ORIGINAL RESEARCH

# Evaluation of Relationship between Body Mass Index (BMI) and Dental Development in the Children in Age-group of 6–13 Years of Malwa Region: A Cross-sectional Study

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## Abstract

**Aim:** To evaluate the relationship between body mass index (BMI) and dental development in the children in age-group of 6–13 years of Malwa region.

**Materials and methods:** A total of 250 orthopantomograms (OPGs) of children aged 6–13 years (130 males and 120 females) collected from the Department of Paediatric and Preventive Dentistry, Government College of Dentistry, Indore, Madhya Pradesh, India, who came for their routine dental treatment. The chronological age, height, and weight were recorded, followed by calculating the BMI of each patient using Centers for Disease Control and Prevention (CDC) growth charts. The dental age was calculated using Cameriere's method. The comparison of the dental and chronological age was done using Wilcoxon signed-rank test.

**Results:** The dental age of underweight patients was significantly lesser than that of the normal, overweight, and obese patients (*p*-value of <0.05). The dental age of the obese patients were greatest and significantly greater than that of the underweight, normal, and overweight patients (*p*-value of <0.05).

**Conclusion:** Dental age is significantly associated with the BMI of children aged 6–13 years. The dental age of obese and overweight children is significantly greater than the chronological age.

**Clinical significance:** Predicting the stage of dental development and eruption periods in children with mixed dentition can help with the sequencing and timing of orthodontic, prosthodontic, and surgical procedures.

**Keywords:** Body mass index, Centers for Disease Control and Prevention growth charts, Indian Cameriere's formula, Obesity.

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## Introduction

In pediatric dentistry, it's crucial to consider dental age and dental development due to continuous growth in children, which plays a major part in diagnosis and treatment planning, especially for myofunctional appliances. With the changes in the dietary habits and lifestyle of newer generations over the past decades, obesity has become more prevalent. Obesity leads to several diseases, such as diabetes, cardiovascular disease, hypertension, and obstructive sleep apnea. On children's health, nutrition has a great impact. Considering India, as a developing country, is severely afflicted by malnutrition and underweight. The risk of illness and mortality is of great concern in underweight children, but being overweight can also adversely affect the development of the child. Close monitoring of manifestations in underweight children is important because of increased health importance.[1]

For the majority of children and adolescents, overweight and obesity can be reliably predicted using the BMI. BMI is specific for certain ages, and it is dependent on age and gender in children and adolescents. For determining a child's dental age, a variety of approaches is available, including tooth emergence and tooth development stages. Probably the most popular method for determining a child's dental age is the dental maturity scale system developed by Demirjian et al. Rather than the length of tooth roots, the Demirjian rating method places special emphasis on the shape of teeth and root closure. Willems developed and verified an adapted method that produced more accurate dental age estimates; however, it may not be applicable to all ethnicities. Cameriere et al. discovered a link between sex and the number of teeth having an apex that is completely closed and chronological age.[2–5]

This study aimed to assess the relationship between dental development in children and their higher BMI.

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## Materials and Methods

This observational study was carried out *in vitro* to assess the relationship between dental development and BMI in age group of 6–13 years in children of Malwa region. A total sample of 250 OPGs (130 males and 120 females) was collected from the Department of Pediatric and Preventive Dentistry, Government College of Dentistry, Indore, Madhya Pradesh, India who came for their routine dental treatment. Following formula has been used for calculating sample size[6]:

$N = [(Z_\alpha + Z_\beta)/C]^2 + 3 = 123$

Where,

r = 0.25 (based on pilot study)

$\alpha = 0.05$

$\beta = 0.20$

The standard normal deviate for $\alpha = Z_\alpha = 1.9600$

The standard normal deviate for $\beta = Z_\beta = 0.8416$

$C = 0.5 \times \ln [(1 + r)/(1 - r)] = 0.2554$

Thus, 123 samples were the bare minimum needed for the study, but it was suggested that the study use 250 samples.

The Institutional Review Board of the Government College of Dentistry, Indore, Madhya Pradesh, India, examined and approved the study.

Chronological age, weight and height were recorded for each patient. BMI was calculated using the following equation:

$\text{BMI} = \text{Weight in kg}/(\text{height in cm})^2 \times 10{,}000$

Centers for Disease Control and Prevention (CDC) pediatric growth charts are used to determine the BMI percentile for each child.[7]

Within the 85th percentile—normal (healthy) weight

Between the 85th and 95th percentile—overweight

Lower than 5th percentile—underweight

Higher than 95th percentile—obese

Panoramic radiographs were reviewed, and widths of the apices of the mandibular permanent teeth were calculated and used to estimate the dental age of the subjects using the following Cameriere's formula. Seven permanent mandibular left teeth were evaluated.[8]

$\text{Age} = 9.402 - 0.879\,C + 0.663\,N_o - 0.711\,s - 0.106\,s\,N_o$

Here, $N_0$ is the number of teeth with completely developed roots and with closed apex, S is the total number of open apices, X is the A/L ratio (X1 … 7) for each tooth with an open apex, the distance between the inner surfaces of a tooth with an open apex is measured radiographically as Ai, radiographic tooth length is denoted as Li, dummy variable C is set to 0 for central or northern India and 1 for the southern region. The sum of the distances between the inner surfaces of the two open apices for teeth with two roots (Ai, I = 6, 7) will be noted. The same observer conducted each measurement. In accordance with the BMI categories, the sample was split into four groups (underweight, normal weight, overweight, and obese) and by age for assessment of the relationship between these two parameters.

Data analysis was done using Statistical Package for the Social Sciences 21.0. Man–Whitney *U* test and Kruskal–Wallis test were used for the intergroup comparison, and then *post hoc* analysis. The comparison of the dental and chronological age was done using Wilcoxon signed-rank test. To examine the link between the continuous variables, Spearman's correlation coefficient was used, and the Chi-squared test was used to determine whether the categorical variables were associated. A *p*-value of <0.05 was regarded as statistically significant.

## Results

Body mass index (BMI) and dental age were shown to be significantly correlated. The median chronological age of obese participants was maximum [10.05 (9.375–11.525) years], whereas it was minimum amongst underweight participants [9.15 (8.175–11.1) years]. The median chronological age of participants belonging to different BMI grade did not differ significantly (*p*-value >.05). The median dental age of the study participants differed significantly amongst participants belonging to different BMI grade (*p*-value of <0.05) (Table 1) (Figs 1 and 2).

The dental age of underweight patients was significantly lower than that of normal, overweight, and obese patients (*p*-value of <0.05) according to a pairwise comparison utilizing *post hoc* analysis. In comparison to underweight, normal weight, and overweight individuals, the dental age of the obese patients was highest and significantly higher (*p*-value of <0.05). The dental age of the normal and overweight patients did not differ significantly (*p*-value of >0.05) (Table 2).

Amongst the underweight and normal patients, the dental age was substantially lower than the chronological age (*p*-value of <0.05). Amongst overweight and obese patients, the dental age was significantly greater than the chronological age (*p*-value of <0.05).

Maximum participants were having normal BMI (49.6%) and 26.4% of participants were underweight. Only 14.0% participants were obese, and 10.0% were overweight (Table 3) (Fig. 3).

The median height of males [127.25 (119.0–137.0) cm] was greater than the height of females [126.0 (120.0–139.0) cm]. However, the weight of females [26.50 (21.175–32.00) kg] was greater than that of males [25.95 (21.4–32.025) kg]. Thus, the median BMI of the males [16.8 (14.175–19.8750) kg/m$^2$ ] was greater than that of the females [15.9 (13.9–18.175) kg/m$^2$ ] (Table 4).

The BMI was found to have a significant association with gender (*p*-value < 0.05). The proportion of obese individuals was significantly greater amongst males (*p*-value < 0.05) (Table 5) (Fig. 4).

**Table 1:** Comparison of chronological age and dental age amongst study participants belonging to different BMI grade

| | | *Median* | *Interquartile range* | *Chi-square value* | *p-value*[a] |
|---|---|---|---|---|---|
| Chronological age | Underweight (*n* = 66) | 9.15 | 8.175–11.725 | 3.911 | >0.05 |
| | Normal (*n* = 125) | 9.4 | 8.0–11.15 | | |
| | Overweight (*n* = 25) | 9.8 | 8.35–11.1 | | |
| | Obese (*n* = 34) | 10.05 | 9.375–11.525 | | |
| Dental age | Underweight (*n* = 66) | 8.2 | 7.2–10.0250 | 52.495 | <0.001* |
| | Normal (*n* = 125) | 9.2 | 8.1–10.9 | | |
| | Overweight (*n* =25) | 10.5 | 8.95–11.65 | | |
| | Obese (*n* = 34) | 11.75 | 10.875–13.2 | | |

[a]Kruskal–Wallis test; **p*-value < 0.05 was considered statistically significant

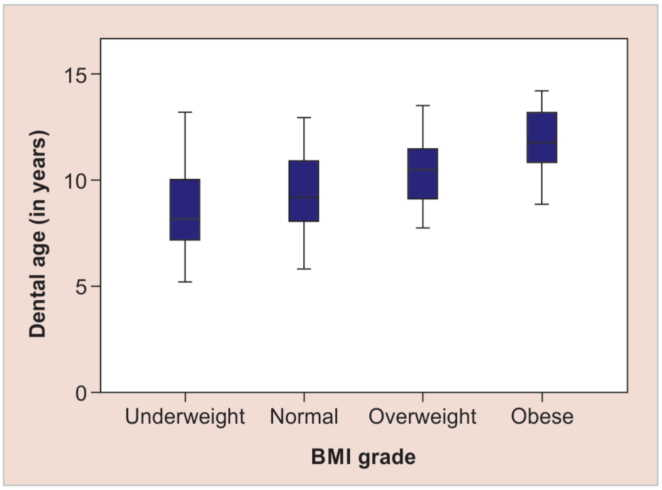


**Fig. 1:** Comparison of dental age amongst study participants belonging to different BMI grade

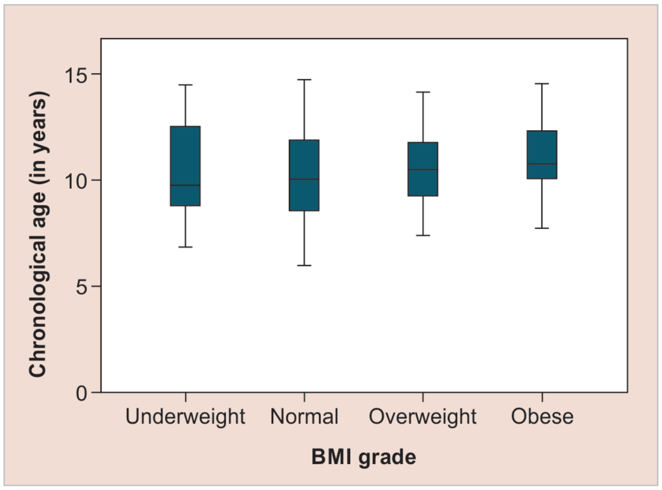


**Fig. 2:** Comparison of chronological age amongst study participants belonging to different BMI grade

**Table 2:** *Post hoc* analysis (dental age)

| *Pairwise* | *p-value* |
|---|---|
| Underweight vs normal | <0.05* |
| Underweight vs overweight | <0.001* |
| Underweight vs obese | <0.001* |
| Normal vs overweight | >0.05 |
| Normal vs obese | <0.001* |
| Overweight vs obese | <0.05* |

**p*-value < 0.05 was considered statistically significant

**Table 3:** Distribution of study participants based on BMI grade

| *BMI grade* | *Number* | *Percentage* |
|---|---|---|
| Underweight | 66 | 26.4 |
| Normal | 124 | 49.6 |
| Overweight | 25 | 10.0 |
| Obese | 35 | 14.0 |
| Total | 250 | 100.0 |

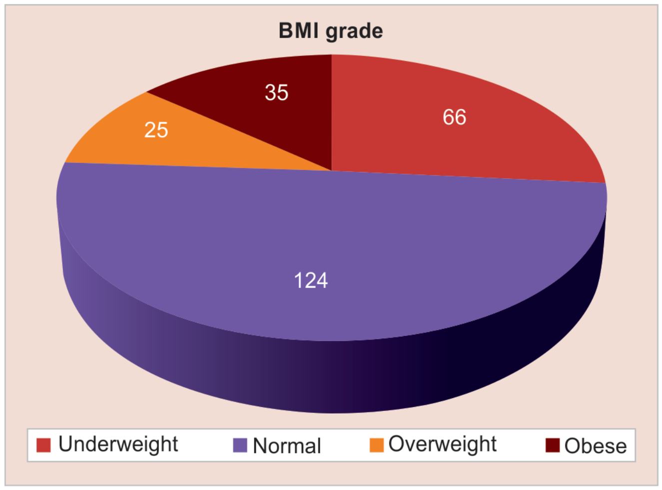


**Fig. 3:** Distribution of study participants based on BMI grade

## Discussion

As the prevalence of obesity rises, dentists must learn more about how obesity and a higher BMI affect oral health and craniofacial development. Predicting the stage of dental development and eruption periods in children with mixed dentition can help with the sequencing and timing of orthodontic, prosthodontic, and surgical procedures. Because orthodontic treatment is initiated based on dental age rather than chronological age, it is critical to forecast dental age and investigate the factors that may influence it.

Our data showed a statistically significant association between dental developments in different BMI categories. In the population of the Malwa region, the maximum number of participants (49.6%) was having normal BMI, and 26.4% of participants were underweight. Obese patients were more dentally advanced as compared to normal or underweight patients. Children who are underweight have dental ages that are significantly lower than their chronological ages. These findings were consistent with the other studies.[3,9–11]

Body mass index (BMI) or obesity has an effect on dental development since fat and adipose tissue behaves as endocrine tissue. Adipose tissue is a metabolic and endocrine organ that is both complex and active. Aside from adipocytes, adipose tissue also comprises connective tissue matrix, nerve tissue, stromovascular cells, and immunological cells, all of which work together to make a genuine endocrine organ. Adipose tissue has been discovered as a primary site for the metabolism of sex steroids and hormones, which could explain why children with a high BMI mature faster, including at an advanced dental age. The fact that obese and overweight children's dental development lags behind their chronological age as they get older could be attributed to them approaching puberty and experiencing growth spurts earlier than normal weight and underweight children, during which skeletal and dentofacial development is accelerated.[12]

Using information from the National Health and Nutrition Examination Survey (2001–2006), Must et al. assess the relationship between the number of erupted teeth and the presence of obesity in children aged 5–14. According to the researchers, obese children's teeth typically erupted earlier than nonobese children's teeth. There were more erupted teeth in Mexican children with higher BMI categories than in other children, according to 4 year

**Table 4:** Comparison of height, weight and BMI amongst males and females

| | | *Median* | *Interquartile range* | *Chi-square value* | *p-value*[∞] |
|---|---|---|---|---|---|
| Height | Male | 127.25 | 119.0–137.0 | –1.003 | >0.05 |
| | Female | 126.5 | 120.0–139.0 | | |
| Weight | Male | 25.95 | 21.4–32.025 | –0.402 | >0.05 |
| | Female | 26.50 | 21.00–31.225 | | |
| BMI | Male | 16.8 | 14.175–19.8750 | –1.799 | >0.05 |
| | Female | 15.9 | 13.9–18.175 | | |

[∞]Man whitney u test

**Table 5:** Association between gender and BMI grade

| | | | *Gender* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | *Male* | *Female* | *Total* | *Chi-square value* | *Degree of freedom* | *p-value*[µ] |
| BMI grade | Underweight | Number | 31 | 35 | 66 | 10.396 | 4 | <0.05* |
| | | Percentage | 23.8% | 29.2% | 26.4% | | | |
| | Normal | Number | 63 | 62 | 124 | | | |
| | | Percentage | 48.5% | 51.7% | 49.6% | | | |
| | Overweight | Number | 10 | 15 | 25 | | | |
| | | Percentage | 7.7% | 12.5% | 10.0% | | | |
| | Obese | Number | 26 | 8 | 34 | | | |
| | | Percentage | 20.0% | 6.7% | 13.6% | | | |
| Total | | Number | 130 | 120 | 250 | | | |
| | | Percentage | 100.0% | 100.0% | 100.0% | | | |

[µ]Chi-squared test; *$p$-value< 0.05 was considered statistically significant

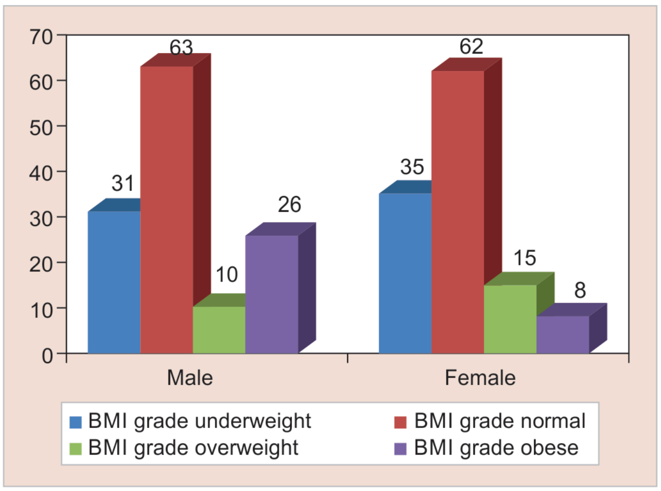


**Fig. 4:** Association between gender and BMI grade

longitudinal research. According to Fatemifar et al. early primary tooth emergence may be a risk factor that is underappreciated for the emergence of obesity in later life.[6,13,14]

In 2014, skeletal maturation and dental development were compared to BMI, according to research by Hedayati et al., in children aged 6–15, and found a direct link between accelerated dental maturation and increased BMI ($p = 0.002$). In another research in 6–14-year-old Brazilian children by Eid et al., they found that there was no significant link between dental maturation and BMI, yet the data revealed that Brazilian children's dental development is typically 0.616–0.681 years ahead of their chronological age.[9,15]

Mack et al. in 2013 reported that in obese children, cervical vertebrae growth and dental age were accelerated. The dental age and cervical vertebrae development were 0.05 years accelerated in these teenagers for a single unit change in BMI percentile. In a study done by DuPlessis et al., in 2016, a significant relationship between BMI and dental development was discovered ($p < 0.01$); however, no distinction between boys and girls was observed. According to Sanchez et al., children who are overweight and have a higher BMI have more teeth than other children of their age ($p < 0.001$) and noted that in pediatric patients, there is a complex link between BMI and oral health in a longitudinal study on Mexican elementary school children.[10,16,17]

Estimating age is important not only in the case of crimes and accidents but also in the case of identifying deceased victims. Several techniques for treating dental age estimation in young people have been mentioned in the literature. Radiographic procedures, for example, require the monitoring of the mineralization of the crowns and roots of deciduous and permanent teeth. Numerous authors have proposed various radiographic stages.[18]

One of the first studies to measure dental maturation and evaluate tooth formation longitudinally was Nolla's study. In addition to providing an age for each tooth at each stage, this method also totals the tooth scores against each year of age, which were then utilized to predict age into 1-year age groups. Haavikko et al. suggested a technique for estimating age focused on the identification of one of each permanent tooth's 12 radiographic phases. Demirjian et al. established one of the most extensively used methods, which is based on measuring tooth mineralization within acceptable error bounds. Tooth formation is divided into eight stages in this system, with requirements for each stage provided separately for each tooth. Sex-specific charts were used for calculating the dental age, and each stage of the left mandibular seven teeth received a score. The final score served as a measurement of the subject's dental development. Fewer stages contribute more to this approach towards the culmination of dental maturation. Thus, a single-stage change might cause a significant increase in dental age. In 2001, after a significant overestimation of the Demirjian method's accuracy in a Belgian Caucasian population was observed, Willems et al. altered the scoring methodology. This version has been tested in a variety of communities and is said to be more accurate than the original method.[19,20]

Cameriere devised a new method of determining dental age by calculating the maturity of apical growth using a mathematical formula that is not based on a specific age. They later devised a model that took into account bone development in the hand and wrist and was able to account for 93% of the differences. However, hand and wrist radiographs are not commonly available for dentists; the new formula faces certain obstacles in terms of implementation in dentistry. Sex was discovered to have a relatively strong influence on the predicted age in Cameriere's method, so it was incorporated as a main element in the age estimation formula. It was discovered that Cameriere's method was more accurate than previously reported methods. As a result, we used it in our research to estimate age.[21,22]

## Conclusion

Based on the study's findings, we rejected the null hypothesis ($H_0$), stating that there was no significant association between BMI and dental age of the children aged 6–13 years.

Further, it is concluded that:

- The dental age was significantly associated with the BMI of the children aged 6–13 years.
- Children who were underweight had dental ages that were noticeably lower than their chronological ages.
- In obese and overweight children, the dental age was significantly greater than the chronological age.
- The relationship between gender and BMI was statistically significant; there are significantly more obese children among males.

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