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Do Nutritional Status Parameters such as Body Mass Index & Mid Upperarm Circumference Need to be Taken into Account when Estimating Dental Age? A Cross-sectional study with Tooth Count as Variable

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ABSTRACT

Context: Age estimation is playing a very important role in the criminal justice system and also in the forensic human identification process. Over the past several decades, the scientific community has done extensive work on age estimation from biological markers of growth, the dental structure being one among them. The routine dental age estimation methods usually apply the mineralization and/or the eruption parameters of the developing dentition. Certain factors like the nutritional status and the socio-economic status of the individual also may influence dental development and eruption.

Aim: The objective of the study was to assess the link between the nutritional status and the dentition status of children and adolescents in the age range of 12 to 18 years.

Settings and Design: This is a cross-sectional population based, descriptive study.

Materials and Methods: The body mass index (BMI) and the mid-upper arm circumference (MUAC) values were measured to assess the nutritional status of the children with a mean age of 14.35 years (± 1.36). The oral examination was done to count the number of teeth present. The tooth count was compared with the BMI and the MUAC values of the children.

Results: The mean BMI of the study population was 17.36 Kg/m^2 ± 3.40 and the mean MUAC value was 21.53cm ± 2.93. There was a strong positive correlation between BMI and MUAC and a significant difference in the deciduous tooth count among the BMI categories. (χ^2 =12.161, df 3, $p<0.05$).

Conclusion: There is no significant association between BMI and deciduous tooth count in the study sample.

Keywords: Body mass index, Age estimation, Malnutrition, Tooth development, Mid upper arm circumference, Tooth count.

Key Messages: The BMI and MUAC values are markers of nutritional status in growing children. Though nutritional status has a link with the tooth development, the present study could not establish a significant association between BMI and deciduous tooth count in children in the age range of 12 to 18 years.

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INTRODUCTION

The mineralization of the teeth and skeletal structures are considered biological markers of growth, which is a physiological process in which nutrition plays a vital role. The nutritional status is thought to have a greater influence on tooth development in children.[1-3] Also, the mineralization status of teeth is regarded as an indicator of physiological maturity and skeletal development.[4,5] Other parameters like the timing of the emergence of teeth and the number of deciduous and permanent teeth at various ages have also been reported to demonstrate the link between dental development and physiological development in children.[6] The anthropometric parameters like height and weight reflect upon the growth and nutritional status of growing individuals. The body mass index (BMI), which is calculated using the above two anthropometric parameters is considered a reliable way of measuring or predicting the nutritional status of growing individuals.[7] The mid-upper arm circumference (MUAC) value is also accepted as a measure of nutritional status in children.[8] Reports have also revealed a significant correlation between nutritional status and the timing of dental emergence.[9] Most of the dental age estimation methods apply the mineralization status and eruption parameters of teeth for predicting age in forensic and human identification cases.[10] However, the parameters like nutritional status and socioeconomic status are overlooked while performing the dental age estimation of children. There is also a scarcity of scientific literature addressing the relationship between anthropometric parameters and nutritional status and its possible effect on dental development.[11] Hence, the present study was undertaken to assess the nutritional status of school children of known age and to determine its relationship with dentition status.

MATERIALS AND METHODS

The study subjects for this research comprised human subjects residing in the state of Gujarat, India. School children who were above 12 years but less than 18 years at the time of the survey were selected from August to November 2019. The school authorities were informed about the aims and objectives of the study and their permissions were obtained before the start of the survey. Approval was granted by the Institutional Ethics Committee of the principal author's dental institute. (Ref. No. IEC/GDCH/S.2/2019) The basic background information such as name, sex, date of birth, date of examination, and residential details of the children was recorded. The chronological age was determined as the difference between the date of birth and the date of recording the details. The height of the child was measured using a wall-mounted stadiometer (Thermocare®, India), which is constructed out of a ruler and a sliding horizontal headpiece that is adjusted to rest on the top of the head. The height was measured to the nearest 0.1 cm.[12] Care was taken to avoid the parallax error while recording the height. The weight of each child barefoot was measured to the nearest 0.1 kg using a portable electronic weighing scale (Hoffen®, Ace Incorporation, Jaipur) which was calibrated before use. Each child was instructed to stand straight so that the mass of the body is equally distributed between feet until the reading in the scale stabilized. The mid-upper arm circumference was measured using a flexible, inelastic color coded measuring tape (IS Indosurgicals®, India) The measure was taken in the patient's non-dominant arm, just at the mid-point between the acromion and the olecranon, in sitting or standing posture.[13] All the values were recorded twice by the same observer and the data was entered in the printed performa and later entered in the excel sheet. The body mass index (BMI) was calculated using the formula: BMI = Weight in kg / (Height in meter)^2. The height and weight and the MUAC measurements of 30 child patients visiting the author's institute was recorded twice by the same examiner prior to the start of the study in order to evaluate the intra-examiner measurement error. The values obtained during the first and second attempts were tested using paired t-test and also subjected to Dahlberg's formula. The oral clinical examination was conducted using the WHO diagnostic criteria.[14] The number of deciduous teeth in both arches were recorded. The data was analyzed using JASP computer software (Version 0.16.1).

Statistical Analysis:

The normality of the data was measured using the Shapiro-Wilks test. The descriptive statistics, Chi-square test, correlation coefficients, nonparametric Kruskal-Wallis test, Mann-Whitney test, and linear regressions were applied for the statistical analysis of the data.

RESULTS

The paired t-test to assess the intra-examiner error and the measurement error testing using Dahlberg's formula revealed an insignificant difference (p>0.05) in the mean values of the measurements obtained in the first and second attempt. In the present study a sample of 1104 school students aged 10 to 20 years with a mean age of 14.35 years ± 1.36 were included. The study subjects included 529 (47.9%) boys and 575 (52.1%) girls. The mean age of boys was 14.37 years ±1.37 and the mean age of girls was 14.32 years ±1.35. There was no significant difference in the chronological age between boys and girls. The Shapiro-Wilks test of normality revealed a non-normal distribution of age (W=0.981, p<0.001), BMI (W= 0.916, p<0.001), and MUAC (W=0.975, p<0.001) values in the overall subjects where 'W' is the test statistic. The mean height and the mean weight of the overall sample were 152.07cms ±9.78 and 40.48kg ±10.19 respectively and the calculated mean BMI was 17.36kg/m2 ±3.40 and the mean MUAC value was 21.53 cm ±2.93. The girls had significantly higher BMI and MUAC values than boys and the difference were highly significant. (Table 1 and 2, Fig. 1) The mean BMI and MUAC values in different age groups are shown in figure 2. The cross-tabulation of the age category with the BMI category is not showing a significant association between boys and girls. (Table 3) Age is positively correlated with BMI (r=0.172, P<0.001) and MUAC values (r= 0.221, P <0.001) but negatively correlated with deciduous tooth count (r=-0.295, P <0.001).

Table 1: Table showing the results of the descriptive statistics of BMI in boys and girls according to their age range category

Age category	Age range (Yrs.)	BMI (Kg/m2)								
		Boys			Girls			Total		
		n	Mean	SD	n	Mean	SD	n	Mean	SD
1	12.00-12.99	89	16.20	3.52	91	16.45	2.74	180	16.33	3.15
2	13.00-13.99	104	16.15	3.08	131	17.33	3.05	235	16.81	3.115
3	14.00-14.99	147	16.99	3.61	163	18.29	3.60	310	17.68	3.66
4	15.00-15.99	117	17.30	3.18	113	18.10	3.25	230	17.69	3.239
5	16.00-16.99	52	18.15	3.79	55	18.70	3.48	107	18.43	3.628
6	17.00-17.99	20	18.08	3.23	22	18.03	2.31	42	18.06	2.755
Total		529	16.92	3.45	575	17.77	3.29	1104	17.36	3.40

Abbreviations: [BMI = Body Mass Index]

Table 2: Table showing the results of the descriptive statistics of MUAC values in boys and girls according to their age range category

Age category	Age range	MUAC (Cm.)								
		Boys			Girls			Total		
		n	Mean	SD	n	Mean	SD	n	Mean	SD
1	12.00-12.99	89	20.897	3.312	91	20.522	2.589	180	20.707	2.966
2	13.00-13.99	104	20.17	2.948	131	21.004	2.459	235	20.635	2.713
3	14.00-14.99	147	21.195	3.206	163	22.325	2.767	310	21.789	3.032
4	15.00-15.99	117	21.784	2.75	113	22.157	2.514	230	21.967	2.638
5	16.00-16.99	52	22.99	3.21	55	22.258	2.519	107	22.614	2.886
6	17.00-17.99	20	23.645	3.139	22	22.218	2.017	42	22.898	2.678
Total		529	21.34	3.19	575	21.69	2.66	1104	21.53	2.93

Abbreviations: [MUAC= Mid Upper Arm Circumferance]

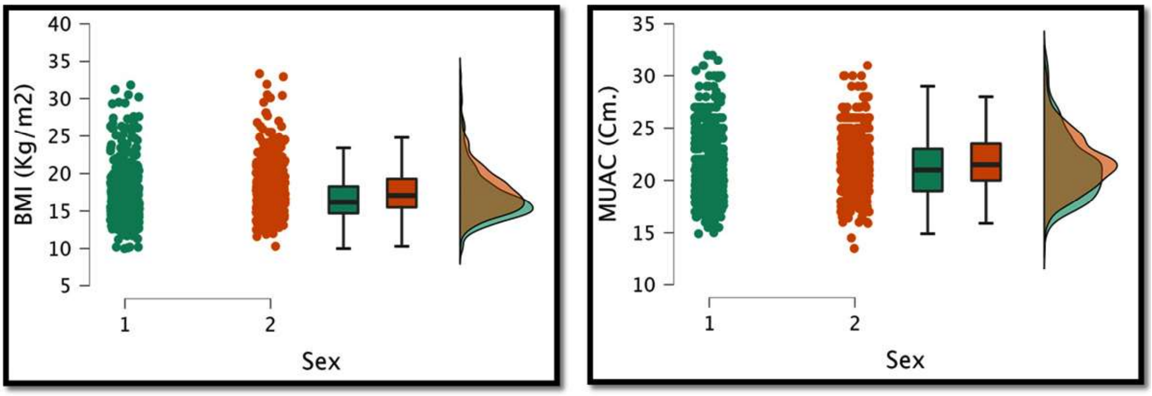

Fig. 1: Raincloud Plots of mean BMI and MUAC values between sexes (1 = Boys, 2 = Girls)

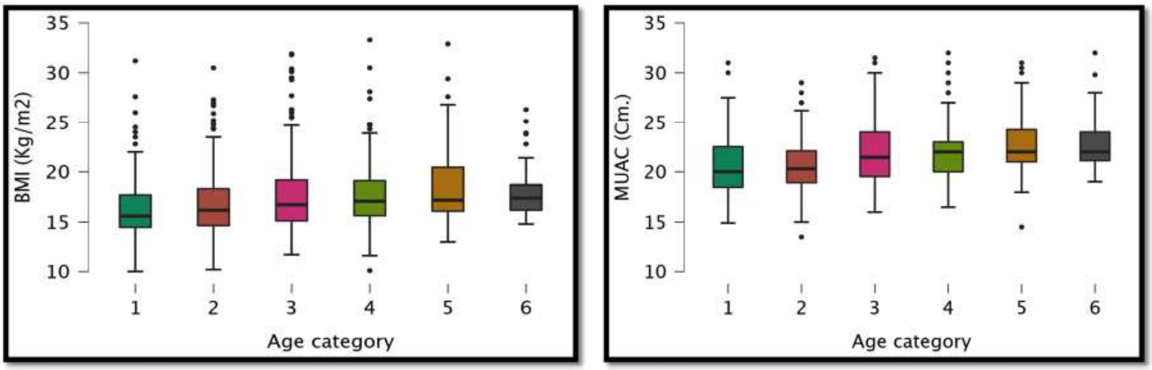

Fig. 2: Box Plot of the mean BMI and MUAC values among the age categories

Table 3: The table showing the distribution of the study subjects according to their BMI category.

BMI category	BMI range	Boys		Girls		Total		X^2	df	Sig*.
		n	%	n	%	n	%			
1	<18.5 (Underweight)	403	76.18	373	64.87	776	70.29			
2	18.5-24.99 (Normal)	104	19.66	185	32.17	289	26.18			
3	25.0-29.99 (Over weight)	18	3.40	11	1.91	29	2.63	24.077	3	0.000
4	>30 (Obese)	4	0.76	6	1.04	10	0.91			
	Total	529	100	575	100	1104	100			

*Chi square test significant at p<0.05; BMI = Body Mass Index.

Relationship between BMI and MUAC:

There is a strong overall significant correlation between BMI and MUAC values. ($r=0.805$, $p<0.001$). The regression equation derived with BMI as the dependent variable and the MUAC as the independent variable for the overall population is given below:

BMI = -2.744 + 0.934(MUAC)

with $r^2 = 0.649$ and standard error of estimate (See) = 2.017.

Male BMI = -2.027 +0.888 (MUAC)

$r^2 = 0.671$ and standard error of estimate (SEE) = 1.98; $P<0.001$

Female BMI = -3.552 + 0.983 (MUAC)

$r^2 = 0.630$, standard error of estimate (SEE) = 2.00; $P<0.001$.

Deciduous tooth count

The deciduous tooth count in the overall sample ranged from 0 to 13. In the overall sample, 86.5%

were not having any deciduous teeth in their dentition. There was a significant difference in the distribution of the deciduous tooth count between boys and girls. (Table 4) The deciduous tooth count showed a significant negative correlation with anthropometric parameters like Height, weight, BMI, and MUAC values. The Kruskal Wallis test revealed a significant difference in deciduous tooth count between different age groups (χ^2= *117.34, df=5, P<0.001*) and with the BMI categories (χ^2= *12.161, df=3, P<0.05*). Only 16% of the underweight category children in the age range of 12 to 18 years were having one or more deciduous tooth/ teeth in their dentition. Out of the 39 overweight and obese children, only 3 (7.7%) were showing the presence of retained deciduous teeth. As there was a significant correlation between age and the deciduous tooth count and other anthropometric parameters, a linear regression model was prepared with age as the dependent variable and other parameters as the independent variables.

Table 4: Table showing the frequency distribution of the deciduous tooth count category in the study subjects.

Dec. tooth count category	Dec. tooth count	Boys		Girls		Total		X^2	df	Sig.
		n	%	n	%	n	%			
0	Nil	447	84.499	508	88.348	955	86.504			
1	1-5 teeth	63	11.909	57	9.913	120	10.87			
2	5-10 teeth	13	2.457	5	0.87	18	1.63	5.936	3	0.115
3	>10 teeth	6	1.134	5	0.87	11	0.996			
Total		529	100	575	100	1104	100			

*Chi square test significant at p<0.05.

Age = 12.544-0.009 (BMI)+0.096 (MUAC)-0.178 (Dec. tooth count)

R = 0.310; r^2= 0.096; SEE = 1.300; P<0.001

Boys age = 12.700 - 0.025 (BMI) + 0.104 (MUAC) – 0.211 (Dec. tooth count)

R = 0.370; r^2= 0.137; SEE = 1.285; P<0.001

Girls age = 12.343 - 0.010 (BMI) + 0.086 (MUAC) – 0.135 (Dec. tooth count)

R = 0.257; r^2 = 0.066 SEE = 1.312; P<0.001

The residual value between the chronological age and the predicted age using the above regression equation ranges from -2.829 to 3.895 years. (Fig. 3) The marginal effects plots in figure 4 show the effect of the independent variables on the dependent variable (age). Through the present study, it was observed that around 84% of the underweight children and 90% of the obese children were not having even a single over retained deciduous tooth. At the same time, only 1.4% of the underweight children had more than 10 retained deciduous teeth in their dentition at the time of examination. (Table 5)

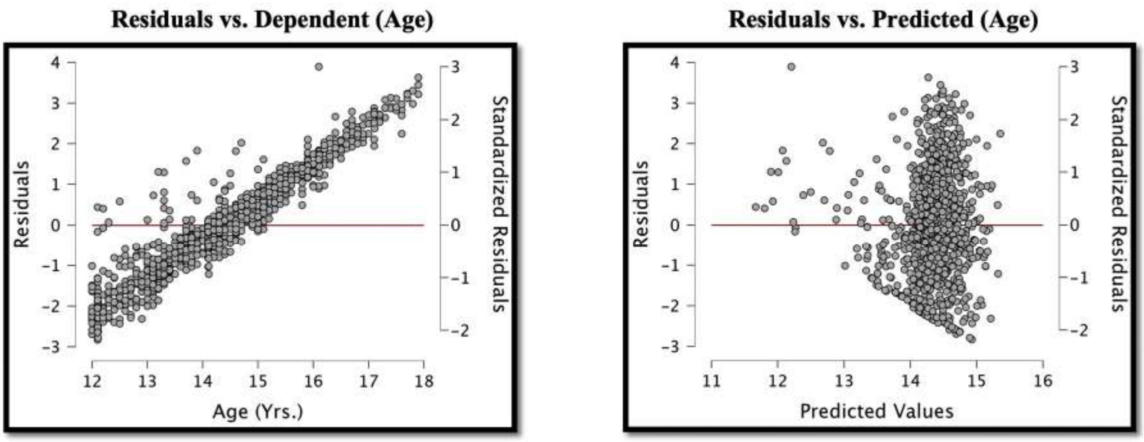

Fig. 3: Residual plots with dependent variable and the predicted variable.

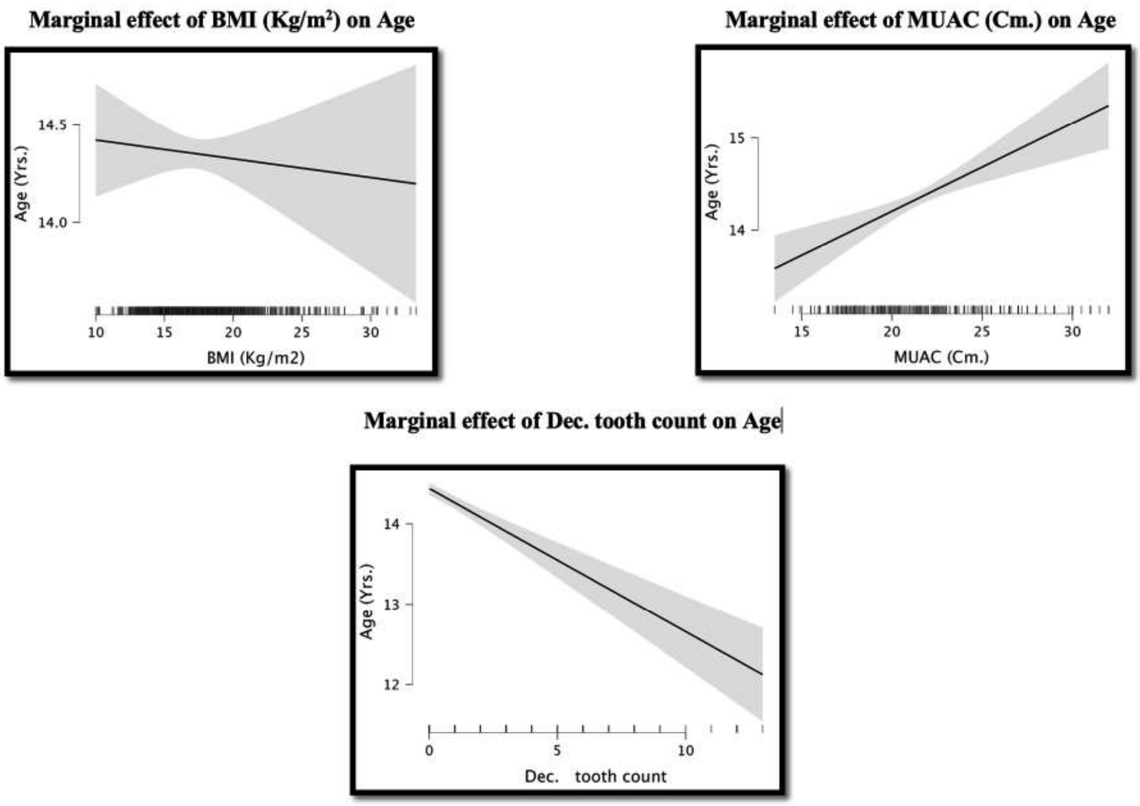

Fig. 4: Marginal effects plot of BMI, MUAC and deciduous tooth count on Age.

Table 5: Table showing the frequency distribution of the study subjects according to their BMI categories and deciduous tooth counts.

Dec. tooth count	BMI categories										X²	df	Sig.
	<18.5 (Underweight)		18.5-24.99 (Normal)		25.0-29.99 (Over weight)		>30 (Obese)		Total				
	n	%	n	%	n	%	n	%	n	%			
Nil	654	84.3	265	91.7	27	93.1	9	90	955	86.5			
1-5 teeth	97	12.5	20	6.9	2	6.9	1	10	120	10.9			
6-10 teeth	14	1.8	4	1.4	0	0	0	0	18	1.6	13.51	9	0.141
>10 teeth	11	1.4	0	0	0	0	0	0	11	1			
Total	776	70	289	26.2	29	2.6	10	0.9	1104	100			

*Chi square test significant at $p<0.05$; BMI = Body Mass Index.

DISCUSSION

The ossifications in bone and the maturation stages of teeth are considered biological markers of age. The dental age estimation methods thus utilize the mineralization and the eruption status of teeth for estimating the age. It has been observed in many of these methods, the chronological age does not exactly match with the biological age and more often the population and sex based variations are most likely to occur. Hence several age estimation methods are being validated and subsequently modified based on populations. The factors like nutritional status and environmental or socioeconomic status might also contribute to variations in age estimation.[15,16] The malnourishment status in children not only affects the oral health, but also dental development.[17] In many of the age estimation methods, which rely on the development status of teeth, the nutritional status of the children is not considered. Further, some of the earlier studies have also pointed out that nutritional status has minimal or nil effect on dental development.[18,19] On the contrary, studies have shown advanced dental development or over estimation of the dental age in overweight and obese children.[20-22] The present study was conducted to explore the relationship between nutritional status and dental development using tooth count as a parameter. The study by Weddell and Hartsfield revealed an insignificant correlation between the BMI and the difference between the chronological age and the estimated age calculated using Demirjian's method.[20] A study by Hilgers et also used the orthopantomograms for estimating the age by Demirjian's method and revealed an over estimation in children with higher BMI.[21] Another radiographic study correlating the BMI with the dental development stages of Demirjian's method was conducted by Erwansyah *et al.* Their results showed that there was a strong correlation between BMI and dental age in 44.6% of the cases.[23] Similarly, a study by Anbiaee *et al*. reported that a significant correlation between BMI and dental age was present only in boys and not in girls.[24] The obese or overweight children were 3.5 times more dentally advanced.[25] As the data in the present study was obtained from a large number of school children during screening in their respective schools, the radiographs were not taken and thus the mineralization of teeth was not used as a parameter for dental development. The nutritional status of children and their BMI also influence the eruption or clinical emergence of teeth.[26] The skeletal dental maturity is accelerated when compared to the chronological age from normal weight to obese children. According to a study, the difference between chronological and skeletal dental age is statistically significant for pre-obese ($p=0.01$) and obese ($p<0.001$) children, while it is not significant for underweight ($p=0.46$) and normal weight ($p=0.33$) children.[27] But in the present study, the BMI was directly correlated with the chronological age and the deciduous tooth count in children. The result revealed a significant difference in the tooth count among the children of different BMI categories. The tooth count method may be considered a simple and economical way of estimating the age especially when the focus of the research community is on the application of advanced tools like CT and CBCT.[28,29] The advantages of using the tooth count method were highlighted by Hagg and Taranger.[30] Quantifying the deciduous and permanent teeth in the oral cavity for age estimation in malnourished children was also earlier attempted by Psoter *et al*.[31] Their study revealed that malnourishment in early childhood may affect the exfoliation of deciduous teeth. The study subjects in their study were in the age range of 11-13 years. The present study quantified the deciduous teeth in the age group when it is less likely to be observed in the oral cavity and correlated with the BMI of the children. As the age increases from 12 years, the probability of the presence of deciduous teeth decreases. Nearly 86% of the children in this age group under study were not having even a single deciduous tooth. More number of underweight category children (15.7%) were having deciduous teeth in their oral cavity when compared to the other categories. However, the association was not statistically significant ($X^2=13.51$, $df=9$, $p>0.05$). The BMI value was also compared clinically with the permanent tooth count in another Brazilian study conducted in children in the age range of 9 to 12 years. The study reported that the mean number of permanent teeth was significantly higher in the overweight/obesity group.[32] An Indian study on 100 children in the age range of 10-18 years has shown an inconsistent association between dental age and BMI.[33] A study by Kutesa *et al* revealed an insignificant influence of height and a non-conclusive influence of weight on tooth eruption in children in Uganda.[34] But the present study did not attempt to correlate the anthropometric data independently with the age. The present study also used the MUAC values as an indicator of malnourishment in children.

CONCLUSION

The present study was an attempt to evaluate the effect of the nutritional status of children in the age group of 12 to 18 years on tooth count. Within the limitations of the study, it may be concluded that there was no significant association between BMI and deciduous tooth count. It is highly recommended that huge sample studies from different populations need to be designed to test the association between BMI and tooth development.

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