Prevalence of weight excess in Brazilian children and adolescents: a systematic review

Prevalência de excesso de peso em crianças e adolescentes brasileiros: uma revisão sistemática

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Abstract - The prevalence of obesity is rapidly increasing worldwide, no mattering age groups and socioeconomic status. In Brazil, it is still unclear the prevalence of obesity in children and adolescents, since most Brazilian studies have only verified regional prevalence of obesity. Therefore, the aim of the present study was to analyze the scientific production regarding the prevalence of weight excess in Brazilian children and adolescents. A search in the relevant electronic databases Medline/Pubmed, Web of Science, Lilacs, Scielo and BVS was performed. After analyzing 61 studies, the overall prevalence was 25.5%. When sample was stratified weight excess degree, a prevalence of 17% and 11.6% for overweight and obesity were observed, respectively. Analyzing differences by sex, boys presented higher prevalence of overall weight excess (e.g., 26.4% vs 23.5%), overweight (17% vs 16%) and obesity (11.9% vs 9.1%) than girls. With respect to Brazilian regions and its differences, individuals from southern presented the highest prevalence of overall weight excess (33.2%) and overweight (20.1%). The southeastern region showed the highest prevalence of obesity (18.2%). The results obtained in the current study indicate that Brazil presents a scenario of crescent increasing on the prevalence of weight excess. These results are in accordance with studies from other countries, and reinforce the increase of the overall weight excess prevalence in Brazilian children and adolescents, highlighting the increasing of obesity rates, since it is a more concerning condition than overweight. Therefore, preventive measures to reduce weight excess increase, as well as treatment programs aiming to tackle obesity in childhood should be public health system top priority.

Key words: Adolescents; Brazil; Children; Obesity.

Resumo – *A prevalência da obesidade tem aumentado em todo o mundo em todas as faixas etárias e níveis socioeconômicos. No Brasil, ainda é incerto a prevalência de obesidade em crianças e adolescentes devido a maioria dos estudos serem de características regionais. Portanto, o propósito do presente estudo foi analisar a produção científica referente à prevalência de excesso de peso em crianças e adolescentes brasileiros. Realizou-se uma busca nas bases de dados MEDLINE/PubMed, WEB of Science, LILACS, Scielo e BVS. Foram analisados 61 estudos, sendo identificado 17% de sobrepeso e 11,6% de obesidade. As prevalências de excesso de peso (26,4% vs 23,5%), sobrepeso (17% vs 16%) e obesidade (11,9% vs 9,1%) foram maiores entre os meninos comparados as meninas, respectivamente. As crianças e os adolescentes da Região Sul apresentaram maior prevalência de excesso de peso (33,2%) e sobrepeso (20,1%), e as do Sudeste maior prevalência de obesidade (18,2%). Nossa análise indicou que o Brasil apresenta um quadro de prevalência crescente de excesso de peso, similar ao de outros países. Os resultados reforçam o aumento da prevalência de excesso de peso em crianças e adolescentes no Brasil, especialmente pelo aumento da obesidade, que é considerada uma condição mais grave que o sobrepeso. Portanto, medidas preventivas para diminuir esta tendência de aumento do excesso de peso, bem como programas de tratamento da obesidade na infância e adolescência deve ser prioridade do Sistema único de Saúde (SUS).*

Palavras-chave: *Adolescentes; Brasil; Crianças; Obesidade.*

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INTRODUCTION

During the last decades, obesity has become a global epidemic that affects practically all ages and socioeconomic groups[1], being considered the most concerning public health issue. Nowadays, there is about 2.8 million deaths every year in consequence of weight excess[1]. The projections for 2025 indicate that the global prevalence of obesity will reach 18% in men and 21% in women, in which severe obese will trespass 6% and 9% in men and women, respectively[2].

Children and adolescents are increasingly more exposed to factors that lead to weight gain[3,4]. Early obese children with 3 to 4 years old present from 15% to 25% more odds to become obese adults, and this odds goes to 50% after 6 years of age[4]. In youth, obesity reflects an direct influence on postural changes, depression, anxiety, and psychological dysfunctions[3,4].

In Brazil, childhood overweight and obesity are major public health issues that affect all ages and regions but with distinct intensity, mostly due to the socioeconomic differences among regions and individuals[5]. Hence, national coverage studies are essential to monitor children and adolescents health[6].

However, evidence about nutritional status of Brazilian children and adolescents are not properly updatep[7-9]. The management of an updated national monitoring panel about children and adolescents nutritional status is seem as essential to organize future prevention and treatment plans aiming to tackle obesity[10,11]. Thus, the aim of the present study was to verify the scientific production regarding the prevalence of weight excess (e.g., overweight and obesity) in Brazilian children and adolescents.

METHODOLOGICAL PROCEDURES

Search strategy

The present systematic review was conducted strictly following the guidance from the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA)[12]. Potential studies were searched in five electronic databases: 1) Medical Literature Analysis and Retrieval System Online (MEDLINE), through PubMed; 2) Web of Knowledge (Web of Science); 3) Latin American and Caribbean Literature in Health Sciences (LILACS); 4) Scientific Electronic Library Online (Scielo); 5) Virtual Health Library (VHL). Articles published between June 1, 2014-March 31, 2018 were considered for eligibility.The following terms were used in studies search: 'Prevalence', 'frequency', 'obesity', 'obese', 'overweight', 'children', 'adolescent', 'youth', 'Brazil', 'Brazilian'. Searches were conducted independently by two authors (CFS and JMR), aiming to duplicate search and match results. In case of divergence, a third author (TLCS) was consulted to establish consensus.

Study selection

Only observational studies were included (e.g., cross-sectional and longitudi-

nal). As inclusion criteria studies had to be performed with Brazilian children or adolescents (e.g., individuals until 19 years old), published from June 2014 to March 2018, who presented the prevalence of overweight and/or obesity. Studies in English and Portuguese were considered eligible for inclusion.

A manual search from the reference lists of the accepted articles was posteriorly performed. Only full reported studies were considered for eligibility (e.g., short communications, editorials or comments were excluded). Potential articles were organized, assessed and further selected with the aid of the software EndNote X7®.

Data extraction

Relevant information from included articles was extracted independently by four reviewers (CFS, JMR, TLCS and FBL) in an electronic spreadsheet. Data was organized in eight domains: author and year of publication, sample, sex, age, prevalence of overweight, criterion used to classify BMI, Brazilian region, administrative e dependence.

Quality assessment of selected studies

To verify the methodological quality of selected articles, the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies was applied in each accepted study individually[13] (Supplementary table 1 and 2).

RESULTS

Search on the aforementioned electronic databases, 2,729 potential articles were retrieved for further analysis. After exclusion of duplicate records and reading of titles and abstracts, 71 studies were selected to be fully examined. Of those, 61 studies met the eligibility criteria and were included to compose the current systematic review (Figure 1).

All selected studies had a cross-sectional design, and two of them were baseline data from cohort studies[14,15].

Beyond prevalence of obesity, studies approached different themes (e.g., weight excess and its behavior determinants (30.2%), weight associated risk factors (30.2%), nutritional status (12.7%), use of other anthropometric measures (6.2%), sociodemographic factors (4.7%), dental problems (3.2%), weight excess measured by different BMI cut-off points (3.2%), breastfeeding (3.2%), BMI and body image (1.6%), genetics (1.6%), quality of life, anxiety and socioeconomic factors (1.6%) and action plans aiming to tackle obesity (1.6%).

The overall total sample of selected studies was 197.763 individuals, in which 47.3% were from female sex. Nevertheless, 11.4% of studies did not present data stratified by sex. Regarding age group, 53.5% of studies had children as sample, 14.8% were developed with adolescents, and 32.8% with both children and adolescents. Studies characteristics of included studies are minutely described in table 1.

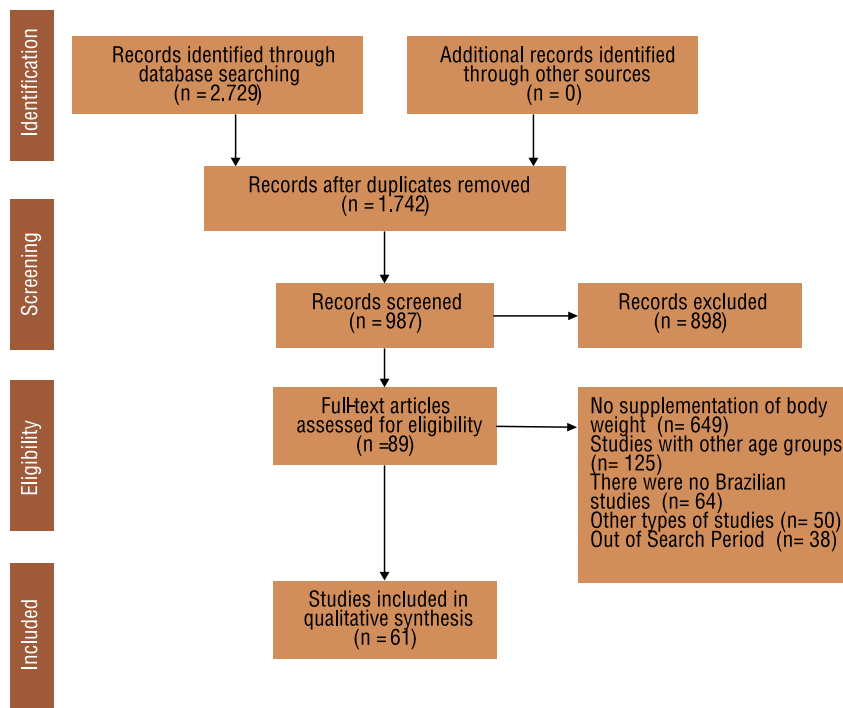The mean of overall weight excess prevalence of selected studies was

Figure 1. Flow chart of the systematic review.

25.5%, in which a prevalence of 17% and 11.6% were verified for overweight and obesity, respectively. Overall weight excess prevalence ranged between 4.2%[15] and 57.4%[16]. Obesity prevalence varied between 0.9%[5] and 28%[17,18], and overweight prevalence ranged between 4.2%[19] and 37.3%[20].

Considering analysis by sex, the prevalence of overall weight excess, overweight and obesity were 26.4%, 17% and 11.9% for boys, respectively. The prevalence of weight excess, overweight and obesity in girls were 23.5%, 16% and 9.1%, respectively.

Table 1. Characteristics of the prevalence studies of overweight and obesity in Brazilian children and adolescents.

Study	N	% Of Male Sex	Age		Overweight (%)			Obesity (%)			Excess of Weight (%)			BMI Class. Crit.	Region	Adm. Dep.
			INF	SUP	T	M	F	T	M	F	T	M	F			
Pozzaet al.[4]	6.829	49.7	0.5	15	17.5	16.8	18.2	12.9	14.4	11.4	30.4	31.2	29.6	WHO	Southeastern	School
Santos et al.[21]	501	50.5	7	10	15.2	12.6	17.7	8.8	9.9	7.7	24	22.5	25.4	COLE	Northeastern	School
Almeida et al.[22]	62	53	9	10	15.5	21	10	10	6	14	25.5	27	24	WHO	Southeastern	School
Anjos et al.[23]	20.113	50.3	3	17	17.6	17.6	17.5	12.4	14.7	10.1	30.0	32.3	27.6	WHO	Allgroups	School
Anzolinet al.[24]	229	100	10	15	25.8	-	-	-	-	-	-	-	-	WHO	Southeastern	Project
Araújo et al.[15]	548	52	2	5	4.2	4	4	-	-	-	4.2	4	4	WHO	Northeastern	School
Carneiro et al.[25]	1.169	46.9	12	18	14.1	-	-	7.1	-	-	21.2	26.3	16.8	WHO	Midwest	School
Ferrari et al.[17]	328	49.1	9	11	23.8	-	-	28	-	-	51.8	50.3	53.4	WHO	Southeastern	School
Gonsalezet al.[26]	1.531	44.9	7	10	28.5	-	-	14.1	-	-	42.6	-	-	WHO	Southern	School
Lira et al.[10]	20.755	-	0.5	5	9.7	-	-	9.3	-	-	19	-	-	WHO	Northeastern	School
Melo et al.[27]	249	44.2	14	19	-	-	-	-	-	-	24.1	-	-	WHO	Northeastern	School
Neves et al.[28]	346	48	8	8	19.9	-	-	20.8	-	-	40.7	-	-	WHO	Southern	School
Pedrazaet al.[29]	1.081	49.9	5	10	12.3	-	-	9.2	-	-	21.5	-	-	WHO	Northeastern	School
Ripkaet al.[30]	374	100	12	17	20.3	-	-	5.6	-	-	25.9	-	-	WHO	Southern	School
Santos et al.[31]	820	51.2	9	18	19.2	-	-	7.8	-	-	27	-	-	CDC	Northeastern	School
Silva et al.[5]	1.132	46	14	19	33.4	17.7	16.3	12.7	5.2	7.5	46.1	22.9	23.8	WHO	Southern	School

Continue…

Study	N	% Of Male Sex	Age		Overweight (%)			Obesity (%)			Excess of Weight (%)			BMI Class. Crit.	Region	Adm. Dep.
			INF	SUP	T	M	F	T	M	F	T	M	F			
Almeida et al.[6]	511	46.8	7	9	13.9	-	-	24.6	-	-	38.5	-	-	WHO	Southeastern	School
Araujoet al.[19]	313	44.3	8	10	21.7	17.8	24.7	17.5	16.1	14.9	39.2	33.9	39.6	WHO	Southeastern	School
Barbosa Filho et al.[32]	2.035	49.9	6	11	-	-	-	-	-	-	9.4	11.4	7.5	WHO	Southern	School
Bloch et al.[33]	73.399	44.6	12	17	17.1	16.6	17.6	8.4	9.2	7.6	25.5	25.8	25.2	WHO	Allregions	School
Bruscatoet al.[34]	2.150	48	6	18	-	-	-	-	-	-	21	-	-	WHO	Southern	School
Cavalcantiet al.[35]	559	41	15	19	11.8	-	-	6.8	-	-	18.6	-	-	CDC	Northeastern	School
Farias Júnior et al.[36]	2.776	42.1	14	18	13.1	-	-	-	-	-	13.1	18.4	9.2	COLE	Northeastern	School
Ferrari et al.[18]	328	48.5	9	11	23.8	17.2	30.8	28	33.1	22.6	51.8	50.3	53.4	WHO	Southeastern	School
Grillo et al.[3]	400	55	6	10	13	14	11.7	10	12.2	7.3	23	26.2	19	WHO	Southern	School
Marques et al.[37]	645	44.4	13	19	18.3	-	-	2.8	-	-	21.1	-	-	WHO	Southern	School
Reuteret al.[16]	406	50	7	17	-	-	-	-	-	-	57.4	-	-	WHO	Southern	School
Silva et al.[38]	2.180	51.05	7	10	9.8	11.2	8.4	11.1	7.4	14.8	20.9	18.6	23.2	WHO	Southern	School
Silva et al.[39]	232	61.2	4	5	16.4	-	-	0.9	-	-	17.3	16.2	18.9	WHO	Southeastern	School
Alves Junior et al.[20]	1.132	44	14	19	37.3	-	-	17.2	8.1	29.2	54.5	-	-	WIL-LIAMS	Southern	School
Bertuolet al.[40]	65	-	2	5	24.62	-	-	13.85	-	-	38.47	-	-	WHO	Southern	School
Bispo et al.[41]	1.030	52.5	11	17	13.8	-	-	8.1	-	-	21.9	-	-	WHO	Southeastern	School
Caldeiraet al.[42]	219	52.5	4	5	-	-	-	-	-	-	9.6	-	-	WHO	Southeastern	School
D'Avilaet al.[43]	962	41.1	11	14	18.3	-	-	11.6	-	-	29.9	34.1	28.8	WHO	Southern	School
Dutraet al.[44]	616	51.3	0	8	-	-	-	-	-	37.5	-	-	37.5	WHO	Southern	Hospital
Eneset al.[45]	476	45.4	11.1±0.81	-	-	-	-	-	-	-	36.1	36.1	36.2	WHO	Southeastern	School
Fernandes et al.[46]	91	54.9	1	10	-	-	-	-	-	-	8.9	87.5	12.5	WHO	Southeastern	Hospital
Ferrari et al.[47]	441	49	9	11	23.1	-	-	22.2	-	-	45.3	-	-	WHO	Southeastern	School
Ferreira et al.[48]	1.338	52.2	9	11	-	-	-	13.4	-	-	-	-	-	WHO	Northeastern	School
Miranda et al.[49]	200	45.5	8	10	14.5	13.2	15.6	19	20.9	17.4	33.5	34.1	33	CDC	Southeastern	School
Monteiroet al.[50]	1.088	47.7	13	19	10.5	-	-	-	-	-	10.5	9.5	11.4	WHO	Northeastern	School
Motteret al.[51]	2.506	46.8	7	14	20.6	-	-	12.6	-	-	33.2	-	-	WHO	Southern	School
Nascimento-Ferreira et al.[52]	1.014	45.2	14	19	13.1	-	-	3.8	-	-	16.9	-	-	WHO	Northeastern	School
Passos et al.[53]	335	49.7	6	10	26	28	24	24.7	15	5	50.7	43	29	WHO	Southern	School
Ramos et al.[54]	1.640	-	0	5	-	-	-	-	-	-	19.1	-	-	WHO	Northeastern	School
Roman et al.[55]	2.759	0	9	17	-	-	8.8	-	-	6.7	-	-	15.5	WHO	Southern	School
Rosiniet al.[56]	1.011	47.6	6	14	21.1	-	-	13.2	-	-	34.3	-	-	WHO	Southern	School
Silvaet al.[57]	19.289	51	5	10	15	16.1	14.8	11	11.9	9.1	26	28	23.9	WHO	Midwest	Datasus
Sparrenbergeret al.[58]	204	50	2	10	-	-	-	-	-	-	34	-	-	WHO	Southern	BHU
Vicenziet al.[11]	782	52.9	6	7	-	-	-	-	-	-	38.1	-	-	WHO	Southern	School
Barbosa Filho et al.[59]	2.035	49.9	7	10	19.4	-	-	6	-	-	25.4	-	-	WHO	Southern	School
Fariaet al.[60]	92	47.8	10	17	-	-	-	51.1	52.3	50	51.1	-	-	WHO	Southeastern	School
Garcez et al.[61]	158	50.1	12	19	11	-	-	2.4	-	-	13.4	-	-	WHO	Southeastern	Residence
Martins et al.[62]	590	46.6	7	14	8.7	-	-	13.3	-	-	22	13.5	13.7	WHO	Northeastern	School
Mendonça et al.[63]	1.168	47.1	12	18	22.4	-	-	14.7	-	-	37.1	28.4	17.1	WHO	Midwest	School
Marthendalet al.[64]	130	51.5	14	18	16.1	22.3	9.2	5.4	7.5	3.2	21.5	29.8	12.4	WHO	Southern	School
Mülleret al.[65]	6.397	50.2	0	5	-	-	-	-	-	-	12	12.8	10.5	WHO	Allregions	Residence
Oppitzet al.[66]	1.663	50.4	0	5	6.4	-	-	1.7	-	-	8.1	31.5	28.9	WHO	Northeastern	School
Pinho et al.[67]	535	32	11	17	-	-	-	-	-	-	18.5	16.4	19.5	WHO	Southeastern	School
Rosaneliet al.[68]	4.609	47	6	11	16.9	17.8	16	7.6	8.6	6.6	24.5	26.4	22.6	WHO	Southern	School
Souza et al.[69]	1.187	48.6	6	14	-	-	-	-	-	-	24.4	24.8	24.1	WHO	Sudeste	School

Note. N: sample number; M: Male; T: Total; F: Female; BMI: Body mass index; WHO: World Health Organization; CDC: Centers for Disease Control and Prevention; DATASUS: Department of the Brazilian single health system; BHU: basic health Unit.

Regarding the studies coverage, included studies were performed in all five Brazilian regions (e.g., Northern, Northeastern, Midwest, Southern and Southern). Only three studies (4.9%) had a national coverage. Studies were mostly developed in Southern region (36.1%). However, other regions have also contributed significantly (e.g., Southeastern (29.5%), Northeastern (23%), Midwest (4.9%) and Northern (1.6%). Studies were largely carried out in scholar environment (e.g., 89.1% of studies were conducted in schools).

Weight excess prevalence stratified by regions are presented in table 2. Regarding the prevalence of overweight, southern region showed the highest percentage (20.1%), followed by northern (19.2%), southeastern (17%), Midwest (15%) and northeastern (11.5%). However, the highest proportion of obese individuals were found in southeastern region (18.2%), being followed by southern (12.1%), Midwest (11%), northern (7.8%), and northeastern (9%).
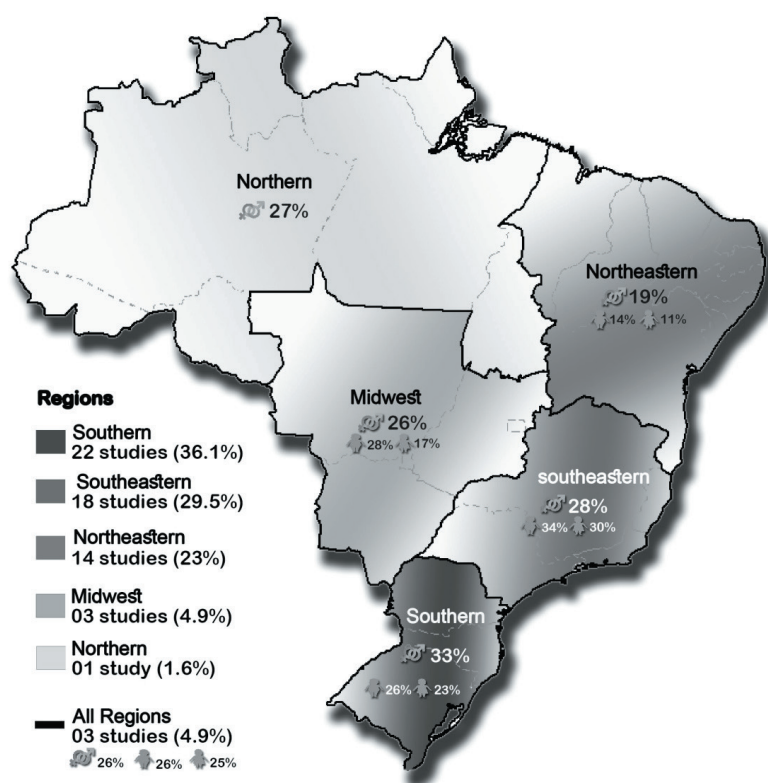

Figure 2. Mean prevalence of weight excess in Brazilian children and adolescents stratified by sex and demographic region the period from 2014 to 2018.

Comparing previously published studies that analyzed prevalence of overall weight excess, overweight and obesity in Brazilian youth[7-9], we could observe a massive increase of obesity in Brazilian children and adolescents of about 150% (e.g., from 4.8% to 11.6%) during the last 28 years. Overweight presented an increase of 11% (e.g., from 15.2% to 17%) while overall weight excess increased 60% (from 16% to 25.4%) (Figure 3).
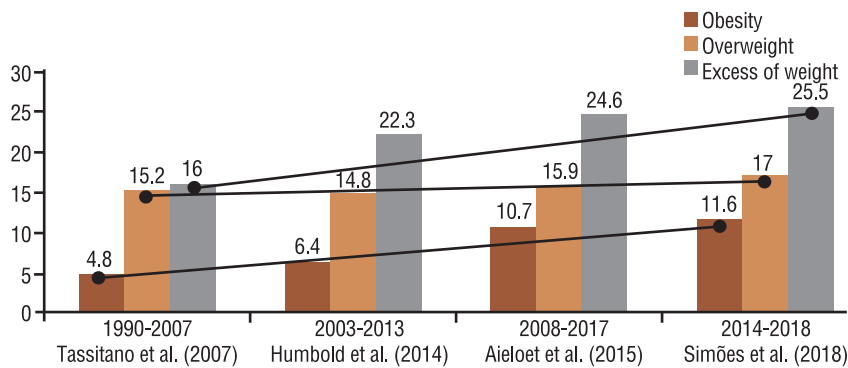
Figure 3. Growth of overall weight excess, overweight and obesity in Brazilian children and adolescents from 1990 to 2018.

DISCUSSION

The aim of the present systematic review was to verify the scientific production covering the period from 2014 to 2018 regarding the prevalence of weight excess in Brazilian children and adolescents. The overall prevalence in Brazilian children and adolescents was 25.5%, being 17% overweight and 11.6% obesity. Boys presented higher prevalence of overweight and obesity when compared to girls. The southern region presented the highest prevalence of overall weight excess (33.2%) and overweight (20.1%), while the southeastern region showed the highest prevalence of obesity (18.2%).

The prevalence of overweight and obesity in children and adolescents has increased over the last three decades. According to Ng et al.[70], from 1980 to 2013, the prevalence of overweight and obesity increase from 16.9% to 23.8% in boys and from 16.2% to 22.6% in girls in developed countries and from 8.1% to 12.9% in boys and from 8.4% to 13.4% in girls in developing countries. This means that the prevalence of overweight and obesity increased about 40% and 60% in developed and developing countries, respectively.

According to national data[71], the prevalence of overweight and obesity in children raised from 10.9% to 34.8% in boys, and from 11.9% to 32.2% in girls and in adolescents raised from 3.7% to 21.7% in boys, and from 7.6% to 19.4% in girls from 1974 to 2009 in Brazil. The present review has verified a prevalence of overweight and obesity in Brazilian children and adolescents of 25.5%, according to studies published between 2014 and 2018. It represents that a quarter of the young population of Brazil is struggling with weight excess.

Interestingly, when the prevalence of overweight and obesity found in the present review was compared with previous reviews[7-9], we have found that the prevalence of overweight increased by 60% between 1990 and 2018. However, when analyzed only the prevalence of obesity, we noticed that the prevalence increased more than 150% in Brazilian children and adolescents.

Although overweight is a concern of health authorities, obesity is a more serious condition and requires urgent action, given its association with other comorbidities and early mortality[72]. According to the present review, more

than 11% of Brazilian children and adolescents are obese. Its means that at least 1 in 10 young people are obese in Brazil. These results are in line with a recent publication by NCD Risk Factor Collaboration study[73] that has shown a dramatic increase in obesity, especially in low-income countries.

Regarding the stratification of the analysis according to sex, the prevalence of overweight and obesity was higher in boys than girls. Some studies have shown boys likely to be obese than girls[3,21,23,49, 53,57,60,64,68]. These differences can be attributed to the different lifestyles adopted by them, in which boys has spending much time in a sedentary behavior, such as watching television and play videogames, as well as access to unhealthy foods[74].

When analyzing the prevalence of overweight by Brazilian regions, we found a higher prevalence in the South (33%) and lower prevalence in Northeast (19%) of Brazil. On the other hand, when observing obesity prevalence alone, the southeastern region was the one with the highest prevalence of obesity. It might be explained by the cultural and economic background differences among Brazilian regions[4].

However, it is important to highlight the paucity of studies developed in the Northern region of Brazil. Only one study[31] developed in one city of the Northern region with a total sample size of 820 scholars from both sexes was selected for inclusion in the present systematic review. This might affect the prevalence of overweight reached in this region, in which was ranked the second higher among all Brazilian regions (19.2%). Probably, the findings from this study cannot be expanded to the whole Brazilian Northern region. Therefore, more studies about the prevalence of weight excess on the Brazilian Northern region are required in order to better elucidate this phenomenon in this region. According to the newest Brazilian national survey, the weight excess and obesity prevalence in Northern were 26.6% and 11.4%, respectively[71].

The present systematic review has some limitations that need to be mentioned. Only data provided by this review do not allow us to establish an average for each nutritional status category. The limited number of databases adopted for the development of the current systematic review, the poor and regular methodological quality of some studies, as well as the lack of other data source searching and the coverage period of the review might be considered as biases. Altogether, differences found in prevalence may be associated to sample heterogeneity and study-addressed themes. Only few studies primarily aimed to investigate the nutritional status of children and/or adolescents. Yet, we aimed to settle all found prevalence, as well as the stratification by sex and country region, addressing the establishment of a potential association with the means found in previously published studies.

CONCLUSION

Summarily, the present systematic review showed that more than 25% of total children and adolescents' population presented weight excess. Of those, 11.6% were severely affected for obesity, in which its prevalence more

than double over the last 30 years. The highest prevalence was identified in boys from Southern and Southeastern of Brazil.

Thus, due to the alarming increase of obesity over the last decade e by the weight excess-related comorbidities in both childhood and adulthood, a follow-up with greater precision of these tendencies, as well as preventive and treatment action plans should be assumed as high priority in Brazilian health policies.

COMPLIANCE WITH ETHICAL STANDARDS

Funding

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: CFS, WAL, JMR, TLCS and NNJ. Performed the experiments: CFS and JMR. Analyzed the data: CFS, JMR, JCL, FBL, TLCS. Contributed reagents/materials/analysis tools: CFS, WAL, JMR, JCL, FBL, TLCS and NNJ. Wrote the paper: CFS, WAL, JMR, JCL, FBL, TLCS and NNJ.

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SUPPLEMENTARY FILE

Supplementary file 1. Quality assessment of the included studies.

Criteria	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
01. Was the research question or objective in this paper clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
02. Was the study population clearly specified and defined?	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N
03. Was the participation rate of eligible persons at least 50%?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
04. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

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Criteria	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
05. Was a sample size justification, power description, or variance and effect estimates provided?	Y	Y	N	N	N	Y	Y	N	Y	Y	Y	Y	N	N	N	Y	N	N	N	Y	Y	N	N	N	Y	N	Y	N
06. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	Y	Y	N	N	N	N	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y
07. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
08. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g. categories of exposure, or exposure measured as continuous variable)?	Y	Y	N	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y
09. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y	N	N	Y	Y	N	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	N
10. Was the exposure(s) assessed more than once over time?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	Y
12. Were the outcome assessors blinded to the exposure status of participants?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13. Was loss to follow-up after baseline 20% or less?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	N	Y	N	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N	N	Y	N	N	N	N	Y	Y	N	N	N	N
Total Score	9	9	4	4	9	9	8	8	9	8	4	8	9	6	7	7	8	8	8	4	8	10	8	8	4	7	8	6

Y: yes; N: no; NA: not applicable; NR: not reported.

Supplementary file 2. Quality assessment of the included studies.

Criteria	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y
	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
	N	Y	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	N	N	Y	Y	N	N	Y	N	N	Y	Y	N	N	Y	N	N	N	N	N
	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	N	N	Y	N	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	N	Y	N	Y	N	Y
	Y	N	Y	N	Y	Y	Y	N	Y	N	N	N	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	N	N	N	N	N	Y	N
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y	N	N	N	Y	Y	N	N	Y	N	N	Y	Y	Y	N	Y	N	N	Y	Y
T. Score	6	4	9	8	9	8	9	6	9	9	4	8	9	6	6	9	8	9	6	9	8	6	9	10	8	4	5	5	6	6	9	8	6

Y: yes; N: no; NA: not applicable; NR: not reported.