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Obesity and dental caries: systematic review

Obesidade e cárie dentária: revisão sistemática

ABSTRACT

OBJECTIVE: Identifying, through a systematic literature review, evidence of a possible association between obesity and dental caries.

METHODS: A search of articles published between 2005 and January 2012 was performed in the Medline/PubMed, LILACS and Web of Science databases. The quality of scientific evidence of the selected articles was assessed by the items proposed for observational studies in the Downs & Black instrument.

RESULTS: Initially, 537 references were found; after checking the titles and abstracts by two independent researchers, twenty-eight articles were selected for complete reading. Ten of them that assessed the primary and/or permanent dentition observed a positive association between obesity and dental caries and one study found an inverse association. According to the Downs & Black classification, thirteen articles with good scientific evidence were found.

CONCLUSIONS: The present review did not find sufficient evidence regarding the association between obesity and dental caries, and it did not clarify the possible role of diet and other possible effect modifiers on this association.

DESCRIPTORS: Dental Caries, Epidemiology, Obesity, Observational Studies, Review.

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RESUMO

OBJETIVO: Analisar evidências da associação entre obesidade e cárie dentária.

MÉTODOS: Foi realizada revisão sistemática de artigos indexados nas bases de dados Medline/PubMed, *Web of Sciences* e LILACS, no período entre 2005 e janeiro de 2012, para identificar associação existente entre obesidade e cárie dentária. A qualidade da evidência científica dos artigos selecionados foi verificada pelos itens propostos para estudos observacionais do instrumento Downs & Black.

RESULTADOS: Inicialmente foram encontradas 537 referências após a verificação dos títulos e resumos por dois pesquisadores independentes. Foram selecionados 27 artigos para leitura completa. Destes, dez avaliaram dentição decídua e/ou permanente e observaram uma associação positiva entre obesidade e cárie dentária, sendo que um estudo encontrou uma associação inversa. Segundo a classificação de Downs & Black, treze artigos foram considerados com boa evidência científica.

CONCLUSÕES: A presente revisão não encontrou evidências suficientes quanto à associação entre obesidade e cárie, assim como não esclareceu o possível papel da dieta e de outros possíveis modificadores de efeito nessa associação.

DESCRIPTORIOS: Dental Caries, Epidemiology. Obesity. Observational Studies. Review.

INTRODUCTION

Overweight and obesity, defined as excess body fat compared to lean body mass,¹⁹ are a growing public-health problem in the world.¹⁵ Decreasing physical activity, increasing sedentary lifestyles and dietary changes are factors strongly associated with the development of overweight and obesity.¹² Studies have observed increases in being overweight in childhood and adolescence since the beginning of 2000,²¹ resulting in the increased risk of cardiovascular diseases, respiratory disorders and other chronic diseases during adulthood.³²

Diet plays an important role in the increased prevalence of obesity⁸ due to the higher consumption of foods rich in fat and carbohydrates.³⁴ Overweight or obese children and adolescents reported higher consumption of sugary drinks and foods such as “fast food” compared with those who reported normal weight.³⁴ Besides being directly associated with obesity, eating habits, especially regarding the intake of sucrose, have a well-established causal relationship with tooth decay, along with socio-demographic aspects, such as low socioeconomic status.²⁷

A systematic review and meta-analysis⁷ published in 2010 identified a positive association between obesity and periodontal disease. However, the relationship between obesity and dental caries is unclear. Dental caries remains the most prevalent problem in oral health and it is associated with pain⁴ and a decrease in quality of life.¹⁶

Because caries is associated with poor dietary habits and inappropriate diets promote obesity, a biologically plausible association between obesity and dental caries has been inferred in the literature.¹⁴ However, the presence of a common factor such as a high-sugar diet, caused by the ingestion of food such as soft drinks, cake, and ice cream, seems to increase the probability of both diseases and seems to be the most acceptable theory to explain the relationship between obesity and dental caries.²¹ The biggest challenge in understanding this relationship is to measure the possible confounding variables (diet and income) and effect modifiers (age, oral hygiene habits and use of fluoridated water) in a standardized manner.³²

A systematic review²¹ on the subject was indexed by Bireme, Medline, ISI (Thomson Scientific) and Cochrane Library in 2006, covering the age groups of childhood, adolescence, and adulthood. The exclusion criteria identified 33 articles for reading. At the end of the review, three cross-sectional studies, all performed with children, were identified as having good methodological quality. They presented conflicting results regarding the presence of a positive association between obesity and dental caries. Another systematic review and meta-analysis¹⁷ including studies published before 2010 indicated the presence of a positive association between obesity and dental caries in permanent dentition without clarifying the direction of this association.

The present study deals with a systematic review in order to use the new evidence to update the literature between 2005 and January 2012 on the subject.

METHODS

A systematic review on obesity and dental caries was performed in the electronic databases of the Medline/PubMed, LILACS, and the Web of Science, between 2005 and January 2012. This review included studies published after 2010, which were not included in the systematic review and meta-analysis published earlier on the subject, new scientific evidence to try to clarify the relationship between obesity and dental caries have been added to this study. The first search used the English terms “dental caries” and “obesity”. These two terms are the same as those used in the systematic review performed on the same subject by Kantovitz & Pascon; Rontani & Gavião²¹ (2006) with articles published between 1984 and 2004. The following keywords were used for the definition of caries: “DMFT index”, “tooth decay”; for the explanatory variable the keywords “waist circumference”, “skinfolts” and “body mass index” were used. These descriptors were found in the articles selected in the first search conducted on the subject. For the combination of descriptors, the logical operators “AND” and “OR” were used.

The process of finding the scientific papers to write the review consisted of four steps. The first was the identification of titles in the databases PubMed, LILACS, and Web of Science. Exclusion criteria used in reading the titles consisted of: review articles, protocols on nutrition and food issues, studies on oral health and diet-specific items and obesity studies related to other oral diseases.

The second stage consisted of two researchers independently reading the eligible abstracts. The search also excluded those items that assessed participants aged six and under, articles published before 2004, articles evaluating specific populations such as schizophrenic patients, and master’s dissertations or PhD theses. The few disagreements that occurred were discussed by the two researchers, who then reached a consensus.

The third stage consisted of reading the articles, applying the same exclusion criteria mentioned above.

In the fourth step, all the references of the selected articles were checked in order to find any study not found in the databases previously consulted by the authors.

The quality of the scientific evidence in the selected articles was assessed using the criteria of Downs & Black¹³ (1998). Of the 27 items proposed by the authors, 18 were selected. Those items evaluating intervention studies were excluded because none of the 28 articles selected for review had used this design. The items excluded from Downs & Black’s classification were:

Are the interventions of interest clearly described? Does the study provide estimates of the random variability in the data for the main outcomes? Have all important adverse events that may be a consequence of the intervention been reported? Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive? Was an attempt made to blind study subjects to the intervention they have received? Was an attempt made to blind those measuring the main outcomes of the intervention? Was compliance with the intervention/s reliable? Were study subjects randomized to intervention groups? and Was the randomized intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable? The articles with ten or more items scored by both evaluators in the review were found to have good scientific evidence. The criteria to consider an article as producing good evidence were given by the study authors. The choice of a cut-off point of ten or more items is due to the fact that the Article evaluated as having good scientific evidence had to have more than 50% of the items from the Downs & Black classification positively evaluated by two researchers of the study. For cases in which there was disagreement about the scores of articles between the two researchers, i.e., one researcher considered the article to have good scientific evidence and the other does not, a new assessment was performed and a consensus reached without the need for a third appraiser’s evaluation.

RESULTS

Initially, 346 titles were identified in PubMed, 21 in LILACS, and 170 in Web of Science. After reading the titles, 81 were selected for reading the abstracts: 66 from PubMed, six from LILACS, and nine from Web of Science. Studies involving participants < 6 years old were excluded after reading the articles. Twenty-eight articles published between 2005 and 2012 were identified. All the references were checked and six articles were found that did not meet the review’s inclusion criteria (Figure).

Among the 28 articles, 25 were in English, two in Spanish and one was in Portuguese. Twenty-four studies had a cross-sectional design, three were prospective cohort and one was a case control (Tables 1 and 2); Table 1 lists all studies that did not perform adjusted statistical analysis, while those with adjusted statistical analysis are shown in Table 2.

The ages evaluated ranged from three to 20. Although one of the exclusion criteria was age < 6 years, few studies have evaluated various age groups including children < 6 years, and therefore, they were included in the review. For those studies that performed separate analyses by age groups, only groups with participants > 6 years were included.

The measure of obesity in the 28 studies was Body Mass Index (BMI), and BMI information was self-reported in two of these studies.^{9,10} The classification of BMI showed no uniformity. Nine studies used the International Obesity Task Force (IOTF) for age and sex and seven assessed BMI through percentiles developed in the United States to determine the population's standard weight (Center for Disease Control and Prevention – CDC 2000). Three studies used BMI for age and one used for age and weight. Finally, eight studies were also checked which had other methods for obtaining BMI.

Seventeen studies assessed decay through teeth or decayed, missing, or filled surfaces – DMFT or DMFS, or, by means of DMFT or DMFS, in case of the primary dentition. The dental caries were assessed by interproximal radiographs in two studies, through the teeth or decayed and filled surfaces in four, by means of decayed teeth and interproximal radiographs in one study, by decayed surfaces and interproximal radiographs in another study, and through surfaces or decayed teeth in two studies (Tables 1 and 2).

The positive association between obesity and dental caries in permanent teeth was identified in six studies, a negative association was found in one, and eight showed no association. For studies evaluating mixed dentition (deciduous and permanent), four of them found a positive association, one found positive correlation, and seven showed no association. There was no correlation between obesity and caries in a study in which permanent dentition was analyzed (Tables 1 and 2).

When considering studies for the presence of some type of analysis adjusted for other variables that could confound the association between obesity and dental caries, 15 articles described which variables performed the adjustment.^{5,8-10,15,19,22-24,27,29,33,36,40,41} Eight studies included adjustments for age and sex,^{6,19,23,27,29,33,36,41} two only for sex,^{15,22} and five for consumption of any type of food, such as soft drinks,^{10,24} fruits or snacks between meals,¹⁰ “fast food”,¹⁰ and milk,⁹ as well as daily sugar consumption¹⁹ and “snack” consumption more than three times a day.²⁹

Among the 28 articles, 13 were considered to have good scientific evidence according to the criteria of Downs & Black. Eight of them with adjusted analysis and five articles without adjusted analysis were considered to be of good scientific quality (Tables 1 and 2).

Of these 13 articles, six found a positive association, showing that individuals with higher BMI values had more caries, and there was no association between obesity and dental caries in the other seven studies (Tables 1 and 2).

DISCUSSION

Between 2005 and 2012, 28 eligible articles which analyzed the relationship between obesity and dental caries were found. After applying the exclusion criteria for the revision and those proposed by Downs & Black,¹³ thirteen studies were shown to have good scientific evidence. However, they did not shed light on the link between obesity and dental caries.

Unlike the systematic review by Kantovitz & Pascon; Rontani & Gavião²¹ (2006), this review excluded studies on individuals < 6 years old, as it has been observed that the use of cariogenic foods have a greater impact on the appearance of dental caries increasing the likelihood of association between obesity and caries, after the age of six.³⁹ Moreover, in early childhood there is greater parental control over food intake and oral hygiene practices, which can mean lower prevalence of both diseases.³⁹ The opposite is also true. Parents that do not perform preventive oral health behaviors and food control, especially regarding the sugar consumption, increase the chances of caries in the primary dentition, and later in the permanent dentition, concomitantly with the presence of obesity.⁵

Studies that evaluated the association between dental caries and obesity indicate a variety of factors to be discussed in order to understand this relationship. The first issue refers to methods for the diagnosis of both diseases. The main diagnostic method for caries is the visual examination of the teeth or surfaces, and this method was used in most studies. However, this diagnostic method can often lead to lower levels of detection of the disease. Some studies using this method considered only the decayed teeth, not those restored or extracted due to caries.⁶ Other studies^{1,2} used interproximal radiographs, a method more sensitive to caries diagnosis. Using this method is likely to identify higher prevalence of the disease by detecting caries at earlier stages of cavitation. Using this type of examination for diagnosis in epidemiological surveys is not suitable because it is an expensive method and is primarily used by exposing the study population to examination when there is no clinical indication of disease.

There are also aspects that can interfere with measuring obesity. All studies included in this review measured obesity by BMI. There was no study measuring obesity using other diagnostic methods such as skinfold thickness, waist circumference, waist/hip ratio, or x-ray densitometry (DXA), all of which are more accurate methods for identifying levels of obesity. The probable explanation for this is the ease of implementation, objectivity, and comparability with a BMI reference standard, especially in population studies.¹⁴ The limitation of this index, which does not differentiate between lean body mass and fat mass and therefore often produces false positive results, must be considered

Table 1. Review of studies on obesity and caries without adjusted statistical analysis, 2005-2012.

Author(s)/ Paper language	Year	Study site	Age group (years)	Sample	Study design	Definition of the main exposure (obesity)	Outcome definition (caries)	Results	Downs & Black Score appraiser 1/ Score appraiser 2
Sadeghi et al ¹⁴ English	2011	Iran (Rafsanjan)	15	747	Cross- sectional	BMI (weight/height ²) – Underweight = BMI for age below the 5 th percentile; Normal = BMI for age between ≤ 5 th percentile and < 95 th percentile; Overweight / Obesity = BMI for age greater than the 95 th percentile	DMFT	In the bivariate analysis – The ANOVA showed no difference between BMI and DMFT. The linear regression analysis also showed no difference among the different groups of BMI for age with the DMFT. No statistical association	12/10 Good scientific evidence
Alm et al ² English	2011	Sweden (Jonkoping)	3, 6, 15 and 20	15 years old 402 20 years old 491	Prospective cohort	Ages 3, 6 and 15: BMI (weight/height ²) Normal = BMI < 25 Overweight = BMI (25 to 29.9) Obesity = BMI ≥ 30 Age 20: BMI (weight/height ²) Underweight = BMI < 18.5 Normal = BMI < 18.5 to 4.9 Overweight = BMI (25 to 9.9) Obesity = BMI ≥ 30	Age 15 radiographs Age 20 COs - decayed or filled surfaces	15 years old There is difference only among those with BMI < 25 and BMI ≥ 30 regarding the decayed and filled surfaces (RO (crude) = 2.8 (1.0, 7.7) There is difference only among those with BMI < 18.5 to 24.9 and BMI ≥ 30 regarding the decayed and filled surfaces (OR (crude) = 3.1 (1.2, 7.7) Positive statistical association	10/11 Good scientific evidence
D/Mello et al ¹¹ English	2011	New Zealand (Otago)	3 to 8	200	Cross- sectional	BMI (weight/height ²)	DMFT	1. There was no association between obese and normal weight regarding the DMFT (p>0.05). 2. Inverse correlation was observed between BMI and DMFT (r = -0.06, p = 0.41) after adjustment for gender ethnicity. Negative correlation No statistical association	5/8
Sales-Peres et al ¹⁵ Portuguese	2010	Brazil (Sao Paulo)	12	207	Cross- sectional	BMI (weight/height ²) Underweight = BMI < 18.5 Normal = BMI < 18.5 to 24.9 Overweight = BMI (25 to 9.9) Obesity = BMI ≥ 30	DMFT	There was no correlation between BMI and DMFT No correlation	8/5
Martinez Sotolongo & Martinez Brito ²⁵ Spanish	2010	Cuba	8 to 13	693	Cross- sectional	BMI normal weight obese	Only decayed teeth	There was statistical difference between the normal weight (with and without caries) and obese group (with and without caries) Positive statistical association	5/7
Tabelini et al ¹⁸ English	2010	Brazil (Londrina)	15 to 19	469	Cross- sectional	BMI (weight/height ²) Underweight Low weight normal overweight obesity	DMFT	There was no association between BMI and DMFT (p = 0.16) There was no association between BMI and DMFT at age 12. No statistical association	1 1

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Jamelli et al ²⁰ English	2010	Brazil (Recife)	12	647	Case and control	BMI (weight/height ²) Underweight = BMI for age below the 5 th percentile Normal = BMI for age between (\leq 5 th percentile and < 95 th percentile) overweight/obesity = BMI of greater age than the 95 th percentile	DMFT	Crude analysis: normal weight: Reference group: normal weight group Underweight = OR 1.31 (0.6-2.83) overweight and obesity = OR 1.35 (0.76-2.42) No statistical association	13/13 Good scientific evidence
Tramini et al ¹⁹ English	2009	France (Montpellier)	12	835	Cross- sectional	BMI (weight/height ²) Underweight = BMI (girls < boys and 14.2 < 14.3) Normal = BMI girls (\geq 14.2-22) and children (\geq 14.2-2.4) Overweight = BMI girls (21.1-26.6) and boys (22.4-26) Obesity = BMI \geq 26.6 girls and boys \geq 26	DMFT	Only crude analysis - BMI (independent) and caries (dependent) - dichotomized logistics 1.05 (1.00-1.10) Poisson 1.03 (1.01-1.05) There was no association between obesity and dental caries No statistical association	11/10 Good scientific evidence
Sharma & Hegde ³⁷ English	2009	India (Karnataka)	8 to 12	500	Cross- sectional	BMI (weight/height ²)	DMFS	Both in the primary and in dentition permanent statistical difference was observed between the four study groups (underweight, normal weight, overweight and obese). Positive statistical association	7/5
Alm et al ¹ English	2008	Sweden (Jonkoping)	15	671 original cohort At 15 years old = 402	Cross- sectional of a cohort	BMI (weight/height ²) Normal = BMI < 25 Overweight = BMI (25-29.9) Obesity = BMI \geq 30	DMFS	Overweight and obesity were more than twice the decay and restorations than those with normal weight ($p < 0.05$) Positive statistical association	10/11 Good scientific evidence
Bailleul- Forestier et al ³ English	2007	France (Paris)	12 to 18	82 (41 obese and 41 non- obese) paired by sex, age and occupation of parents	Cross- sectional	BMI (weight/height ²) Underweight = BMI < 20 Normal = BMI (20-24.9) Overweight = BMI (25-30) Obesity = BMI > 30	DMFT	The mean decayed teeth was higher in the obese group compared with the non-obese group ($p = 0.003$) The group of obese people has higher DMFT compared to the non-obese group. Positive statistical association	7/8
Moreira et al ²⁸ English	2006	Brazil (Paraíba)	12 to 15	3330	Cross- sectional	BMI (weight/height ²) Underweight normal overweight obesity	DMFT	There was no association between obesity and dental caries. No statistical association	10/7
Hilgers et al ¹⁸ English	2006	United States (Kentucky)	8 to 11	178	Cross- sectional	BMI (weight/height ²) normal overweight obesity	Radiograph	Difference was observed between low weight compared to obese ($p = 0.004$) and normal weight ($p = 0.05$) in caries permanent When caries in permanent and deciduous teeth were evaluated there was no difference No statistical association	9/6

BMI: Body Mass Index; DMFT: decayed, missing and filled teeth; DMFS: decayed, missing and filled surfaces

prior to the study. The non-use of DXA as a more appropriate method to measure obesity is probably due to the examination cost, which often makes it impossible to use in population studies.

A second point refers to the population's access to oral health services and the use of fluorinated substances. These two factors are considered as potential effect modifiers that may lead to a weak or negative association between obesity and caries.¹⁹ However, these factors were treated as potential confounders in studies in this review. In the present work, most studies showing an association were performed in European countries where oral health services are organized and available to the public, in addition to various forms of administering

fluorinated substances being made available. The lack of association between obesity and dental caries was identified mainly in Latin American countries. Four of these studies were conducted in Brazil at the following locations: Bauru,³⁵ Southeastern Brazil, with 6.8 to 8.5% of adolescents studied presenting overweight and obesity; in cities belonging to the state of Paraíba, Northeastern Brazil,²⁸ with 30% participants aged between 12 and 15 obese; in Londrina,³⁸ Southern Brazil, with 22.4% of the adolescents aged between 15 and 19 being overweight and obese; and in the city of Recife, Northeastern Brazil,²⁰ with 12.5% of adolescents aged 12 with overweight and obesity. Some of these cities have used a fluoridated water supply for over 30 years, even though dental services are still not adequately structured to meet

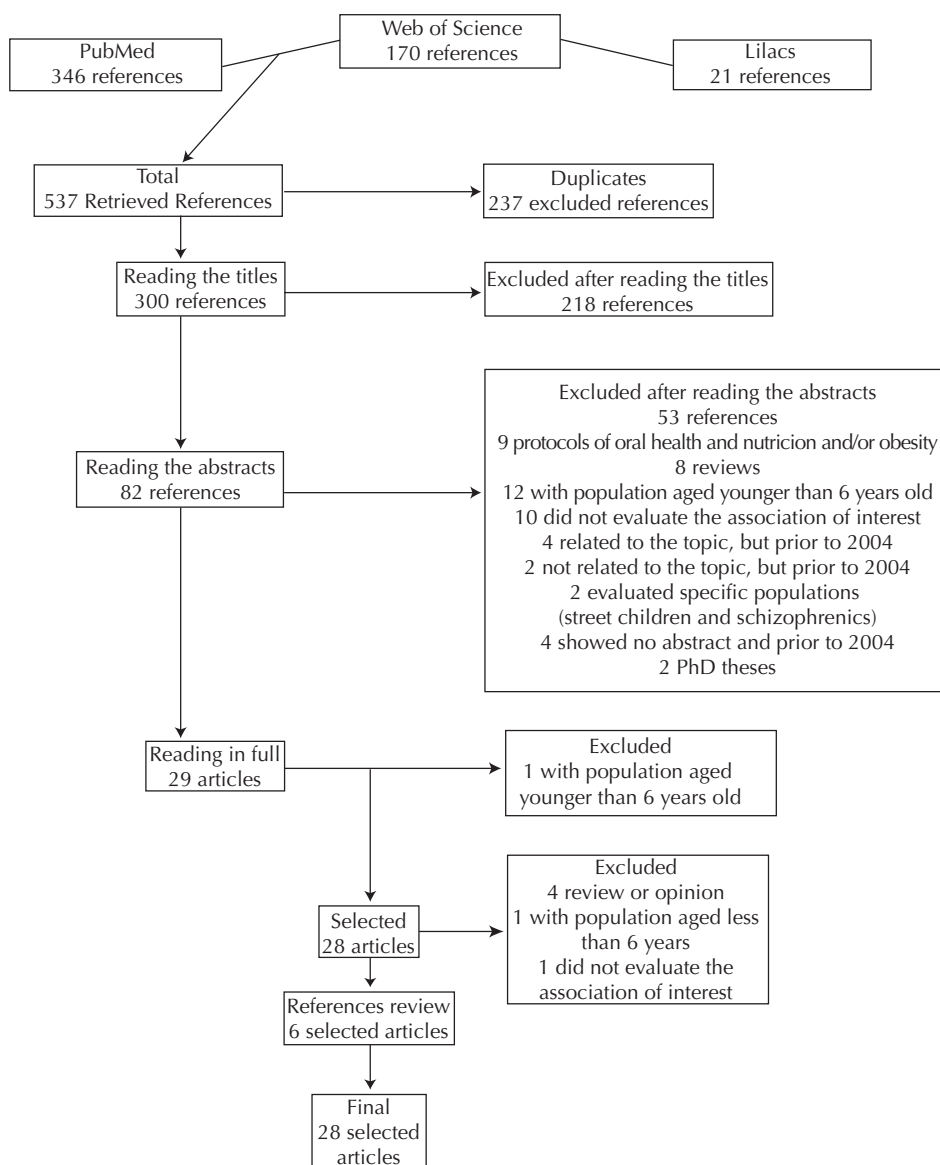


Figure. Search for scientific articles for the systematic review on obesity and dental caries, 2005-2012.

Table 2. Review of studies on obesity and caries with adjusted statistical analysis, 2005-2012.

Author(s) and paper Language	Year	Study site	Age group (years)	Sample	Study design	Definition of the main exposure (obesity)	Outcome definition (caries)	Results	Downs & Black Score Appraiser 1/ Score Appraiser 2
Honne et al ¹⁹ English	2012	India (Udupi district)	13 to 15	462	Cross-sectional	BMI (weight/height ²) Normal = BMI <25 Overweight = BMI (25 - 29.9) Obesity = BMI ≥ 30	DMFT	Crude analysis - Reference group: normal weight group 1. overweight and obesity OR = 3.67 95%CI 1.79;7.56 Adjusted Analysis – daily sugar consumption, school type, gender and age. 2. overweight and obesity OR = 3.68 95%CI 1.79;7.56 Positive statistical association	14/12 Good scientific evidence
Cinar et al ¹⁸ English	2011	Denmark	15	824	Cross-sectional	BMI (weight/height ²) Normal = BMI for age between (≤ 5 th percentile and <95 th percentile) Overweight = BMI percentile for age between 85–95 Obesity = BMI for age greater than the 95 th percentile.	DMFT	No association between obesity and dental caries in the crude analysis and adjusted for variables related to lifestyle (drinking milk for breakfast and frequency of brushing). No statistical association	10/8
Cinar & Murtomaa ⁹ English	2011	Turkey (Kadikoy district)	10 to 12	611 (360 public school) 254 (private school)	Cross-sectional	BMI (weight/height ²) Self-reported	DMFS	Crude and adjusted analysis There was no association between BMI and DMFS in the crude or adjusted analysis for the lifestyle (frequency of brushing teeth and milk consumption at breakfast and at bedtime) No statistical association	8/7
Modéer et al ²⁷ English	2010	Sweden (Stockholm)	Obese = (10.3 to 17.2) Not obese = (11 to 18.3)	65 obese 65 non-obese	Cross-sectional	BMI (weight/height ²) Normal = BMI <25 Obesity = BMI > 30	DMFT analyzing only the decayed component and radiographs	Crude Analysis reference group of normal weight. 1. Obesity: OR = 1.31 95%CI 1.11;1.56 Adjusted Analysis: 1. Age, sex, chronic illness, medications, and salivary flow: OR = 1.30 95%CI 1.08;1.58 2. Adjusted for parental education and country of birth of parents: OR = 1.36 95%CI 1.12;1.64 Remained associated after adjustments. Positive statistical association	11/10 Good scientific evidence

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Sanchez-Pérez et al ¹⁶ English	2010	México (City México)	7 to 11	135 accepted 110	Prospective cohort	BMI (weight/height ²) Obesity = Above the 95 th percentile Risk of obesity = between the 85-95 percentile Normal = (5 th percentile Underweight = below the 5 th percentile	DMFS	There was no association between BMI and dmfs (adjusted for age, deciduous dentition, sex, socioeconomic status) in the middle of the study. The longitudinal effect suggests that children with higher BMI experienced lower levels of dmfs (deciduous dentition) and CPOs (permanent dentition) (adjusted for age, permanent dentition, sex, socioeconomic status) in the middle of the study. No statistical association	11/11 Good scientific evidence
Cereceda et al ⁶ Spanish	2010	Chile (Santiago)	5 to 15	1190	Cross-sectional	BMI (weight/height ²) Underweight = BMI below the 5 th percentile Normal = BMI for age < 85 th percentile and higher than 5 th percentile Overweight = BMI percentile 85-95 Obesity = BMI ≥ 95	Deciduous dentition-DMFT. Permanent Dentition-DMFT	No association between BMI and deciduous teeth (DMFT) and permanent teeth (DMFT) Reference: normal weight Crude Analysis Underweight = OR = 0.36 95%CI 0.12;1.03 Overweight = OR = 0.86 95%CI 0.61;1.21 Obesity = OR = 0.96 95%CI 0.66;1.37 Adjusted Analysis: Adjusted (age and sex) Underweight = OR = 0.35 95%CI 0.12;1.01 Overweight = OR = 0.86 95%CI 0.61;1.21 Obesity = OR = 0.96 95%CI 0.66;1.38 No statistical association	12/12 Good scientific evidence
Gerdin et al ¹⁵ English	2008	Sweden (Ostergotland)	4 to 7; 10 and 12	6 and 12 years old = 2303 10 years old = 4305 (when caries was measured)	Prospective cohort	BMI (weight/height ²) Normal = BMI < 25 Overweight = BMI > 25 Obesity = BMI > 30	Decayed teeth and filled - (10 years) Decayed teeth and filled proximal surfaces - (12 years)	BMI as a continuous variable at age 4 and caries at age 12 adjusted for socioeconomic status and sex = 0.048 (p = 0.021) BMI at age 5 and caries at age 12 adjusted for socioeconomic status and sex = 0.007 (p = 0.050) BMI at age 5 and caries at age 12 adjusted for socioeconomic status and sex = 0.032 (p = 0.017) BMI at age 5 and caries at age 12 adjusted for socioeconomic status and sex = 0.024 (p = 0.010) BMI had independent effect, though weakened by decay at age 12. Positive statistical association	12/10 Good scientific evidence

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Cinar & Murtomaa ¹⁰ English	2008	Finland (Helsinki) and Turkey (Kadikoy)	10 to 12	338 Finland 611 Turkey	Cross-sectional	BMI (self-reported by mothers) Normal = between the percentile (5-85) Risk of obesity = between the (85-95 percentile) Obesity = Above the 95 th percentile.	DMFT	There was no association between BMI and caries both in crude and adjusted analysis for the time watching TV per day; regularly having lunch with the family, consumption of fruits or snacks between meals, consumption of "fast food" and drinks a week and if practicing physical activity in leisure time. No statistical association	9/6
Narksawat et al ²⁹ English	2008	Taiwand – (5 provinces)	12 to 14	862	Cross-sectional	BMI (weight/height ²) Underweight normal overweight obesity	DMFT	Adjusted analysis Reference = group of overweight and obesity Normal OR = 1.94 95%CI 1.25;3.00 Underweight OR = 2.22 95%CI 1.27; 4.09 The analysis was adjusted for frequency of brushing, flossing, using toothpaste with fluoride, consumption of snack more than three times a day, visiting the dentist more than twice a year, receiving oral health education, area of residence (urban/rural), age and sex. Negative statistical association	11/9
Kopycha – kedzierawski et al ²² English	2008	United States (NHANES and NHANES III)	2-18 years old	10180 of NHANES III 7568 of NHANES	Cross-sectional	Body Mass Index- BMI (weight/height ²) Normal = BMI for age <85 th percentile. Overweight = BMI percentile 85-95 Obesity = BMI ≥ 95	Deciduous dentition DFS - decayed and filled surfaces Permanent dentition- DMFS	No differences were observed between BMI and COs and CPOs adjusted for sex, race, geographic region, economic status, education of household head, the time of last visit to the dentist and lead levels No statistical association	13/11 Good scientific evidence
Marschall et al ²⁴ English	2007	United States (Iowa)	4,5 to 6,9	427	Cross-sectional of one cohort	BMI (weight/height ²) Parents and children Normal = BMI <25 Overweight = BMI (25-29.9) Obesity = BMI ≥ 30	Decayed or filled surface	The analysis was adjusted for fluoride intake, maternal education, risk of obesity and soft drinks consumption. Regression analysis found maternal education and the risk of obesity to influence children having twice the risk of caries compared with those with normal weight or overweight. Positive statistical association	12/11 Good scientific evidence

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Pinto et al ³³ English	2007	United States (Pennsylvania)	Mean 8,7	142	Cross-sectional	Permanent Decayed surfaces and deciduous carious surfaces	No association between BMI and caries in the crude and adjusted analysis for age, sex and ethnicity. No statistical association	10/7
Willerhausen et al ⁴¹ English	2007	Germany (Johannes Gutenberg)	6 to 10	2.071	Cross-sectional	Decayed and filled permanent teeth Decayed and filled deciduous teeth	There is a significant increase in the average of decayed/filled teeth from the normal weight to the obesity category after adjusting for age of the child. (p = 0.0021) Positive statistical association	9/8
Willerhausen et al ⁴⁰ English	2007	Germany (Johannes Gutenberg)	6 to 11	1.298	Cross-sectional	Decayed and filled permanent teeth Decayed and filled deciduous teeth	An association was observed between BMI and caries in both deciduous and permanent dentition. This association remained after adjusting for age. Positive statistical association	11/8
Macek & Mitola ²³ English	2006	United States (NHANES)	2 to 17	2 to 5 = 1.719 6 to 17 = 5.889	Cross-sectional (survey)	Decayed and filled deciduous teeth DMFT	There was no association between BMI and caries in the deciduous and permanent dentition in the regression analysis both crude and adjusted for age, sex, race and socioeconomic status Deciduous dentition Group of reference = normal weight Underweight RO = 0.6 95%CI 0.3;1.3 Overweight RO = 1.0 95%CI 0.5;1.7) Obesity = OR = 0.8 95% CI (0.5-1.3) Permanent Dentition Reference = normal weight Underweight = RO = 0.9 95% CI (0.5-1.7) Overweight = RO = 1.1 95%CI 0.9;1.3 Obesity RO = 1.0 95%CI 0.8;1.4 However, it was observed that participants aged between 6-17 years old and overweight had fewer caries than those with normal weight No statistical association	13/10 Good scientific evidence

BMI: Body Mass Index; DMFT: decayed, missing and filled teeth; DMFS: decayed, missing and filled surfaces

most of the population's needs. The lack of association in studies conducted in Latin America probably addresses socioeconomic and dietary conditions, different factors in countries of these two continents. Dietary habits and income²⁰ are considered important factors for both dental caries and obesity. Dietary habits related to obesity and low incomes may provide a higher quantity and frequency of sucrose intake, which are important factors in caries etiology.³⁵ Higher fat intake and decreased fiber may be associated with increased prevalence of caries and overweight/obesity among individuals with lower socioeconomic conditions.³ However, other authors reported that excessive consumption of fatty foods has less influence on the development of caries than diets rich in sugar, which could be somewhat responsible for the lack of association between obesity and the presence of caries observed in some studies.³⁹

This review presents some limitations. A small number of studies (five) analyzed longitudinal data. When considering only those studies with good scientific evidence according to the criteria of Downs & Black¹³ (1998), four used longitudinal data. The use of longitudinal data including information on various points of time is important because obesity in early life often leads individuals to change their habits to reduce body weight, resulting in a change in BMI scores. However, the scores for caries by means of DMF can remain high because this index considers caries throughout the individuals' lives.³⁹ Moreover, children identified by parents as obese may be guided to restrict their sugar intake; however, if there is still a high consumption of fats and if their caloric intake is greater than expenditure, they will become overweight.³⁶

The second limitation is the lack of adjustment in several studies for variables such as diet and socioeconomics. These two factors have been cited as associated with both diseases, and they should be considered in studies that aim to explain the relationship between obesity and dental caries. However, of the 28 articles examined, five had some kind of adjustment for diet, and four adjusted for socioeconomic issues.

A third limitation involves using the Downs & Black instrument¹³ (1998) to evaluate the quality of scientific evidence from the studies. This instrument was originally developed to evaluate intervention studies, but it has been used for studies with other designs, excluding some of their items.^{26,30,31} Despite this limitation, it was considered useful for the present review because of its ideas about article quality.

It was not possible to perform a meta-analysis. First, due to the heterogeneity of the studies, particularly the methods used to obtain exposure – obesity of this review, and according to non-submission of primary data by most authors of the articles considered as good scientific evidence. A meta-analysis would help clarify the relationship between obesity and dental caries.

This review identified six studies with good scientific evidence, which observed a positive association between obesity and dental caries in children and adolescents, in contrast to what was described in the review by Kantovitz & Pascon; Rontani & Gavião²¹ (2006). They noted three studies with good scientific evidence, and of these one with positive association in children. Although this review found six studies with a positive association between obesity and dental caries, the causal mechanism remains unclear. It is unknown if the associations actually occurred because there is a direct relationship between obesity and dental caries or if diet, a factor common to both diseases, is responsible for this association. None of the studies was designed to consider all the possible effect modifiers (access to health services, use of fluorides, and oral health habits) and confusion factors (diet and income) from the literature. These results were similar to the recent systematic review and meta-analysis,¹⁷ although the present study had included articles from the literature published between 2011 and 2012. Thus, the studies identified in the literature provide clues about this relationship and indicate the need for new and more clearly delineated studies.

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