CHILDHOOD OBESITY
August 2015 | Volume 11, Number 4

DOI: 10.1089/chi.2014.0117

REVIEW

Sugar-Sweetened Beverages and Obesity among Children and Adolescents: A Review of Systematic Literature Reviews

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Abstract

Background: The prevalence of overweight and obesity among children and adolescents has increased worldwide and has reached alarming proportions. Currently, sugar-sweetened beverages (SSBs) are the primary source of added sugar in the diet of children and adolescents. Contradictive findings from studies and reviews have fueled an endless debate on the role of SSBs in the development of childhood obesity.

Methods: The primary aim of the present review of reviews was to assess how review- and study-level methodological factors explain conflicting results across reviews and meta-analyses by providing an up-to-date synthesis of recent evidence regarding the association between SSB consumption and weight gain, overweight, and obesity in a population of 6-month-old to 19-year-old children and adolescents. The secondary aim was to assess the quality of included reviews using the Assessment of Multiple SysTemAtic Reviews (AMSTAR) measurement tool. Systematic literature reviews and meta-analyses were included. The literature search was performed through the platforms Pubmed/Medline, Cinahl, and Web of Knowledge.

Results: Thirteen reviews and meta-analyses were included. Nine reviews concluded that there was a direct association between SSBs and obesity in children and adolescents and four others did not. The quality of the included reviews was low to moderate, and the two reviews with the highest quality scores showed discrepant results.

Conclusions: The majority of reviews concluded that there was a direct association between SSB consumption and weight gain, overweight, and obesity in children and adolescents. However, recent evidence from well-conducted meta-analyses shows discrepant results regarding the association between SSB and weight gain, overweight, and obesity among children and adolescents. Improving methodological quality of studies and reviews as well as ensuring responsible conduct of research and scientific integrity is essential for the provision of objective results.

Introduction

The prevalence of overweight and obesity among children and adolescents has increased all over the world and has reached alarming proportions, especially in industrialized countries.[1,2] Obesity during childhood and adolescence is of major concern given that obese children and adolescents are at higher risk of being obese adults and developing comorbidities, such as diabetes and cardiovascular diseases.[3–7]

Evidence suggests that the consumption of sugar-sweetened beverages (SSBs) has increased in parallel to overweight and obesity trends.[8–11] Currently, SSBs contribute between 10% and 15% of youth's caloric intake and are the primary source of added sugar in the diet of children and adolescents.[12] Approximately 25% of US adolescents consume more than 750 mL of SSBs per day, which represents more than 350 calories.[10,13]

Numerous studies, reviews, and meta-analyses evaluating the association between SSBs and weight gain, overweight, and obesity in childhood and adolescence have been published, with some finding a positive association and others finding none. These contradictive findings have fueled intense debates, as illustrated in a pro versus con debate regarding the role of SSBs in obesity published in 2013, highlighting divergent expert opinions.[8,14] Some experts argued that evidence supporting a causal relation between SSB intake and weight outcomes was sufficient,[8]

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whereas other experts considered it to be weak.[14] More recently, a systematic review showing mixed findings supplemented to the ongoing debate.[15] These conflicting results may be owing to methodological issues in original studies and reviews.

Three reviews of reviews regarding SSB consumption and health outcomes among children and adults have previously been published.[11,16,17] Two of these reviews[11,16] studied different health outcomes, and their aims were not toward critically assessing the association between SSB consumption and obesity. Indeed, Weed and colleagues assessed the quality of reviews on SSBs and health outcomes and found that most reviews lacked comprehensive reporting of epidemiological evidence and use of systematic methodologies. The aim of the review by Althuis and Weed was to show the usefulness of evidence mapping among primary studies of SSBs and four health outcomes. Their findings showed great study-level methodological variability.[11,16] The third review,[17] examining SSBs and body weight, assessed how reviews' conclusions relate to their quality and source of funding. The results showed that quality scores were not correlated with reviews' conclusions or with the source of funding. However, industry-funded reviews were more likely to report weak evidence between SSB consumption and weight gain.

The primary aim of the present review of reviews was to assess how review- and study-level methodological factors explain conflicting results across reviews and meta-analyses by providing an up-to-date synthesis of recent evidence regarding the association between SSB consumption and weight gain, overweight, and obesity in a population of 6-month-old to 19-year-old children and adolescents. The secondary aim was to assess the quality of included reviews using the Assessment of Multiple SysTemAtic Reviews (AMSTAR) measurement tool.

Methods

Search Methods and Terms Used

The literature search was performed through the platforms Pubmed/Medline, Cinahl, and Web of Knowledge. Reference lists of articles and other reviews were cross-searched in order to include eventual nonidentified reviews. One article search combining the following key terms was performed: Adiposity; Body Weight; Body Mass Index; Adipose Tissue; Carbonated Beverages; Dietary Sucrose; Sucrose; Fructose; Sweetening Agents; Glucose; Energy Drinks; Beverages.

Selection of Articles

The selection of articles was performed in three steps. First, one researcher selected articles by title in the three databases mentioned above. Second, two researchers independently selected reviews published up to August 31, 2013, based on information available in the abstracts. Third, selected reviews were combined, duplicates were removed, and full texts of articles were screened for relevance. During the selection process, when opinion discrepancy occurred regarding the inclusion of an article, the two researchers individually proceeded to a second evaluation of the article and further discussed it until agreement was reached. There was only one discrepancy where reaching consensus was required.[18]

The following criteria were used to include or exclude articles of systematic reviews.

Exposure. The exposure of interest was SSB consumption. There is no official definition for SSBs. However, as a convention, SSBs are defined as beverages with added sugar, such as carbonated or noncarbonated sodas, fruit drinks (non-100% fruit juices), and sport drinks.[18,19]

Study design. Systematic literature reviews and meta-analyses were included. To be considered systematic, as a minimum criterion, a description of the literature search performed had to be presented in the method section of the article or online supplementary data Articles without literature search description were considered nonsystematic and were excluded. Only systematic literature reviews and meta-analyses of primary studies were included. Reviews of reviews were excluded.

Outcome. Systematic reviews and meta-analyses evaluating SSB consumption in regard to weight gain, overweight, and obesity among 6-month-old to 19-year-old children and adolescents were included.

Population. The population was defined as children and adolescents less than 19 years of age. Restriction to children and adolescents was made on the basis that BMI values during childhood and adolescence are important risk factors for the presence of adult overweight and obesity. Further, efforts to prevent overweight and obesity in the pediatric population might contribute to preventing adult morbidity and mortality.[3–7,20,21]

Only few reviews focused solely on children and adolescents; therefore, mixed systematic literature reviews, including both children and adults, were also included. However, data extraction and analysis exclusively considered studies on children and adolescents. Reviews including adults only were excluded. Article types were systematic reviews and meta-analyses in English published from 1990 up to August 2013.

Statistical Analysis

Descriptive information for each published review was extracted (*i.e.*, design, number, and type of studies summarized, age range, and geographical origin) using a structured form developed for this review. Each review was summarized and described with regard to design, population, number of included studies, authors' conclusions, and funding (Table 1). The evaluation of dietary assessment methods and tools used in original studies was beyond the scope of the present review. However, information

regarding dietary assessment tools mentioned in the included reviews was collected. In addition, the standardized instrument AMSTAR was used to assess the methodological quality of included reviews. The AMSTAR tool was developed by Shea and colleagues by combining previous tools, empirical evidence, and expert consensus to easily evaluate the quality of systematic literature reviews.[22] The AMSTAR is a 1-page tool with 11 questions (see Supplementary Table 1) (see online supplementary material at http://www.liebertpub.com). Questions answered by "yes" give 1 point and the maximum score is 11 for meta-analyses and 9 for reviews. Scores of 0–4 indicate low quality, 5–8 moderate quality, and 9–11 high quality.[11,16,23] The AMSTAR instrument was completed independently by two researchers. The researchers agreed on the final score of each included review.

At first, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was considered. However PRISMA has not been developed as a quality assessment instrument to assess the quality of systematic reviews per se.[24] Therefore, AMSTAR was preferred over PRISMA.

Results

The literature search resulted in 13 reviews and meta-analyses (Supplementary Fig. 1) (see online supplementary material at http://www.liebertpub.com). Eight were systematic reviews,[18,25–31] three were combined systematic reviews and meta-analyses,[32–34] and two were meta-analyses.[14,35] The erratum by Forshee and colleagues[36] was included as part of the review by Forshee and colleagues.[35] In addition, four of the included reviews came from two authors' groups. The reviews by Malik and colleagues and Malik and colleagues are from the same group of authors as well as the reviews by Mattes and colleagues and Kaiser and colleagues. The review by Kaiser and colleagues is an update of Mattes and colleagues. The characteristics of each included study are presented in Table 1. See Supplementary Table 2 (see online supplementary material at http://www.liebertpub.com) for the list of excluded articles after full-text screening and reasons for exclusion.

Of the 13 included reviews, nine concluded that there was a direct association between SSB intake and weight gain, overweight, and obesity in children and adolescents.[7,12–18,20] Two reviews concluded that there was no association[25,35] and two others, from the same group of authors, reported that no conclusion could be drawn and that more studies were needed.[19,22] No reviews concluded that there was an inverse association.

Of the 13 included reviews, five[14,32–35] assessed effect sizes of included longitudinal or intervention studies. The effect size of increasing SSB intake was comprised between 0.03 (95% confidence interval [CI], −0.01, 0.07) BMI unit change per serving of SSB and 0.14 (95% CI, −0.15, 0.42)[14] (standardized mean difference) BMI increase. The effect size of decreasing SSB consumption was comprised between 0.007 (95% CI, −0.073, 0.086)[33] and 0.329 (95% CI, 0.13, 0.53) (positive numbers showing that studies favored the treatment group).

Malik and colleagues[32] reported effect sizes between 0.05 (95% CI, 0.03, 0.07) and 0.16 (95% CI, 0.15, 0.16) on BMI and body weight for a daily increase of one serving of SSB intake in prospective studies and an effect size of −0.12 (95% CI, −0.22, −0.02) (negative numbers showing that studies favored the treatment group) of reducing SSB intake between intervention and control groups.[32]

In the meta-analysis by Vartanian and colleagues,[34] the effect size of increasing SSB consumption was $r = 0.03$ (95% CI, 0.01, 0.04) in prospective studies and $r = 0.29$ (95% CI, 0.22, 0.35) (positive numbers showing that studies favored the treatment group) in intervention studies aiming at decreasing SSB intake. In the review by Forshee and colleagues,[35] the effect size was ≈ 0.03 (95% CI, −0.01, 0.07) unit change per serving of SSB. In the meta-analyses by Kaiser and colleagues[14] and Mattes and colleagues,[33] the effect of adding mandatory SSB consumption to a person's diet was 0.14 (95% CI, −0.15,0.42),[14] whereas the effect of reducing SSB consumption on body composition/adiposity was between 0.007 (95% CI, −0.073, 0.086[33] and 0.329 (95% CI, 0.13, 0.53)[14] (positive numbers showing that studies favored the treatment group).

Within the 13 reviews, a total of 30 longitudinal, 12 intervention, and 34 cross-sectional studies on SSB intake and weight gain, overweight, and obesity in children and adolescents were included. The list of studies within each review is presented in Supplementary Tables 3–5 (see online supplementary material at http://www.liebertpub.com). All reviews concluding that there was a direct association between SSB intake and weight gain, overweight, and obesity in children and adolescents included longitudinal studies, eight included intervention studies,[18,26,27,29–32,34] and four included cross-sectional studies as well.[26,29,31,34] Among the four reviews that did not find a direct association between SSB intake and weight gain, overweight, and obesity in children and adolescents, all included intervention studies,[14,25,33,35] two further included longitudinal studies,[25,35] and one also included cross-sectional studies[25] (Table 1). No clear pattern between inclusion of different study designs and reviews' conclusion could be established.

Most reviews[25–28,31–33,35] mentioned measurement limitations in the dietary assessment tools used to measure beverage consumption, such as self-reported data, use of a single 24-hour recall or noninclusion of weekend days. Heterogeneity in dietary measurement tools used and lack of homogeneity regarding SSB definition between studies were also reported. Other limitations inherent to study designs mentioned in reviews[30–32,35] were related to small sample sizes, short follow-ups, and convenience samples. Whether or not measurement limitations were mentioned did not influence reviews' conclusions.

Table 1. Description of Included Reviews and Meta-analyses

Reference (author and date)	Country	Study design	Population	Databases searched	No. of included studies		Authors' conclusion	Funding and conflict of interest (COI)	AMSTAR score[b]
					Children	Adults[a]			
Clabaugh K, Neuberger GB, 2011	USA	Review	Children	CINAHL, PubMed, Trip database, Cochrane Library	L (3) CS (4) IN (2)	N/A	(+)	Unknown COI not mentioned	5
Forshee RA, Anderson PA, Storey, 2008	USA	Meta-analysis	Children	MedLine	L (8) (two more not included in meta-analysis) IN (2)	N/A	(x)	Private[c] no COI	7
Gibson S, 2008	UK	Review	Children and adults	PubMed, Google scholar, Cochrane Library	L (11) CS (20) IN (3)	L (6) CS (3) IN (1)	(x)	Commissioned by the UNESDA[d] COI not mentioned	3
Harrington S, 2008	USA	Review	Children	CINAHL, MedLine	L (5) IN (2)	N/A	(+)	Unknown COI not mentioned	2
[A]Kaiser and colleagues, 2013	USA	Meta-analysis	Children and adults	PubMed, PsycINFO, Cochrane Collaborative Website, SCOPUS, Dissertation Abstracts (PROQUEST)	IN (3)	IN (3)	(o)	Unknown Reported COI[e]	9
[B]Malik VS, Schulze MB, Hu FB, 2006	USA and Germany	Review	Children and adults	MedLine	L (6) CS (13) IN (2)	L (4) CS (2) IN (3)	(+)	Public[f] No COI	2
[B]Malik and colleagues, 2013	USA and Singapore	Review and Meta-analysis	Children and adults	PubMed, Embase, Cochrane Library	L (14) IN (5)	L (7) (6)[a] IN (5) (2)[a]	(+)	Public[f] No COI	9
[A]Mattes and colleagues, 2011	USA	Review and Meta-analysis	Children and adults	PubMed, PsycINFO, Cochrane Collaborative Website, Web of Science, Dissertation Abstracts	IN (6)	IN (6)	(o)	Public[f] Reported COI[e]	7

continued on page 342

Table 1. Description of Included Reviews and Meta-analyses *continued*

Reference (author and date)	Country	Study design	Population	Databases searched	No. of included studies		Authors' conclusion	Funding and conflict of interest (COI)	AMSTAR score[b]
					Children	Adults[a]			
Olsen NJ, Heitmann BL, 2009	Denmark	Review	Children and adults	MedLine, Scirus	L (11) IN (2)	L (3) IN (3)	(+)	Unknown funding No COI	4
Osei-Assibey and colleagues, 2012	UK	Review	Children	MedLine, Embase,CCTR, DARE, CINAHL, Psycho-Info	L (3) IN (1)	N/A	(+)	Public No COI	6
Perez-Morales E, Bacardi-Gascon M, Jimenez-Cruz A, 2013	Mexico	Review	Children	PubMed, MedLine, SciELO, EBSCO	L (7)	N/A	(+)	Unknown	4
Vartanian LR, Schwartz MB, Brownell KD, 2007	USA	Review and Meta-analysis	Children and adults	MedLine, PsycINFO	L (7) CS (13) IN (2)	L (2) CS (5) IN (5)	(+)	Public[g] COI not mentioned	6
Woodward-Lopez G, Kao J, Ritchie L, 2011	USA	Review	Children and adults	PubMed	L (19) CS (25) IN (4)	L (5) CS (7) IN (3)	(+)	Public[h] COI not mentioned	4

A and B: same author groups. (+) association; (x) no association; (o) no conclusion.

[a]Not included in the analysis.

[b]Maximum AMSTAR score is 11 for meta-analysis and 10 for reviews.

[c]American Beverage Association.

[d]Union of European Beverages Association.

[e]Gifts and grants from Coca-Cola Company, PepsiCo, Red Bull and Kraft Food.

[f]NIH.

[g]Rudd Foundation.

[h]The California Endowment, the California Center for Public Health Advocate.

AMSTAR, Assessment of Multiple SysTemAtic Reviews; L, longitudinal; CS, cross-sectional; IN, intervention.

The population of interest for the present review of reviews was children and adolescents. The mean age of children and adolescents among the included reviews was 9.37 (±standard deviation [SD] 7.23) ranging from 0.5 to 19 years. The mean age within studies included in reviews was 9.62 (±SD 5.0) ranging from 0.5 to 19 years (Supplementary Graphs 1 and 2) (see online supplementary material at http://www.liebertpub.com). Most reviews included children from the age of 2 to 18–19, and only one review solely focused on younger children.[28] The age ranges analyzed in the reviews were not related to their conclusions.

Five reviews[14,18,27,28,31] did not state their source of funding, six[26,29,30,32–34] were publicly funded, and two[25,35] were funded by the industry. Conflict of interest was not reported in six reviews,[18,25,28,29,31,34] authors of five reviews[26,27,30,32,35] reported not having any conflict of interest, and authors of two reviews[14,33] reported having conflict of interest (Table 1).

Quality

Among the 13 included reviews, none received the maximum score of 9 for reviews and 11 for meta-analyses. The mean quality score was 3.75 (SD ± 1.39) for reviews, 7.3 (SD ± 1.52) for the combined reviews and meta-analyses, and 8 (SD ± 1.41) for meta-analyses. The overall mean quality score was 5.23 (SD ± 2.26), ranging from 2 to 9. Based on the AMSTAR score, all reviews were classified as low quality, reviews combined with a meta-analysis were of moderate quality, and the two meta-analyses were of high quality. The two reviews/meta-analyses with the highest quality scores (=9) had discrepant results. The review by Kaiser and colleagues concluded that ''the currently available randomized evidence for the effects of reducing SSB intake on obesity is equivocal,'' whereas Malik and colleagues concluded that ''our systematic review and meta-analyses provide additional evidence that SSB consumption is associated with weight gain in both children and adults.'' Questions 11 (''was conflict of interest stated?'') of the AMSTAR tool scored the lowest, only 17%, compared to the other questions for which percentage scores were comprised between 31% and 100% (Supplementary Table 1) (see online supplementary material at http://www.liebertpub.com).

Discussion

Overall, the majority of reviews concluded that there was a direct association between SSB consumption and weight gain, overweight, and obesity in children and adolescents. These findings are in agreement with expert opinion, including primary studies, reviews, and meta-analyses on children and adults, which mentioned that there is sufficient evidence to conclude that SSB intake causes excess weight gain and that limiting its consumption will have significant impact on the prevalence of obesity and obesity-related diseases.[8]

However, recent evidence from well-conducted meta-analyses shows discrepant results. Contradictory results from studies, reviews, and meta-analyses might occur owing to differences in study design, inclusion criteria, and data analyses.

To illustrate, the discrepant results from the two highest-quality reviews/meta-analyses[14,32] might be explained by the fact that one[14] included intervention studies ($n = 3$) only, whereas the other[32] included both intervention ($n = 5$) and cohort studies ($n = 14$). In the meta-analysis by Kaiser and colleagues, intervention studies had, on average, a shorter duration than in the review by Malik and colleagues. In addition, one of the three included randomized, controlled trials (RCTs) was not designed to assess the association between SSB intake and weight outcome.[38] In comparison, all five RCTs included in the review by Malik and colleagues were testing the effect of reducing SSB intake on weight among children and adolescents. Reviews and meta-analyses based on RCTs that assess short-term weight loss might not be appropriate to identify dietary determinants of long-term weight change and prevention of weight gain.[8] Further, the inclusion of studies not primarily designed to assess the association between SSB consumption and weight outcome might bias findings. Additionally, cross-sectional studies were included in 5[25,26,29,31,34] of the 13 reviews. Owing to the high risk of reverse causation, longitudinal studies should be privileged.[39,40] Hence, reviews based on cross-sectional studies do not provide strong evidence.

Another factor influencing studies and reviews' results is linked to problems in exposure measurements, such as the use of single-day dietary assessments (insufficient to take into account large within-person variability), underrepresentation of weekend days, self-reported data, the use of nonquantitative food frequency questionnaires, as well as heterogeneity regarding SSB definition. For example, the inclusion of chocolate milk, which contains protein or 100% fruit juice and which contains vitamins and minerals, in some studies might change the results. Reliable assessment of dietary intake is difficult, especially among children and adolescents.[41] Participants' age might influence misreporting owing to recall bias and cognitive abilities that may limit the reliability of dietary intake assessment methods. Evidence suggests that involvement of a parent for children under the age of 8 improves the reliability of dietary assessment, and for younger children, ages 0.5–4.0 years, weighted food records have been reported to provide the best estimates.[41,42]

In addition, different practices regarding total energy intake adjustments are likely to influence the direction of the association between SSBs and weight and change research results. In regard to best practice for meta-analyses of the association between SSBs and body weight, divergent expert opinions are present in the literature.[43] On the one hand, adjustment for total energy intake is performed by some researchers in order to control for confounding factors, reduce extraneous variation, and predict the effect of dietary interventions.[14,15,44] On the other hand, because

SSBs are a source of calories, it has also been argued that adjusting for total energy intake might result in underestimating the effect of SSBs on body weight, given that total energy intake mediates the association between SSBs and BMI.[43]

Discrepant results regarding effect sizes in the included meta-analyses were found. Indeed, effect sizes of increasing SSB consumption on BMI change (increase) was statistically significant in half of the four meta-analyses evaluating effect sizes from both prospective (cohort) and intervention studies. Whereas effect sizes of decreasing SSB consumption on BMI change (decrease) was statistically significant in two of the three meta-analyses evaluating effect sizes from intervention studies. These discrepant findings might be explained by the factors mentioned above, such as heterogeneity in SSB definition, as well as analytical disparities in calculating effect sizes. Comparing effect sizes found in meta-analyses was also limited by the different inclusion criteria used. Some meta-analyses evaluated effect sizes from intervention studies only[33] and other from both intervention and prospective studies.[14,32,34,35] In addition, some meta-analyses evaluated the effect of increasing[35] versus decreasing[33] SSB consumption on BMI change or both.[14,32,34] Hence, discrepant results across reviews and meta-analyses evaluating the association between SSB consumption and weight gain, overweight, and obesity in children and adolescents are likely to be owing to heterogeneity in research methods and design as well as analytical disparities.

Reviews not showing a direct association between SSB intake and weight outcomes were either funded by the food and beverage industry[25,35] or conflict of interest[14,33] was reported. The source of funding for reviews concluding that there was an association between SSB consumption and weight outcomes was either unknown[18,27,28,31] or public.[26,29,30,32,34] In accord with our results, Massougbodji and colleagues[17] also reported differences regarding the nature of reviews' results between nonindustry- and industry-funded research. This suggests that reviews' conclusions might be influenced by funding sources as well as authors' conflict of interest.

Overall, reviews that concluded that there is a direct association emphasized the public health importance of identifying dietary determinants of obesity and the great potential of recommendations aiming at limiting the consumption of SSBs to prevent weight gain, especially among high-risk populations, such as overweight children. Reviews that did not conclude that there was a direct association underlined the importance of overall diet quality and physical activity and argued that evidence to reduce SSB intake to prevent weight gain or induce weight loss are equivocal.

Quality

The overall mean AMSTAR quality score (combining reviews and meta-analyses) was 5.23 (SD ± 2.26), which is slightly higher than another review that assessed the quality of reviews and meta-analyses on SSBs and weight, obesity, coronary heart disease, and diabetes, which had an average AMSTAR score of 4.4.[4]

These average low-to-moderate AMSTAR scores are likely to influence the conclusions of reviews and meta-analyses. This suggests that the methodology of reviews regarding SSB intake, as well as other exposures, in relation to weight outcomes could be improved.

Most reviews did not fulfill the criteria for question 11 (''was conflict of interest stated?''). Some reviews did not disclose their source of funding or conflict of interest, and most reviews that did so did not provide information on the source of funding of the cited studies, which is required to score ''yes.'' The AMSTAR instrument does not distinguish between reviews providing partial information regarding funding sources and conflict of interest and reviews that do not provide any information. Another limitation of the AMSTAR measurement tool relates to the 11 questions being equally weighted. Therefore, questions that are more important for the reviews integrity are not given more weight than less-fundamental ones. As with any assessment tool, the quality criteria present some limitations, and our quality assessment approach may hence also have introduced some errors. However, the AMSTAR tool is validated and the clear guidance for each question limits interpretation bias and was found to be highly reliable.

Strengths and Weaknesses

The main strength of this review of systematic reviews and meta-analyses is the use of a validated quality assessment tool, AMSTAR, as well as the systematic approach used, which provides a more critical evaluation.

Of course, quality assessment remains subject to interpretation, but having two researchers performing the evaluation independently and using a validated tool should improve reliability. A limitation of our study is the inclusion of only published studies and restriction to English language. Publication bias cannot be excluded, given that studies with positive results tend to be published more easily.[45]

Conclusions

The majority of reviews concluded that there was a direct association between SSB consumption and weight gain, overweight, and obesity in children and adolescents. However, recent evidence from well-conducted meta-analyses shows discrepant results regarding the association between SSB and weight gain, overweight, and obesity among children and adolescents.

Our findings suggest that review- and study-level bias, such as the use of inappropriate study and review design, energy adjustment, as well as the acknowledged limitations linked to dietary assessment methods may impair the assessment of SSB consumption and its impact on

weight gain among children and adolescents. Improving methodological quality of studies and reviews as well as ensuring responsible conduct of research and scientific integrity is essential for the provision of objective results.

Acknowledgment

The authors thank Birgitte Marie Skogstad for proofreading the manuscript.

Author Disclosure Statement

No competing financial interests exist.

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