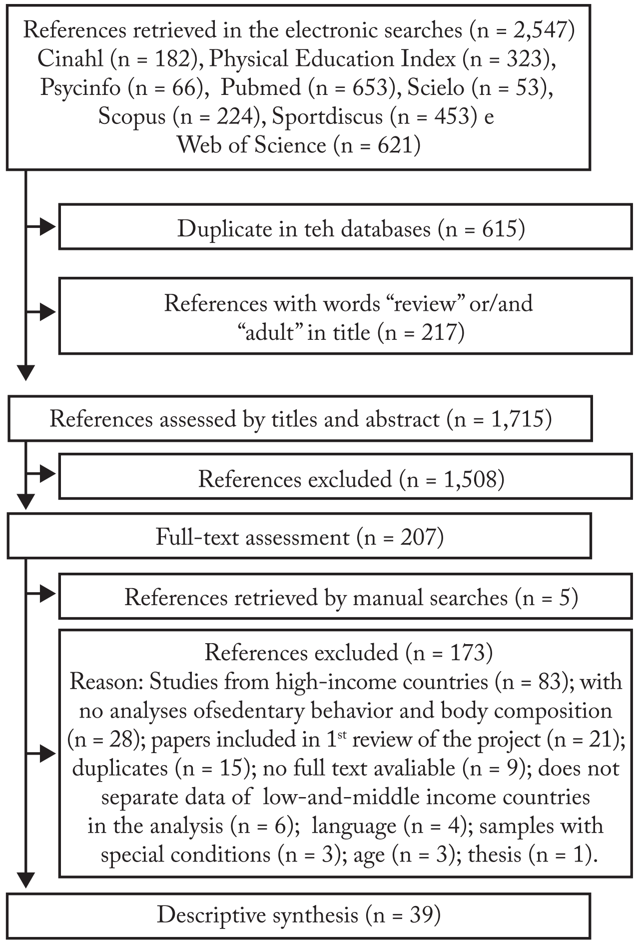

Figure 1 – Flowchart of systematic review.

a sample composed only by girls[52] (Table 1).

Thirty-six studies assessed SB by questionnaires (92,3%) and in one by accelerometer[27]. In LeBlanc et al.[37], SB was assessed both by questionnaire and accelerometer. In regard to adiposity markers, only four studies not showed Body Mass Index measures [24,38,42,55] (Table 2).

In risk of bias assessment, the most frequent problems found in included papers were the absence of reports: blindness of outcome assessor (if aware of research question and/or exposure status of participants) (n = 0); previous validation of questionnaire (n = 25 of 37; 67.6%); number of withdrawals and dropouts (n = 25; 64.1%) and sample representativeness (n = 15; 38.5%) (Table 2).

In Table 3 results are summarized. At all, 75 analyses were retrieved, being 71 based on screen behaviors, as television, computer television and videogame (94.7%). Eighteen studies showed more than one result (46.2%), by sex (n = 7)[23, 30, 38, 48, 50, 54, 58], weight marker (n = 5)[21, 26, 27, 39, 38, 48], age group (n = 3)[24, 35, 53, 58], SB type (n = 4)[23, 31, 33, 39], nutritional status (n = 1)[56], and SB measure (n = 1)[37].

Table 1 – Descriptive characteristics of included studies (n = 39).

Reference	Country (Year of data)	Sampling/ Sample no. (%F)	Age*
Al Sabbah et al.[20]	Palestine (2003–4)	R/ 10,726 (55)	12–18
Arango et al.[21]	Colombia (2008)	R/ 546 (49)	14.4
Bishwalata et al.[22]	India (2005–6)	nd/ 3,356 (56)	12–19
Bukara-Radujkovic & Zdravkovic[23]	Bosnia and Herzegovina (2004)	nd/ 1,204 (52)	11.6
Chen et al.[24]	China (1998; 2003)[CO]	nd/ 424 (51)	5.5; 10.5
Duque & Parra[25]	Colombia (nd)	R/ 325 (47)	10–12
Fernandes et al.[26]	Brazil (nd)	C/ 60 (nd)	11.9
Ferrari et al.[27]	Brazil (2012–13)	R/ 485 (51)	10.1
Fronza et al.[28]	Brazil (nd)	C/ 283 (47)	13.7
Geremia et al.[29]	Brazil (nd)	R/ 590 (59)	12.5
Guedes et al.[30]	Brazil (2008)	R/ 1,268 (51)	15–18
Hajian-Tilaki & Heidari[31]	Iran (2008)	R/ 1,200 (50)	14.2
Hatami et al.[32]	Iran (2009–10)	R/ 1,157 (nd)	10–18
Hong et al.[33]	Vietnam (2004)	R/ 2,684 (49)	12.9
Ishaque et al.[34]	Pakistan (nd)	C/ 431 (43)	13.4
Janssen et al.[35]	Mexico (2012)	R/ 5,660 (nd)	10–18
Kuriyan et al.[36]	India (nd)	nd/ 598 (nd)	6–16
Lajous et al.[38]	Mexico (1999)	R/ 9,132 (62)	13.9
LeBlanc et al.[37]	Brazil; China; Colombia, India, Kenya, South Africa (2011–13)	R/ 3,060 (nd)	9–11
Lee et al.[39]	Malaysia (nd)	R/ 1,736 (53)	10.0
Lima et al.[40]	Brazil (nd)	C/ 175 (61)	11.9
Ma et al.[41]	China (nd)	R/ 9,356 (51)	4–8
McVeigh & Meiring[42]	South Africa (nd)	C/ 767 (nd)	11.0
Micklesfield et al.[43]	South Africa (2009)	nd/ 381 (51)	12.1; 15.1
Mocanu[44]	Romania (2008–12)	C/ 3,444 (51)	6–10
Morales-Ruán et al.[45]	Mexico (2006)	R/ 18,784 (51)	14.0
Mushtaq et al.[46]	Pakistan (2009–10)	R/ 1,860 (nd)	8.5
Nawab et al.[47]	India (nd)	nd/ 660 (42)	10–16
Nogueira & Costa[48]	Brazil (2009)	R/ 326 (37)	13.0
Olaya-Contreras et al.[49]	Colombia (nd)	R/ 603 (45)	10–14
Peltzer & Pengpid[50]	Ghana (2003); Uganda (2007)	R/ 5,613 (51)	13–15
Rani & Sathiyasekaran[51]	India (2009)	R/ 1,842 (51)	12–18
Rathnayake et al.[52]	Sri Lanka (nd)[CC]	C/ 100 (100)	15.3
Seo & Niu[53]	China (2009)	R/ 630 (nd)	11.4
Siegel et al.[54]	Mexico (1998)	nd/ 1,004 (51)	9–18
Tayyem et al.[55]	Jordan (nd)	R/ 735	16.2
Wells et al.[56]	Brazil (2005)	BC/ 4,451 (51)	10–12
Woon et al.[57]	Malaysia (nd)	R/ 781 (63)	10.5
Zhang et al.[58]	China (2004)	R/ 5,497 (nd)	6–18

*: Age of samples in means or ranges; %F: percentage of females in sample; BC: birth cohort; C: convenience sampling; CC: case-control study; CO: cohort study; nd: not described; R: random sampling.

About data of the included cohort and case-control studies, were verified risk associations between the TV viewing exposures ≥ 4h/d and weight-for-height ratio both at five (β = 0.62) and ten years old (β = 0.86)[24]. In case control study[52], risk association was verified in group with screen time exposures over two hours per day OR = 2.96 (95%CI: 1.33-6.61) (Table 3).

In regard to the associations between variables, 15 of 25 analyses showed risk associations between SB and body composition (Table 3). When focusing on the dose of sedentary behavior, risk associations were found in distinct cut off points: 1h/d (3 of 3 analyses); 2h/d (9 of 16); 3h/d (2 of 5); 4h/d (4 of 5) and 5h/d (3 of 6). By type, television time showed a large number of risk associations in all categories.

Table 2 – Methodological characteristics of included studies (n = 39).

Reference	SB assessment tool	Adiposity markers	Method for associations analyses/ Effect measure	Risk of bias
Al Sabbah et al.[20]	QDS	BMI	Logistic Reg./ OR	Low
Arango et al.[21]	QDS	BMI; WC	Linear Reg./ Coef.	Low
Bishwalata et al.[22]	QDS	BMI	Logistic Reg./ OR	Low
Bukara-Radujkovic & Zdravkovic[23]	QDS	BMI	Correlation/ Coef.	High
Chen et al.[24]	QDS	WFH	GLM/ Means	Low
Duque & Parra[25]	QDS	BMI	Kol. Smir./ Means	Moderate
Fernandes et al.[26]	IPAQ short	BF%; BMI; Σ8ST; WC	Correlation/ Coef.	High
Ferrari et al.[27]	Accel	BF%; BMI;	Linear Reg./ Coef.	Moderate
Fronza et al.[28]	QDS	BMI	Logistic Reg./ OR	Low
Geremia et al.[29]	QDS	BMI	Poisson Reg./ OR	Moderate
Guedes et al.[30]	QDS	BMI	Logistic Reg./ OR	Moderate
Hajian-Tilaki & Heidari[31]	QDS	BMI	Logistic Reg./ OR	Moderate
Hatami et al.[32]	QDS	BMI	Logistic Reg./ OR	Low
Hong et al.[33]	QDS	BMI	Logistic Reg./ OR	Moderate
Ishaque et al.[34]	GSHS	BMI	nd/ OR	High
Janssen et al.[35]	YAQ	BMI	Logistic Reg./ OR	Low
Kuriyan et al.[36]	nd	BMI	Logistic Reg./ OR	High
Lajous et al.[38]	QDS	BMIz; TSF; SSF	Linear Reg./ Coef.	Low
LeBlanc et al.[37]	Accel and DLQ	BMI	GLM/ Means	Moderate
Lee et al.[39]	CAPANS	BMI; BMIz; BF%; WC	Logistic Reg./ OR	Moderate
Lima et al.[40]	QDS	BMI	Linear Reg./ Coef.	High
Ma et al.[41]	QDS	BMI	Logistic Reg./ OR	Moderate
McVeigh & Meiring[42]	PAQ	WFH	Logistic Reg./ OR	High
Micklesfield et al.[43]	QDS	BMI	Linear Reg./ Coef.	High
Mocanu[44]	CATCH	BMI	Logistic Reg./ OR	High
Morales-Ruán et al.[45]	YAQ	BMI	Logistic Reg./ OR	Low
Mushtaq et al.[46]	QDS	BMI	Linear and Logistic Reg./ Coef. and OR	Moderate
Nawab et al.[47]	GPAQ	BMI	Logistic Reg./ OR	High
Nogueira & Costa[48]	QDS	BMI	Linear Reg./ Coef.	High
Olaya-Contreras et al.[49]	ISCOLE	BMI	ANOVA/ Means	High
Peltzer & Pengpid[50]	QDS	BMI	Logistic Reg./ OR	Moderate
Rani & Sathiyasekaran[51]	QDS	BMI	Chi–Squared/ Prop.	Moderate
Rathnayake et al.[52]	QDS	BMI	Logistic Reg./ OR	Low
Seo & Niu[53]	QDS	BMI	Logistic Reg./ OR	Moderate
Siegel et al.[54]	PAQ	BMI	Linear Reg./ Coef.	Moderate
Tayyem et al.[55]	QDS	WFH	ANCOVA/ Means	Moderate
Wells et al.[56]	QDS	BMI; TSF; SSF	Linear Reg./ Coef.	Low
Woon et al.[57]	QDS	BMIz	Linear Reg./ Coef.	High
Zhang et al.[58]	QDS	BMI	Linear Reg./ Coef.	Moderate

Legends:*: Accelerometer Actigraph model GT3x+; Σ8ST: Sum of 8 Skinfolds; BF%: body fat percentage; BMI: Body Mass Index; BMIz: Body Mass Index z-score; CAPANS: Child and Adolescent Physical Activity and Nutrition Survey; CATCH: CATCH Kids Club After-School Student Short Questionnaire; Coef.: coefficient; DLQ: Diet and Lifestyle Questionnaire; GLM: general linear model; h/ d: hour(s) per day; GPAQ: Global Physical Activity Questionnaire; GSHS: Global School-based Student Health Survey; h/ w: hour(s) per week; ISCOLE: The International Study of Childhood Obesity, Lifestyle and the Environment; Kol. Smir.: Kolmogorov-Smirnov; nd: not described; OR: Odds Ratio; PAQ: Physical Activity Questionnaire; Prop.: proportion(s); QDS: questionnaire developed for the study; RP: Prevalence Ratio; Reg.: Regression; SSF: Suprailiac skinfold; TSF: Triceps skinfold; WC: Waist Circumference; WFH: Weight for Height Ratio; YAQ: Youth Activity Questionnaire.

Discussion

The present study had as the main purpose to review the relationship between SB and body composition in children and adolescents from LMIC. As main findings, risk associations between SB and body composition were found in data of included cohort and

Table 3 – Synthesis of the relationships between sedentary behavior and high levels of weight in children and adolescents from low-and-middle income countries. (Included studies = 39)

Association as a risk factor	No association
Correlations or Associations between variables	
SCREEN TIME LeBlanc et al.[37](a) BF%: Accelerometer-based measures (β-coefficient = 0.76; SE = 0.11) BF%: Self-reported measures (β-coefficient = 0.003; SE = 0.001)	**SCREEN TIME** Duque et al.[25] No differences among groups Olaya-Contreras et al.[49] BMI: No differences among groups (normal weight, overweight and obese) by ANOVA
Lee et al.[39] (b) BMIz (β-coefficient = 0.06; SE = 0.03) WC (β-coefficient = 0.44; SE = 0.22)	Tayyem et al.[55] No association between screen time and higher waist-height ratio (≥ 0.5)
TELEVISION Guedes et al.[30](c) BMI cutoff: >23kg/m^2 Girls (OR = 1.64; 95%CI: 1.15-2.22) Boys (OR = 1.51; 95%CI: -1.09-2.08)	Geremia et al.[29] No associations between screen time and excess weight OR = 1.02; 95%CI: 0.97-1.07 Lima et al.[40] BMI: No correlation (r = -0.15)
Chen et al.[24](d) Relationship between TV viewing time and WFH At 5 years old (β-coefficient = 0.62; SE = 0.24) At 10 years old (β-coefficient = 0.86; SE = 0.22)	Woon et al.[57] BMIz: No correlation (r = 0.06)
Zhang et al.[58] Boys with 12–18 years old: (β-coefficient = 0.07)	Ferrari et al.[27](n) BF% (β-coefficient = -0.11; 95%CI: 0.25; 0.03) BMI (β-coefficient = -0.006; 95%CI: -0.13; -0.001)
Seo & Niu[53](e) 6–11 years old with overweight OR = 1.11; 95%CI: 1.01-1.22	Lee et al.[39] BF% (β-coefficient = 0.31; SE = 0.18) BMI (β-coefficient = 0.17; SE = 0.09) (j)
TELEVISION AND COMPUTER Siegel et al.[54] BMI: Girls (β-coefficient = 0.9)	Micklesfield et al.[43] BMI (β-coefficient = 6.3; 95%CI = -17;30)
TOTAL SEDENTARY BEHAVIOR Fernandes et al.[26] Σ8ST (r = 0.43) BF% (r = 0.40) BMI (r = 0.42) WC (r = 0.43)	Nogueira & Costa[48](o) BMI: Girls (β-coefficient = -0.01; SE = 0.06) BMI: Boys (β-coefficient = 0.00; SE = 0.01) FMI: Girls (β-coefficient = -0.03; SE = 0.02) FMI: Boys (β-coefficient = 0.00; SE = 0.00)
	Seo & Niu [53](e) 12–18 years old with overweight OR = 0.99; 95%CI: 0.88-1.13)
	TELEVISION Fronza et al.[28] High BF% OR = 0.85; 95%CI: 0.34-2.17 Zhang et al.[58] Girls with 6–11 and 12–18 years old Boys with 6–11 years old
	TELEVISION AND COMPUTER Siegel et al.[54] BMI: Boys (no association)
	TOTAL SEDENTARY BEHAVIOR Lee et al.[39](b) BF% (β-coefficient = 0.14; SE = 0.13) BMI (β-coefficient = 0.10; SE = 0.06) BMIz (β-coefficient = 0.03; SE = 0.02) WC (β-coefficient = 0.19; SE = 0.15)

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Cutoff point of 1 hour per day	
SCREEN TIME Mushtaq et al.[46] Risk cutoff: > 1 to 3h/d OR = 1.56; 95%CI: 1.19-2.03 **TELEVISION** Kuriyan et al.[36](f) Risk cutoff: > 1.5 h/d OR = 19.8; 95%CI: 5.4-71.9 Hatami et al. [32](e) Risk cutoff: 5 to 13.3 h/w OR = 1.58; 95%CI: 1.01-2.47	–
Cutoff point of 2 hours per day	
COMPUTER Bukara-Radujkovic & Zdravkovic[23] Risk cutoff: > 2 h/d Boys (computer use for more 2 h/d was correlated to increased BMI) Hajian-Tilaki & Heidari[31] Risk cutoff: > 2h/d (crude analysis) OR = 1.57; 95%CI: 1.14-2.16 **SCREEN TIME** Janssen et al.[35](g) 15–18 years old: higher chance for the normal weight children to meet the screen time recommendations of ≤ 2h/ d OR = 2.10; 95%CI: 1.31-3.38 Rathnayake et al.[52] Risk cutoff: > 2h/d OR = 2.96; 95%CI: 1.33-6.61 Moralez-Ruan et al.[45] (h) Risk cutoff: ≥ 21h/w OR = 1.29; 95%CI: 1.13-1.48 **TELEVISION** Hong et al.[33] Risk cutoff: 2 to 3 h/d (i) OR = 1.9; 95%CI: 1.5-2.5 Nawab et al.[47] Risk cutoff: > 2 h/d OR = 3.3; 95%CI: 1.4-7.6 Bishwalata et al.[22] Risk cutoff: > 2h/d OR = 2.05; 95%CI: 1.19-3.53 Ma et al.[41](j) Risk cutoff: > 2h/d OR = 1.4; 95%CI: 1.1-1.8	**COMPUTER** Bukara-Radujkovic & Zdravkovic[23] Risk cutoff: > 2 h/d Girls (no correlation) **COMPUTER AND VIDEOGAME** Hong et al.[33] Risk cutoff: > 2 h/d (crude analysis) OR = 1.2; 95%CI: 0.8-1.6 **SCREEN TIME** Janssen et al.[35] (g) 10–14 years old: no chance for the normal weight children to meet the recommendations of ≤ 2h/ d OR = 1.23; 95%CI: 0.78-1.93 **TELEVISION** Rani & Sathiyasekaran[51] Risk cutoff: > 2h/d No association (x2 test) Hajian-Tilaki & Heidari[31] Risk cutoff: > 2h/d (crude analysis) OR = 1.03; CI95%: 0.78-1.35 Al Sabbah et al.[20](p) Risk cutoff:> 2h/d OR = 1.01; 95%CI: 0.84-1.21 **TELEVISION AND COMPUTER** Mocanu[44] Risk cutoff: ≥ 2h/d (d) OR = 1.01; 95%CI: 0.73-1.38
Cutoff point of 3 hours per day	
SCREEN TIME Arango et al.[21] (k) Risk cutoff: > 3h/d BMI (β-coefficient = +0.43; SE = 0.09) WC (β-coefficient = +0.40; SE = 0.09)	**SCREEN TIME** Ishaque et al.[34] Risk cutoff: > 3h/d OR = 0.97 Peltzer & Pengpid[50] Risk cutoff: ≥ 3h/d (crude analysis) Girls (OR = 1.01; 95%CI: 0.67-1.51) Boys (OR = 1.33; 95%CI: 0.75-2.35)

Continue…

… continue

Cutoff point of 4 hours per day	
SCREEN TIME McVeigh et al.[42] Risk cutoff: > 4h/d (strata of overweight children) OR = 1.96; 95%CI: 1.06-3.64 **TELEVISION** Wells et al. [56](l) Risk cutoff: ≥ 4h/d Overweight (OR = 1.31; 95%CI: 1.05-1.62) Obesity (OR = 1.56; 95%CI: 1.04-2.33) Bukara-Radujkovic & Zdravkovic[23] Risk cutoff: > 4h/d Boys (television time for > 4 h/d was correlated to increased BMI)	**TELEVISION** Bukara-Radujkovic & Zdravkovic[23] Risk cutoff: > 4h/d Boys (television time for > 4 h/d was correlated to increased BMI)
Cutoff point of 5 hours per day	
SCREEN TIME Lajous et al. [38](m) Risk cutoff: ≥ 5h/d, comparing to 2h/d cutoff - Boys BMIz (Difference = 0.13; 95%CI: 0.04; 0.23) SSF (Difference = 0.74; 95%CI: 0.24; 1.22) TSF (Difference = 1.08; 95%CI: 0.36; 1.81)	**SCREEN TIME** Lajous et al.[38] (m) Risk cutoff: ≥ 5h/d, comparing to 2h/d cut off - Girls BMIz (Difference = 0.02; 95%CI: -0.07; 0.10) SSF (Difference = 0.22; 95%CI: -0.22; 0.68) TSF (Difference = 0.35; 95%CI: -0.29; 0.98)

Legends: (a) Adjusted for sex, age, and highest parental education; (b) Adjusted for age, sex, area of residence, energy intake, ethnicity, household income and parental education; (c) Adjusted for age, marital status of parents, family nucleus, number of siblings, parent's education, socioeconomic status, school structure, time of study, transport to school, paid work, smoking, alcohol use and BMI; (d): Adjusted for gender and family income; (e) Adjusted for age and sex; (f): Adjusted for age, gender, living location and socioeconomic status and the other significant predictors of overweight in the data; (g): Adjusted for gender, BMI classification, Region of country, Urban/rural area, Socioeconomic status and Education level; (h): Adjusted for gender, urban o rural setting, and indigenous ethnicity, studying at present, tobacco use, alcohol consumption and physical activity; (i): Adjusted analysis from the equation corresponding to the level in which the risk factor was first entered; (j): adjusted for sex, age, domicile regions, domicile situation, income, educational level of parents, breakfast frequency, fast food consumption frequency, desired body size by children and their parents; (k): Adjusted for age, location, physical activity level, type of institution (public or private), consumption of sweetened beverages, consumption of fast foods, consumption of food fries and cardio respiratory fitness;(l) Adjusted for child sex, birthweight, birth length, maternal smoking and alcohol intake during pregnancy, maternal prepregnancy BMI, socio-economic level, physical activity patterns, and systolic and diastolic blood pressure, number of hours of sleep; (m): Adjusted for age, height, socio-economic status, single-parent family, birth in hospital, parental education level, family income, family health insurance, physical activity, inactivity excluding television, video and videogames, community type, sexual maturity, diagnosis of asthma, dieting and frequency of restaurant dining; (n): Adjusted for sex, school and moderate-to-vigorous physical activity; (o): Adjusted for age and maturation; (p) Adjusted for region, grade, weight status and weight dissatisfaction; Σ8ST: Sum of 8 Skinfolds; 95%CI: 95th Confidence Interval; BF%: Body Fat Percentage; BMI: Body Mass Index; BMIz: Body Mass Index z-score; d: day; FMI: Fat Mass Index; h: hour(s); OR: Odds Ratio; w: week(s); SSF: Suprailiac Skinfold; TSF: Triceps Skinfold; WC: waist circumference; WFH: weight for height ratio; SE: standard error.

case-control studies. In regard to dose of SB, risk associations were verified in cutoffs of 1, 2 and 4 hours per day. Also, television time was the most frequently SB type associated as risk with body composition.

However, it is important to point the majority of the studies were cross-sectional, and does not allow inferences about causality. Therefore, it is important to recognize these associations, either for the support for future studies or as a support message in preventive strategies.

On the other hand, the recognition of the inverse associations between screen time and aerobic fitness during childhood in longitudinal studies[13], and associations between SB and consumption of energy-dense nutrient-poor food meals[59], suggests that greater exposures of SB are associated with an increase energy intake and a decrease in daily energy expenditure, favoring the excessive energy accumulation, which is a concern associated with overweight and obesity. Moreover, it is important to note that the reduction of the enzyme activity LPL (Lipoprotein Lipase) during the adoption of SB contributed to unfavorable changes in lipid and glucose profile, contributing to the increase in the amount of body fat[60].

In the present review, the data from two longitudinal studies [24, 52] corroborates previous evidence from longitudinal studies conducted in high-income countries, such as Australia, Canada, Netherlands and the United States[61]. Therefore, aiming to advance and deepen the debate, the current evidence allows demonstrating that novel longitudinal studies direct to children and adolescents from LMIC are needed.

Methodological issues verified in the available articles are another important concern. Current synthesis presented high variability in the types of SB assessed, with predominance of the screen measures (television, computer and non-active electronic games), in special to the measure separated by TV time and sum of time for TV, computer and non-active electronic games. The literature demonstrates that the key determinants of the screen time are different from the determinants of the total spent time in SB[12]. However, it is important that future studies add observations beyond traditional screen time measures (television, computer and videogame), such as time in mobile phone and tablets. This observation is important, taking into account the frequency of its use in daily life of children and adolescents.

Is also important that future researches broaden their observations in a way that reaches a total measure through the day, raising different domain issues (leisure time, school and travelling)[62]. Taking into account the interest of domains can strengthen the adoption of more specific intervention strategies with the purpose to control and/or reduce this type of SB at an interest venue.

Based on risk of bias assessment, the findings of the current synthesis reinforce, those future studies in these thematic report important issues, as blindness of outcome assessor, previous validation of questionnaire, number of withdrawals and dropouts and sample representativeness. As the information of the questionnaire validity, can be highlighted that this is also a limitation in studies conducted in high-income countries, such as the need of an adequate report of the validity tools to measure the sedentary behaviors, as well as the recommendation to their use, along with, tools that allow objective and subjective measures of SB[62].

Even with the growing investigation about this topic, remains the need for adequate tools to assess SB in epidemiological researches[63] and the use of objective meausres in parallel of questionnaire, allowing a total sitting time measure all over the day, while the adolescents are awake. It is noteworthy that only two included studiesused objective measures to assess SB[27, 37]. Therefore, is important that further studies assess SB through quality validity tools to the population of interesting, in which will reduce the evidence's risk of bias.

The high heterogeneity of the available data in the original articles did not allow the realization of a meta-analysis. On the other hand, one of the main limitations of this review is the fact that the synthesis are based, in the majority, by cross-sectional evidence, requesting caution in extrapolating this result, due to the reverse risk of causality and possible confounder variables. This reinforces the need of studies that look forward to analyze the relationship between SB and body composition in a longitudinal perspective in LMIC. Nevertheless, because the current review presented a specific issue about the associations between sedentary behaviors and body composition in children and adolescents from LMIC, the current work sought to fill the gap once specified by revisions that were based, for the most part, in evidence from high-income countries[12, 17, 62, 64].

Finally, some conclusions can be made. The recognition of these associations is important both to support future studies and preventive messages in the population of interest. Also, further longitudinal studies are necessary for narrowing the casual relationships between the aforementioned variables.

Conflict of interest

The authors declared no conflict of interest.

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Contribution of the authors

Guerra PH, elaboration of the central idea; Identification, assessment and data extraction of original studies; development and interpretation of the results; drafting of the manuscript. Ribeiro EHC, identification, assessment and data extraction of original studies; interpretation of the results; critical review of the text. Leme ACB, interpretation of the results; translation and critical review of the text. Mota J, interpretation of the results; critical review of the text. Farias Junior JC, interpretation of the results; critical review of the text. Florindo AA, elaborated the idea; assessment of original studies; interpretation of the results; critical review of the text.

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