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Review Article

The Association of Body Mass Index with Malocclusion in Children - A Systematic Review & Meta-Analysis

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Abstract

Introduction: The relationship between Body Mass Index (BMI) and dental malocclusion remains uncertain. This systematic review aims to assess the link between BMI and malocclusion in children and adolescents.

Sources of Data and Study Selection: Through electronic and manual searches up to August 2021, 1002 records were found, with 610 screened after removing duplicates. Eight studies were included in qualitative synthesis, and four in quantitative analysis. Malocclusion types, including crossbite, spacing, and crowding, were key review outcomes. The NIH quality assessment tool was used for bias assessment. This review encompassed eight studies involving 4128 children. Pooled analysis demonstrated significantly larger spacing in normal BMI children compared to those with low BMI. No significant difference was found in crossbite prevalence [1.33 (0.42, 4.25), p=0.63, I2=0%, p=0.85]. A quality assessment revealed four good-quality studies and the rest with poor/fair quality.

Conclusion: The impact of BMI on childhood malocclusion remains debated. Current research lacks consistent evidence linking BMI to malocclusion. To progress, future studies need standardized classifications and robust evaluation of confounding factors. This approach will strengthen understanding and guide effective interventions.

Clinical Significance: Despite extensive research, the association between Body Mass Index (BMI) and dental malocclusion remains unclear, highlighting the complexity of this relationship. This systematic review suggests that normal BMI children tend to exhibit larger spacing between teeth compared to those with low BMI. Understanding such associations can aid in early detection and intervention strategies for malocclusion in children and adolescents.

Keywords: Dental Malocclusion; Body Mass Index (BMI); Children; Adolescents; Malnutrition; Systematic review; Meta-analysis; Crowding; etc

Introduction

Malocclusion is one of the most common oral health problems that affects both adolescents and children. Any type of misalignment in the jaw arches or any anomalies related to tooth position is known as Malocclusion [1]. Malocclusion affect the overall personality and may lead to psychological distress in children [2,3]. In 1987, The World Health Organization (WHO) had included malocclusion under the group of "Handicapping Dentofacial anomalies [4]. Several factors such as nutritional status, extraoral habits, mastication forces, habitual mouth breathing, non-nutritive sucking, and premature loss of primary teeth have been associated with the development of malocclusion [1,4-6]. Among these factors, the nutritional status of children majorly affects the growth pattern of the facial bones including jawbones. Although health consequences related to change in nutritional status of children are very well documented but its effect on the oral health of children has recently gained attention [7-12]. Body Mass Index (BMI) can be used as a parameter to assess the nutritional condition of children by classifying as underweight (Low BMI), healthy (normal BMI) or overweight (High BMI). In children and adolescents, BMI can be calculated by using Z scores or percentiles [13,14]. Many researchers had described that correlation of BMI with dental and skeletal development [15,16]. Literature suggested that hormonal changes cause precocious pubertal development i.e. high BMI correlates with an early onset in menarche which can further lead to changes in bone metabolism and tooth movement. Additionally, it was found that children with increased BMI have increased bone density and size as well as accelerated dental and skeletal maturation [17]. It was also described by authors that children with high BMI requires earlier orthodontic consultations, along 4 with potential alterations of serial extraction timing, space maintenance and growth modification [18,19]. Additionally, any alteration in the morphometry of maxillary or mandibular bone can lead to a change in the spacing between the dentition which is known as interdental spacing. Similarly, Lack of this interdental spacing due to impaired jaw growth in children with low BMI can also cause crowding and crossbite in the dentition as the total space required for the teeth eruption gets decreased resulting in the upper teeth fitting inside the

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lower teeth [20]. This process can also cause dental malocclusion due to the eruption of teeth at the incorrect place in the oral cavity.

Several other studies also commented on factors associated with impaired jaw or facial bones growth and their relation with BMI of the children by considering various parameters of malocclusion such as crowding (anterior & posterior, cross bite, interdental spacing etc [21-23]. But still, there is no conclusive evidence can be generated regarding the association of BMI with the development of malocclusion in children. That's why the present review was planned to assess the association between BMI and malocclusion among children & adolescents and underlines the need of implementing prevention program about malocclusion correlated to nutrition.

Sources of Data and Study Selection

PRISMA (Preferred Reporting of Systematic Reviews) guidelines were followed for this systematic review. The protocol was registered in PROSPERO (CRD42021284733).

Inclusion Criteria

This systematic review and meta-analysis include only cohort and cross-sectional studies. Studies were included as per PECO frame work is given below: P (Population), I (Intervention), C (Comparison), O (Outcome)

P Children aged 1 to 18 years

E Children with high and low Body Mass Index (BMI)

C Children who are categorized as having 'normal' BMI.

O Malocclusion, deep bite, overbite, overjet, cross bite, crowding, spacing in primary, mixed & permanent dentition among children & Adolescents

Search Strategy for the Identification of Studies

Search terms used were "(Maloccusion) OR (deep bite) OR (overbite) OR (overjet) OR (crowding) OR (spacing) AND (Pediatric Obesity) OR (Obesity) OR (Body Mass Index) OR (body weight) OR (overweight) OR (Low BMI) OR (High BMI) OR (Malnutrition) OR (bmi)". The databases searched were PubMed, Ovid, Embase, EBSCO CINAHL upto September 2021. Grey literature was also checked for additional studies. Only English literature was included in the study. There was no restriction of sample size. All identified titles/abstracts from all the databases were then screened as per the inclusion criteria set for the systematic review. Duplicates were removed after screening of titles/abstracts of the identified papers. Two independent reviewers independently reviewed the full text of selected titles/abstracts. Joint consensus was made by two reviewers for inclusion or exclusion of disputed papers. A pilot-tested data extraction form was formed by the research team for data extraction.

Data Extraction and Data Synthesis

A comprehensive data extraction process was undertaken and the results were synthesized into a structured table (Table 1). This table included key demographic information about study participants, study design, sample size, and outcome particulars. To ensure accuracy, two separate researchers conducted the data extraction independently, resolving any discrepancies through collaborative discussion. Additionally, the authors of the studies included were contacted via email to obtain complete outcome details, enhancing the comprehensiveness of the analysis.Data analysis was carried out utilizing RevMan version 5.4 software [24]. Quality assessment of the included studies was performed using the assessment tool developed by the National Institutes of Health (NIH), consisting of criteria related to study design, participant selection, data collection, exposure and outcome assessment, statistical analysis, and other critical aspects of conducting observational studies. Two independent authors assigned a quality grade of "good," "fair," or "poor" to each study, and in cases of disagreements, resolutions were reached through discussion. Statistical heterogeneity was evaluated using the I2 statistic. Studies presenting dichotomous data were subjected to analysis using the Mantel-Haenszel (M-H) model, with Risk Ratio (RR) and a 95% Confidence Interval (CI) employed to quantify outcomes. Throughout the review, a random-effects model was consistently utilized for analysis, taking into account potential variations between studies [25]. In this specific systematic review, the GRADE approach was not utilized due to the limited extent of meta-analysis conducted.

Results

PRISMA Flow Diagram is shown in Figure 1. 1002 potential studies were retrieved by initial search. 610 studies remained after duplicates removal and 580 studies which didn't match the inclusion criteria were excluded. Of the remaining 30 papers, 22 non-relevant full texts were excluded (Figure 1). Total, eight studies were finally included in the systematic review.

Study Characteristics

The details of the eight included studies along with their study characteristics are shown in table 1. Two studies from India [26,27], Each one from Brazil [28], Bangladesh [29], Baghdad [30], Japan [20], Indonesia [8], and Saudi Arabia [31]. Out of eight studies, seven were cross sectional and one was cohort in design. The ages of participants were up to 18 years with a total of 4128 participants.

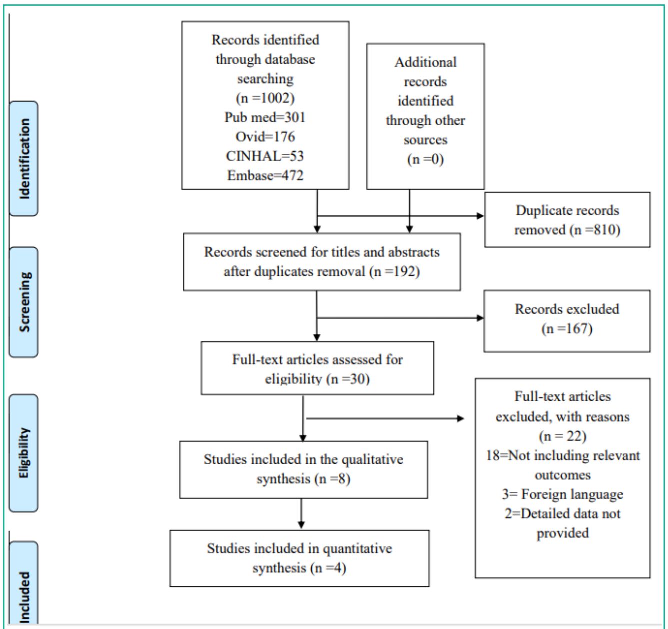

Figure 1: PRISMA flow diagram showing the study selection process.

Table 1: Study characteristics and quality assessment of included studies.

S. No	Author/ Year/ Country	Study design	Study Population	Study Setting	BMI cut-off criteria	Findings	Overall Quality
1.	Thomaz et al., 2010, Brazil [28]	Cross-sectional study	N=1915;12-15 yrs	School Based	WHO criteria	BMI/T Low/159 Normal / 1491 High /265 p Crowding (OR) 86(1.28) 711(1.00) 110 (0.66) >0.05	Good
2.	Khan et al., 2014, Dhaka, Bangladesh [29]	Cross-sectional study	N= 627; 7-15 yrs (276 male, 349 female)	School Based	Not mentioned	BMI/T Low/52 Normal/263 High/75 p Malocclusion (OR) 28 (1.28) 237(0.66) 36(1.00) >0.05	Good
3.	Al-Refeidi et al., 2016, Saudi Arabia [31]	Cross-sectional study	N= 200; < 6 yrs	School Based	Low weight ≤ 5 Percentile Normal= 5 percentile to less than 85 percentiles Overweight= 85 to less than 95 percentiles Obese >95 percentile	BMI/T Low/27 Normal/151 High/22 p Spacing 5 99 7 >0.05 Crowding 3 5 0 >0.05	Fair
4.	Jasim et al., 2016, Baghdad [30]	Cross-sectional study	N= 600, 9-11 yrs (312 males, 288 females)	School Based	Low weight ≤ 5 Percentile Normal= 5 percentile to less than 85 percentiles Overweight= 85 to less than 95 percentiles Obese > 95 percentile	BMI /T Low/14 Normal/348 High/238 p Anterior cross bite 0 34 14 >0.05 Posterior cross bite 2 36 26 >0.05 Crowding 4 206 180 <0.05	Good
5.	Kaushal et al., 2017, Udaipur, Rajasthan [26]	Cross-sectional study	N=120; 6-12 yrs	Hospital Based	Not mentioned	BMI /T Low/118 Normal/2 p Crowding 48 1 0.79 Spacing 36 1 0.55 Crossbite 18 0 0.56	Poor
6.	Toyama et al., 2019; Japan [20]	Cohort	N=238; 18 yrs	Hospital Based	Low BMI <18.5 Normal BMI=18.5 to less than 25 High BMI= Greater than or equal to 25	BMI/T Low/41 Normal/180 High/17 p Malocclusion (OR) 29(2.34) 89 (1.00) 10 (1.41) <0.05 Crowding (OR) 26 (2.52) 71 (1.00) 9 (1.67) <0.05	Good
7.	Sembiring LS et al., 2020, Bandung, Indonesia [8]	Cross-sectional study	N= 208; 9–12 yrs (90 boys & 118 girls)	School Based	Not Mentioned	BMI/T Low/156 Normal/50 High/2 p Anterior crowding4.7±1.965 3.82±0.983 3.5±2.1 <0.05	Poor
8.	Anand et al., 2021 Bihar, India [27]	Cross sectional study	N= 220; 12-15 yrs (136 female & 84 male)	Hospital Based	Low BMI <18.5	<18.5 BMI Angle's Class I malocclusion with crowding 98(44.54%) Angle's Class I malocclusion with spacing 18 (8.1%) Angle's Class II division 1 malocclusion 52 (23.63%) Angle's Class II division 2 malocclusion 38 (17.27 %) Angle's Class III malocclusion 14 (6.3%) P<0.05	Poor

OR: Odd Ratio, BMI: Body Mass Index, T: Total no. of participants

Qualitative Synthesis

Malocclusion was assessed in the form of cross bite, spacing, deep bite, crowding, Angle's classification of malocclusion. Thomaz et al. examined crowding and malocclusion in Brazilian children, while Khan et al. conducted similar assessments in Bangladeshi children [23,29]. Al-Refeidi et al., Jasim et al., and Kaushal et al. explored spacing, crowding, and crossbite through cross-sectional studies [30-32]. Toyama et al. conducted a prospective cohort study in Japanese children to investigate the association between malocclusion and crowding with BMI [20]. More recently, two studies highlighted correlations between BMI and crowding and malocclusion in Indonesian and Indian children respectively [8,27]. Within the eight included studies, only two studies were found to have a positive correlation between BMI & malocclusion [20,27] and one studies clearly showed no association between malocclusion & BMI [29]. Crowding was found to be associated with BMI in four studies [8,20,27,30], while no association was seen in spacing, crossbite and crowding and BMI in other studies [26,28,31]. Out of 8 included studies, only three studies were assessed to have a good overall quality [20,23,29]. Rest all the studies showed a fair or poor quality due to high risk of bias in one or more than one domain (Table 1) [26,27,30,31].

Qualitative Synthesis

For the outcome of crossbite, there was no difference in low/ high BMI and normal BMI group. This was based on pooling of two studies with 720 participants [26,30]. The RR was 1.33 (0.42, 4.25), p=0.63, I^2=0%, p=0.85 (Figure 2a). For the outcome of spacing, data from two studies was pooled with 153 participants with normal BMI and 145 participants having low BMI. The children with normal BMI are having normal spacing in dentition while spacing is found to be lesser in low BMI group [26,31] (Figure 2b). For the outcome of crowding, pooled analysis of four studies showed non-significant risk of developing crowding in low BMI group [26,28,30,31] with moderate heterogeneity was reported in the results (Figure 2c). Probable reasons for such heterogeneity could be due to differences

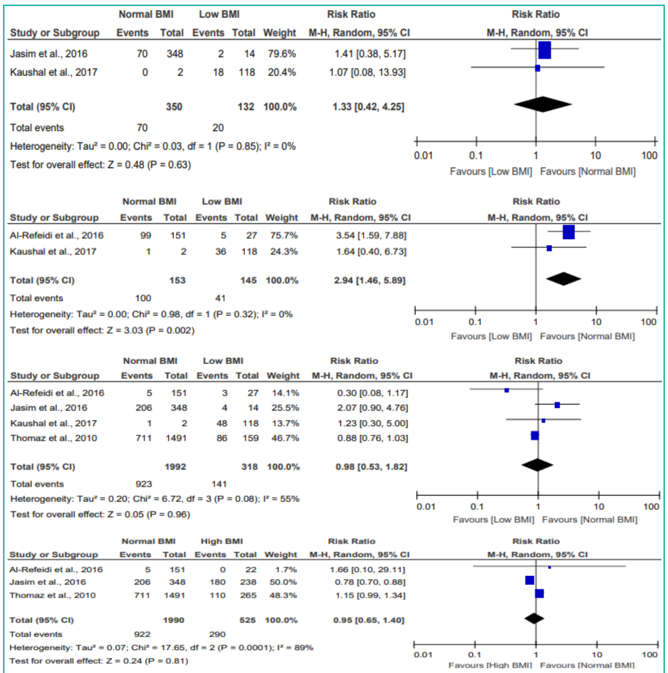

Figure 2: (a) Association of crossbite with low BMI **(b)** Association of spacing with low BMI **(c)** Association of crowding with low BMI **(d)** Association of crowding with high BMI.

in the characteristics of sample (e.g. age, country etc.) methodological differences involving different method of sample collection, different study settings, different diagnostic or classification criteria used for malocclusion, differences in the statistical analysis methods, different outcomes and last but not the least differences in the risk of bias among the included studies. Result of pooled analysis of three studies demonstrated the risk of development of crowding in high BMI group as compared to normal BMI group [26,28,31] but the results showed non-significant association with substantial heterogeneity (Figure 2d).

Discussion

The present systematic review and meta-analysis was conducted to summarize the association between BMI and development of malocclusion among children and adolescents. Dental malocclusion is an oral health problem of high importance that needs to be addressed on time for a proper intervention to be given. Previously conducted studies by many researchers have not provided any correlation and consistent evidence regarding association between malocclusion and BMI which can affects the growth of craniofacial bones leading to inadequate space for teeth to erupt, resulting in crowding and dental malocclusion [6,20,30,33]. There is also no existing systematic review and meta –analysis available till date, that can give any evidence whether any fluctuation in BMI can lead to malocclusion or not in children and adolescents' population [26,31]. This highlights the need for such a review to be conducted.

Out of 8 studies included in the present review, seven studies were of cross-sectional in design except one which was of cohort in nature [20]. Out of 8 included studies, only two studies Toyama et al. & Anand et al. had reported statistically significant results regarding the association of BMI and malocclusion [20,27]. These results are consistent with the results of the studies conducted by Sembiring et al. but overall quality of that study was reported as poor due to lack of sample size justification and intra examiner reliability accessibility [8]. The association between BMI and dental malocclusion was contraindicated by the observations reported in a previous study done by Khan et al. among Bangladeshi children [29]. No correlation was noticed between both the variables.

Pooled analysis regarding association of crossbite & spacing with low BMI was found to be non-significant when compared with normal BMI group [26,30,31]. The children having normal BMI showed an ample amount of spacing in dentition as compared to experimental group i.e. low BMI group. This normal inter dental spacing will prevent any kind of disruption in the path of normal eruption of teeth which in results can increase the chances of having normal occlusion of teeth. The study conducted by Toyama et al. provides a clear significant association of crowding and malocclusion with low or high BMI in children [20]. But this study couldn't be included in the meta-analysis because of having a different study design. Recently, Anand et al. observed in their study that children having BMI less than 18.5 were showing a higher rate of development of dental malocclusion [27]. More than 50% of the study participants were showing spacing and crowding in their study [27]. High BMI was also showed no association with crowding while comparing with normal BMI group but the heterogeneity was reported 89% which is very high clinical heterogeneity. Reason could be due to different cut off criteria used for classification of BMI.

As literature suggested, malocclusion is a multifactorial condition and thus a direct relationship between malocclusion and BMI is complex. Their association is well documented in the previous studies as an abnormal facial development is significantly affected by low BMI [4,34-36]. Present systematic review has recognized a few factors those needs to be addressed while looking at association between BMI and malocclusion because these variables may likewise represent the heterogeneity of results between previous studies. A difference in techniques of assessment of malocclusion and its analysis is quite possibly the main reason for such a high heterogeneity. Additionally, previous studies showed different cut off criteria for BMI classification in studies which might have presented variations in the effect size and may lead to considerable heterogeneity. In future studies, this point needs to be addressed by using standardized criteria for classification of BMI as well as a definitive diagnostic parameter for measurement of malocclusion.

Although as per the results of this meta-analysis, low as well as high BMI was not found to be associated with development of malocclusion but still onset of obesity is one factor that is needed to be taken into consideration in the included studies to correlate with the other causal factor instead like crowding, spacing, crossbite etc. It is not clear how increased adiposity will influence the overall growth of jaw or eruption of teeth. Thus, it is very important to understand that a number confounding factor such as genetic inheritance, genetic mutations, age, gender, ethnicity, dental anomalies like macrodontia, congenital diseases, muscular diseases, hormone imbalance, and human behavior which can influence the development of dental malocclusion and these factors should be considered beforehand. Dentists and orthodontists regularly encounter patients with malocclusion, and obesity is a prevalent health condition. If a clear link between BMI and malocclusion were established, it could help dental professionals consider obesity as a potential risk factor while planning treatments and providing preventive care. The findings of this study can be used to educate both healthcare professionals and the general public about the potential relationship between BMI and malocclusion. It emphasizes the importance of a healthy lifestyle and its potential impact on dental health.

Limitations

Presence of methodological heterogeneity as well differences in study design leads to less numbers of studies available for quantitative synthesis. Present review consists of observational studies and these type of studies lies low in the hierarchy pyramid of evidence due to that a conclusive comment on evidence of this relationship is very difficult to make. Only the published English literature was included in the present study thus there might be a probability of having a high publication bias.

Conclusion

The influence of BMI on malocclusion in children remains debatable. The present study concluded that there is no consistent evidence regarding association of BMI and malocclusion. For future, well designed studies with standardized classification for malocclusion and weight status are needed for better comparison. To strengthen the existing body of literature and to draw more accurate conclusion, impact of confounding factors & effect modifiers should be thoroughly evaluated in further studies.

Author Statements

Conflict of Interest Statement

The authors declare that there is no conflict of interests.

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Author Contributions

Conceived and designed the study: Kusum Singal, Vivek Singh Malik

Literature search and data analysis: Kusum Singal, Pranita Pradhan, Vivek Singh Malik

Data interpretation and manuscript drafting: Kusum Singal, Meenu Singh, Manvi Singh, Meenakshi Sachdeva

The final manuscript was critically reviewed, revised, and approved by all the authors.

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