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Original Article

Impact of Body Mass Percentile Categorization on Dental Emergence Among a Cross Section of Nigerian Children

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Abstract

Objective: Although multiple studies have highlighted the influence of body mass index (BMI) on the emergence of the dentition, controversies still exist in the body of literature. The purpose of this research was to determine if the categories of body mass percentile have significant predictive effects on dental emergence staging of pre-orthodontic children and adolescents.

Materials and Methods: This was a cross-sectional study, comprising of 424 participants (186 males and 238 females) ages 4 to 15 years. Dental emergence was classified using the Bjork criteria while BMI was used to categorize the body mass percentile using the Centre for Disease Control (CDC) criteria for gender-based BMI-for-age growth chart for 2–20 years. One-way ANOVA was used to compare the mean BMI of the different categories of BMI-percentile in the dentition stages among males and females. Spearman correlation was used to determine the association between body mass percentile and the dentition stages while multinomial logistic regression was thereafter used to ascertain if the body mass percentile had any effect on developmental staging of the dentition. The statistical significance level was set at $p<0.05$.

Results: The category of BMI-percentile significantly predicts the stage of the deciduous dentition and the permanent dentition excluding the permanent molars ($p=0.005$). Underweight participants were more likely to have delayed dental developmental stage compared to overweight participants who were more likely in the advanced late mixed and adolescent dentition stages with greater odds of 0.788 and 0.501 respectively. The category of the BMI-percentile was not a significant predictor of the permanent molars' dentition ($p=0.463$).

Conclusion: Orthodontists and pedodontists could consider the body mass of patients to determine the timing of commencement of intervention.

Keywords: Body mass percentile, dental emergence, children

Introduction

The specific timing of orthodontic interventions such as commencement of orthopedic and functional appliance therapies are closely related to the period of dental emergence.[1–4] In 1981, Hagg & Taranger classified dental emergence into deciduous, early-, intermediate- and late-mixed dentitions, adolescent and the adult dentition stages.[5] Factors that influence the period of attainment of these stages are multifactorial, ranging from genetic, racial, ethnicity, sexual dimorphism and environmental factors such as nutrition and socio-eco-

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nomic factors.[6,7] The impact of nutrition has specifically received the attention of several authors especially with changes in the dietary habit and lifestyle.[8] One of ways that nutritional status can be evaluated is the use of body mass index, which allows an individual to be classified as underweight, normal, at risk of overweight and overweight according to the body mass percentile.[9] Multiple studies have evaluated the relationship between body mass and oral health status with respect to; caries,[10–12] dental eruption and dental maturation[13,14] and periodontal diseases.[15] Body mass percentile has also been reported to be a weak predictor of skeletal maturation stages.[16,17]

Although higher body mass percentile has been reported to be associated to advanced dental development and dental emergence,[16,18–22] delayed eruption of permanent teeth among obese children have also been reported.[23,24] These findings are at variance with reports of early eruption of permanent teeth in overweight and obese children.[20,25,26] On the contrary, Paz-Cortés et al[27] noted that the category of BMI percentile did not affect the sequence of eruption of permanent teeth.

Children that present with extremes of BMI percentile would probably require extra clinical evaluation to determine if the variations are in keeping with their clinical presentations. Also, delayed dental development among underweight could predispose to a high prevalence of malocclusion[28] and accelerated dental development in overweight and obese children could alter the timing of orthodontic intervention.[29] This is so because different observations have been made with regard to overweight/obesity and skeletal maturation.[30,31]

A few studies in Nigeria that have focused on the relationship between body mass percentile and the development of the dentition with little or no attention given to dental emergence stages. Therefore, the aim of the current study was to ascertain if there an association between dental emergence and the body mass percentile among a cross section of Nigerian children.

Materials and Methods

Study design and setting

This was a cross-sectional descriptive study and data were collected from study participants over a fourteen-month period (June 2022 to August 2023) at the orthodontic and paedodontic clinics. A total of 424 participants comprising of 186 males and 238 females ages 4 to 15 years that met the selection criteria were recruited for the study.

Sample size determination and sampling method

The minimum sample size for the study was determined using the formulae below.

$$N=\frac{Z^2P(1-P)}{D2}$$

N=sample size; Z as the statistics for the desired confidence (which is 1.96 at 95% CI). Since the prevalence was not known, P (the prevalence) was set at 50% (that is, 0.5). The acceptable margin of error (D) was set at 0.05. The minimum sample size (N) for participant to be recruited for this study was three hundred and seventy-eight (378). However, a total of 424 was recruited during the study period. Convenience sampling was used to recruit participants for the study.

Selection criteria

Clinically healthy children with no history of orthodontic treatment, no congenital or developmental anomalies like cleft lip and palate, parents who gave informed consent and children who gave assent were recruited for the study. Participants who presented to the clinic appearing chronically ill were excluded from the study.

Ethical consideration

The author obtained ethical approval from the Ethics and Research Committee of the Hospital Management Agency prior to commencement of the study (A732/T/5) and the study follows the principles of the Declaration of Helsinki. Informed consent was obtained from parents. Assent was also obtained from children over 7 years of age.

Data collection

The information obtained from the participants and/or their parents/guardians included chronological age and gender. The weight (kg) and the height (m) were measured in the clinic using the standard stadiometer.

Body mass index (BMI) was calculated by dividing the weight (in kilogram, kg) by the square of the height (in meters, m). The BMI-percentile category of each study participant was determined using the growth chart provided by the Center of Disease Control (CDC) specific for age and gender: 2–20 years.[9]

According to Center of Disease Control (CDC) the growth charts specific for age and gender (2–20 years) are as follows: BMI-for-age; $<5^{th}$ is underweight; $\geq5^{th}$ - $\leq85^{th}$ is normal; $\geq85^{th}$ - $\leq95^{th}$ is at risk of overweight while >95% is overweight.

Assessment of dental emergence

A visual assessment of the dental emergence of the study participants was conducted with the participant seated on a dental chair. Prior to the assessment, each participant was asked to rinse the mouth with water for 30 seconds, and the gingival was cleaned with a sterile gauze for adequate visibility. The oral cavity was then examined by the researcher (AO) using a mouth mirror and periodontal probe to identify an emerging tooth. The dental development of the participants, which in this study is the dental emergence staging, was based on the gingival emergence/visibility of a set of teeth in the oral cavity, corresponding to the dental stages (DS) as described by Bjork et al[32] Assessment of the emergence was conducted the researcher (AO) who is experienced in the field utilizing the assessment tool. Intra-examiner reliability was conducted using kappa statistics. A total of 40 patients were recruited for the pilot assessment of the dentition stages and kappa statistics showed substantial agreement of the anterior dentition stages (k=0.664) while the molar dentition stages showed almost perfect agreement (k=0.945) with p value <0.0001 respectively.

Summary of Bjork et al[32] dental staging assessment tool (Appendix 1).

1. If any part of a tooth is visible in the oral cavity, it is said to have emerged. When a tooth reaches the occlusal level, it is said to be completely erupted.
2. The individual is in DS 02, DS 2, or DS 4 even if not all the teeth concerned are present, provided that the reason for the absence of a tooth is extraction or dentition (developmental) anomaly.
3. Recording only one of the stages implies that all the earlier stages are complete. If a new stage occurs before the previous one is complete – for example when a canine or premolar is visible before all the incisors are fully erupted – this finding will be recorded, as DS 1 and DS 3.

Data analysis

The data collected from the questionnaires were coded and inputted into IBM SPSS statistics 22.0 (SPSS Inc., Chicago, Illinois, USA). Unpaired t-test was used to compare the mean BMI of the participants' dentition stage and the mean BMI of the participants' BMI-percentile according to gender. Also, a comparison of the mean BMI of participants' dentition stages in relation to the body mass percentile according to gender was done using unpaired t-test. One-way ANOVA was used to compare the mean BMI of the different categories of BMI-percentile in the anterior dentition stages among males and females. Tukey post-hoc test was thereafter used to identify specific areas of significant differences. In addition, Spearman correlation was used to determine the association between body mass percentile and the dentition stages. Also, multinomial logistic regression was used to check if the body mass percentile had any effect on the developmental stages of the dentition. The statistical significance level was set at $p<0.05$.

Results

A total of 424 participants were recruited for the study. The anterior dentition stages were assessed for all the participants, with a mean age of 8.64±3.10 years and a mean BMI of 17.12±3.87 kg/m^2. The molar dentition stages were assessment among 363 participants with a mean age of 9.27±2.85 years and mean BMI of 17.55±3.92 kg/m^2, as shown in Table 1.

Table 2 presents the comparison of the mean BMI in the different percentiles. In the anterior dentition, the mean BMI of underweight male participants was higher than the females; 13.20±1.052 kg/m^2 and 13.05±1.53 kg/m^2) respectively, p=0.649. Statistically significant difference was only observed among those at risk of overweight, where the BMI of females (21.46±2.53 kg/m^2) was significantly higher than the male study participants (19.54±1.69 kg/m^2), p=0.006. On the contrary, assessment of the molar dentition stages showed that the BMI of male participants in the underweight category was lower than the female study participants, p=0.361. Again, female study participants had significant higher BMI compared to male in at risk of overweight category, p=0.005. The mean BMI in the normal percentile category in the anterior dentition and in the molar dentition stage were fairly comparable between males and females with no statically significant differences.

Table 3 describes comparison of mean BMI in the dentition stages. In the dentition stages anterior to the molars, the mean BMI of male participants (15.03±1.69 kg/m^2) with fully erupted deciduous dentition was higher in males than females (14.00±2.21 kg/m^2) but not statistically significant p=0.077. In the intermediate mixed, late mixed and adolescent dentition stages, female participants had higher mean BMI but statistical different was only observed in the late mixed dentition (p=0.045). In the molar dentition stages, the mean BMI of females was higher from the eruption of the first molars to the stage of fully erupted second molars, p>0.005. No male participant had a fully erupted third molar while only one female with a mean BMI of 16.55kg/m^2 had a third molar fully erupted.

Table 1. Mean chronological age and body mass index (BMI) of the study participants

Dentition stage anterior to the molars					
Variables	**Gender**	**n**	**%**	**Mean (years)**	**SD**
Chronological age (years)	Male	186	43.9	8.53	3.00
	Female	238	56.1	8.72	3.17
	Total	424	100.0	8.64	3.10
BMI (kg/m^2)	Male	186(43.9)	16.78	3.19	
	Female	238(56.1)	17.39	4.31	
	Total	424(100.0)	17.12	3.87	
Molar dentition stage					
Chronological age (years)	Male	156	43.0	9.16	2.76
	Female	207	57.0	9.35	2.92
	Total	363	100.0	9.27	2.85
BMI (kg/m^2)	Male	156	43.0	17.06	3.93
	Female	207	57.0	17.92	4.300
	Total	363	100.0	17.55	3.92

SD: Standard deviation

Table 2. Comparison of the mean BMI of the different BMI-percentiles of study participants in relation to gender using unpaired t-test

Dentition stage anterior to the molars												
	BMI-percentile		**Male**			**Female**			**MD**	**95% CI**		**p**
	n	**%**	**n**	**Mean-BMI (SD)**	**%**	**n**	**Mean-BMI (SD)**	**%**		**Lower**	**Upper**	
Underweight	68	16.04	30	13.20 (1.05)	44.1	38	13.05 (1.53)	55.9	0.150	-0.505	0.805	0.649
Normal	276	65.09	126	16.53 (1.65)	45.7	150	16.57 (2.10)	54.3	-0.040	-0.494	0.414	0.862
At risk of overweight	49	11.56	18	19.54 (1.69)	36.7	31	21.46 (2.53)	63.3	-1.918	0.669	-3.264	0.006
Overweight	31	7.31	12	24.18 (5.03)	38.7	19	25.87 (6.51)	61.3	-1.694	-6.214	2.827	0.450
Molar dentition stages												
Underweight	46	12.67	22	13.33 (1.09)	47.83	24	13.64 (1.18)	52.17	-0.309	-0.983	0.365	0.361
Normal	241	66.39	106	16.62 (1.67)	43.98	135	16.73 (2.13)	56.02	-0.112	0.594	0.370	0.648
At risk of overweight	48	13.22	17	19.63 (1.69)	35.42	31	21.46 (2.53)	64.58	-1.822	-5.053	-0.591	0.005
Overweight	28	7.71	11	24.70 (4.93)	39.29	17	26.90 (6.05)	60.71	-2.198	-6.689	2.293	0.324

BMI: Body mass index, CI: Confidence interval, SD: Standard deviation, MD: Mean difference

In the fully erupted deciduous dentition, male participants in the underweight, normal and overweight BMI percentile categories had higher BMI compared to the female participants. Statistically significant was only observed in the normal BMI-percentile category, p=0.020. Also, in the early mixed dentition stage, the BMI of male participants in the underweight, normal and overweight BMI-percentile categories were higher in male participants than females, with statistically significant noted in the normal BMI-percentile category, p=0.006. In the late mixed dentition stage, the mean BMI of females in the normal BMI-percentile category was significantly higher than the males, p=0.009. Among participants with fully erupted first permanent molars, females within the normal BMI-percentile categories and those at risk of overweight, had significantly higher BMI compared to the males; p=0.019 and 0.022 respectively (Table 4).

The results in Table 5 and Table 6 showed that there were significant differences in the mean BMI of the various dentition stages in the different categories of BMI-percentile in both the anterior and molar dentition stages. Post-hoc revealed that the mean BMI of underweight male participants in the early mixed dentition stage differ significantly from the normal, those at risk of overweight and those that were overtly overweight, p<0.000. Conversely, there was no statistically significant difference in

Table 3. Comparison of the mean BMI of the different dentition stages of study participants according to gender using unpaired t-test

Dentition stage anterior to the molars												
	Dentition stage		Male			Female			MD	95% CI		p
	n	%	n	Mean-BMI (SD)	%	n	Mean-BMI (SD)	%		Lower	Upper	
Fully erupted deciduous	51	12.03	22	15.03 (1.69)	43.1	29	14.00 (2.21)	56.9	1.023	2.161	-0.116	0.077
Early mixed	128	30.19	60	16.28 (3.137)	46.9	68	15.75 (2.65)	53.1	0.530	1.543	-0.483	0.302
Intermediate mixed	88	20.76	37	16.69 (2.17)	42.0	51	17.12 (3.29)	58.0	-0.431	0.802	-1.665	0.488
Late mixed	63	14.86	36	16.82 (3.05)	57.1	27	18.74 (4.36)	42.9	-1.915	-0.044	-3.786	0.045
Adolescent	94	22.17	31	19.05 (4.12)	33.0	63	20.36 (5.12)	(67.0)	-1.309	0.790	-3.406	0.219
Molar dentition stages												
First molar erupting	113	31.1	52	15.96 (2.29)	46.0	6	16.03 (2.64)	64.0	-0.0757	0.854	-1.005	0.872
First molar fully erupted	204	56.2	89	17.24 (3.33)	43.6	115	18.08 (3.81)	53.4	-0.837	0.167	-1.841	0.102
Second molar fully erupted	45	12.4	15	19.78 (4.374)	33.3	30	21.18 (6.42)	66.7	-1.405	2.216	-5.126	0.451

MD: Mean difference

the BMI of male participants in the early mixed dentition stage that were within the normal BMI percentile and those at risk of overweight, p=0.139. Among the female participants, statistically significant differences were recorded in the BMI between the various BMI-percentile in the early mixed, intermediate mixed, late mixed and adolescent dentitions. In the first molar erupting stage, statistical differences existed between the various categories of BMI-percentile in both gender, p<0.0001; except among male participants between those at risk of overweight and those that were overtly overweight; p=0.178. Statistical differences were recorded between the various categories of BMI-percentile in both gender among those participants with first molars fully erupted. Female participants within the underweight and normal BMI-percentile categories did not show significant different in the stage of fully erupted second molar dentition, p=0.780.

Table 7 showed that the body mass percentile significantly predicts the outcome of the participants' anterior dentition stages, p=0.005. On the other hand, BMI-percentile category did not significantly predict the molar dentition stages (p=0.463). Therefore, further analysis was not conducted for the molar dentition stages.

In Table 8, a unit increase in the underweight individual will increase its log-odds to be in the deciduous dentition stage rather than in the early mixed dentition by 0.952 than individuals that are overweight (p=0.188), with an odd ratio of 2.597, indicting a small effect size. Also, individuals that are at risk of overweight are less likely (with log-odds of -1.003) to be deciduous dentition and more likely going to be in the advanced dental stage (early mixed dentition), although with a small effect, indicated by the OR of 0.369.

The regression model also shows that underweight individuals when compared to overweight participants, are more likely to be in the reference category (early mixed dentition stage) than to be in the intermediate mixed, late mixed dentition and adolescent dentition stages, as the log-odds of been in the aforementioned stages decreases by 0.087 (p=0.903), 0.087 (p=0.895) and 0.662 (p=0.275) respectively. The model therefore explains that participants that are overweight have the tendency of advanced dentition stages of late mixed and adolescent dentition than the underweight participants.

Correlation between body mass percentile and the anterior dentition shows a weak positive (R=0.136) but statistically significant correlation. This shows a small effect size (r2 of 0.019) of the correlation. It however shows that an increase in the category of the BMI percentile would be accompanied by an increase the dental stage of the individual. On the contrary, the molar dentition did not show a statistically significant correlation with BMI-percentile, as shown in Table 9.

Discussion

The findings from this current study add to the evolving field of research which buttresses the notion that a relationship exist between dental emergence and the category of the body mass percentile. This is important because timing is considered critical as far as orthodontics and pedodontics interventions are concern.

Table 4. Mean BMI comparison of dentition stages in different BMI-percentiles according to gender using unpaired t-test

Dentition stage anterior to the molars												
BMI-percentile / Dentition	**Underweight**		**p**	**Normal**		**p**	**At risk of overweight**		**p**	**Overweight**		**p**
Fully erupted deciduous	M: 6 (35.3)	F: 11 (64.7)		M: 15 (50.0)	F: 15 (50.0)		M: 0	F: 1 (100.0)		M: 1 (33.3)	F: 2 (66.7)	
BMI-M(SD)	12.86 (0.88)	11.94 (1.72)	0.245	15.66 (0.83)	14.86 (0.89)	**0.020**	–	17.08	–	18.47 (0.00)	17.18 (2.89)	0.777
Early mixed	M: 12 (50.0)	F: 12 (50.0)		M: 38 (45.8)	F: 45 (54.2)		M: 4 (40.0)	F: 6 (60.0)		M:6 (54.5)	F: 5 (45.5)	
BMI-M(SD)	12.90 (0.87)	13.07 (0.97)	0.657	16.12 (1.36)	15.36 (1.07)	**0.006**	18.10 (0.18)	18.74 (1.65)	0.471	22.90 (4.25)	22.14 (3.40)	0.319
Intermediate mixed	M: 3 (37.5)	F: 5 (62.5)		M: 25 (41.7)	F: 35 (58.3)		M: 8 (50.0)	F: 8 (50.0)		M: 1 (25.0)	F: 3 (75.0)	
BMI-M(SD)	13.16 (0.89)	13.06 (1.22)	0.904	15.99 (1.02)	16.22 (1.58)	0.523	19.66 (0.75)	20.36 (0.91)	0.119	20.98 (0.0)	25.77 (3.51)	0.358
Late mixed	M: 5 (50.0)	F: 5 (50.0)		M: 24 (63.2)	F: 14 (36.8)		M: 5 (50.0)	F: 5 (50.0)		M: 2 (40.0)	F: 3 (60.0)	
BMI	13.13 (1.03)	13.64 (0.85)	0.414	16.27 (0.92)	17.70 (2.24)	**0.009**	19.81 (2.45)	21.42 (1.09)	0.215	25.29 (3.92)	27.61 (2.01)	0.431
Adolescent	M: 4 (44.4)	F: 5 (55.6)		M: 24 (36.9)	F: 41 (63.1)		M: 1 (8.3)	F: 11 (91.7)		M: 2 (25.0)	F: 6 (75.0)	
BMI-M(SD)	14.73 (0.99)	14.84 (1.30)	0.887	18.58 (2.01)	18.44 (2.07)	0.796	22.94 (0.0)	24.15 (1.19)	0.353	31.36 (3.80)	31.07 (7.55)	0.961
Molar dentition stages												
First molar erupting	M: 10 (71.4)	F: 4 (28.6)		M: 34 (42.5)	F: 46 (57.5)		M: 4 (36.36)	F: 7 (63.64)		M: 4 (50.0)	F: 4 (50.0)	
BMI-M(SD)	12.84 (0.91)	12.78 (0.72)	0.899	15.98 (1.06)	15.32 (1.19)	**0.011**	19.00 (1.34)	19.11 (2.05)	0.924	20.50 (0.55)	22.14 (3.93)	0.441
First molar fully erupted	M: 12 (40)	F: 18 (60)		M: 58 (45.7)	F: 69 (54.3)		M: 13 (40.6)	F: 19 (59.4)		M: 6 (40.0)	F: 9 (60.0)	
BMI-M(SD)	13.73 (1.09)	13.56 (0.96)	0.667	16.49 (1.49)	17.30 (2.20)	**0.019**	19.83 (1.77)	21.53 (2.07)	**0.022**	25.94 (3.87)	25.80 (2.72)	0.936
Second molar fully erupted	M: 0	F: 2 (100.0)		M: 14 (42.4)	F: 19 (57.6)		M: 0	F: 5 (100.0)		M: 1 (20)	F: 4 (80)	
BMI-M(SD)	–	15.99 (0.91)		18.76 (1.95)	18.14 (1.91)	0.367	–	24.47 (1.12)		34.05 (0.0)	34.12 (7.54)	0.994

BMI-Body mass index, M: Mean, SD: Standard deviation, M: Male, F: Female

Table 5. BMI comparison of dentition stages in different Percentiles among males and females using One-way ANOVA

BMI-percentile / Dentition	Dentition stage anterior to the molars									
	Underweight	**Normal**	**At risk of overweight**	**Overweight**	**p (ANOVA)**	**Underweight**	**Normal**	**At risk of overweight**	**Overweight**	**p (ANOVA)**
	Male					**Female**				
Fully erupted deciduous	12.86 (0.88)	15.66 (0.83)	–	18.47 (0.00)	0.000	11.94 (1.72)	14.86 (0.89)	17.08 (0.0)	17.18 (2.89)	0.000
Early mixed	12.90 (0.87)	16.12 (1.36)	18.10 (0.18)	22.90 (4.25)	0.000	13.07 (0.97)	15.36 (1.07)	18.74 (1.65)	22.14 (3.40)	0.000
Intermediate mixed	13.16 (0.89)	15.99 (1.02)	19.66 (0.75)	20.98 (0.0)	0.000	13.06 (1.22)	16.22 (1.58)	20.36 (0.91)	25.77 (3.51)	0.000
Late mixed	13.13 (1.03)	16.27 (0.92)	19.81 (2.45)	25.29 (3.92)	0.000	13.64 (0.85)	17.70 (2.24)	21.42 (1.09)	27.61 (2.01)	0.000
Adolescent	14.73 (0.99)	18.58 (2.01)	22.94 (0.0)	31.36 (3.80)	0.000	14.84 (1.30)	18.44 (2.07)	24.15 (1.19)	31.07 (7.55)	0.000
	Molar dentition stages									
	Male					**Female**				
First molar erupting	12.84 (0.91)	15.98 (1.06)	19.00 (1.34)	20.50 (0.55)	0.000	12.78 (0.72	15.32 (1.19)	19.11 (2.05)	22.14 (3.93)	0.000
First molar fully erupted	13.73 (1.09)	16.49 (1.49)	19.83 (1.78)	25.94 (3.87)	0.000	13.56 (0.96)	17.30 (2.20)	21.53 (2.07)	25.80 (2.72)	0.000
Second molar fully erupted		18.76 (1.85)		34.05 (0.0)	0.000	15.99 (0.91)	18.14 (1.91)	24.47 (1.12)	34.12 (7.54)	0.000

BMI-Body mass index, ANOVA: Analysis of variance

Although the importance of racial, individual and ethnic variation cannot be overlooked,[33] a vast majority of research findings have followed the trend of advanced dental development with increasing body mass.[16,18–22]

This current study revealed a significant difference in the body mass index in the different categories of BMI-percentile in the various dentition stages. The result of the multinomial regression showed that the stage of a participant's BMI-percentile is a significant predictive factor in the development of the dentition especially the anterior dentition stage, showing that those in the higher BMI-percentile are more likely to be in the advanced dentition stages compared to their peers in the lower BMI-percentile categories.

This finding is in agreement with the observation made by DuPlessis et al[16] The author observed an acceleration in the dental age of participants with increasing BMI-percentile especially among overweight and obese children.[16] Young children in the deciduous dentition stage as early as 4 years with increased BMI-percentile have also been reported to have advanced dental development in the pubertal stage.[29] The study conducted among a Jordanian population made specific reference to dental emergence in phase II mixed dentition where attainment of this stage was much earlier among those with higher BMI.[34] This observation is corroborated by findings in this current study; where attainment of the intermediate mixed dentition occurred earlier among the participants that were overweight compared to those in the normal or underweight categories. This current research also agrees with other results published by previous authors.[20,26] In 2013, Sabharwal et al[25] reported a negative correlation between BMI and eruption time of permanent first molars and incisors, indicating an inverse relationship. Although correlation does not show a cause-effect relationship, it shows that attainment of advanced dental stage occurs at an earlier age compare to individuals with lower BMI. This present study is comparable to the author's[25] report because this current study showed that body mass percentile had a significant positive correction with the anterior dentition stage, indicating an advanced dental staging as the category of BMI-percentile increases. Although this present study shows a positive correlation between BMI-percentile and the molar dentition stages which agrees with inverse relationship that exist between BMI and eruption timing as earlier reported[25] however, the finding was not statistically

Table 6. Tukey Post hoc analysis for significant variables

Dentition stage anterior to the molars							
Dentition	**Gender**	**Under-weight vs normal**	**Under-weight vs at risk of overweight**	**Under-weight vs overweight**	**Normal vs at risk of overweight**	**Normal vs overweight**	**At risk of overweight vs overweight**
Fully erupted deciduous	Male	NA	NA	NA	NA	NA	NA
	Female	NA	NA	NA	NA	NA	NA
Early mixed	Male	0.000	0.000	0.000	0.139	0.000	0.000
	Female	0.000	0.000	0.000	0.000	0.000	0.001
Intermediate mixed	Male	NA	NA	NA	NA	NA	NA
	Female	0.001	0.000	0.000	0.000	0.000	0.000
Late mixed	Male	0.000	0.000	0.000	0.000	0.000	0.000
	Female	0.002	0.000	0.000	0.005	0.000	0.001
Adolescent	Male	NA	NA	NA	NA	NA	NA
	Female	0.046	0.000	0.000	0.000	0.000	0.000
Molar dentition stages							
First molar erupting	Male	0.000	0.000	0.000	0.000	0.000	0.178
	Female	0.014	0.000	0.000	0.000	0.000	0.014
First molar fully erupted	Male	0.000	0.000	0.000	0.000	0.000	0.000
	Female	0.000	0.000	0.000	0.000	0.000	0.000
Second molar fully erupted	Male	NA	NA	NA	NA	NA	NA
	Female	0.780	0.013	0.000	0.002	0.000	0.000

NA: Non applicable: Post-hoc test could not be conducted because at least one group has fewer than 2 cases

significant. Again, this agrees with the non-statistically significant relationship that was observed among the female participants but contrary to the findings among male study participants in the study conducted by a previous author.[25] This current study revealed that BMI-percentile is not a significant predictive variable in determining the dentition stage of the molar dentition.

Our current study is however at variance with the findings reported by some authors.[23,24] The authors conducted the studies among a cross section of Indian population and reported a delayed eruption among obese children compared to their underweight counterpart.[23,24] This is a departure from the established reports of early dental development among overweight and obese children which was also noted in this current study. However, Raghavan et al[23] cited uneven distribution of children among the BMI-percentile group as factor to consider for the variation in their study. It is important to state that the study conducted by Anu et al[24] was specific for the permanent mandibular first molar and incisors unlike the entire dentition that was assessed in this current study. This shows that findings by the author[24] may not be used to generalize the effect of BMI on dental emergence. The category of BMI percentile has been reported not to influence the sequence of eruption of permanent teeth among 4–14 years old children.[27] This present study did not evaluate the sequence of eruption of individual teeth. In addition, Paz-Cortés et al[27] categorized the growth of the children using the International Obesity Task Force classifying it into underweight (BMI<18.5), normal weight (BMI 18.5–24.9), or overweight (BMI 25–29.9) as against the gender-specific BMI-for-age growth charts (2–20 years) recommended by the Centre for

Table 7. Multinomial logistic model fitting information describing the effect of body mass percentile on the dental stages anterior to the molars

Dentition stage anterior to the molars				
	Model fitting criteria	**Likelihood ratio test**		
Model	**-2Log likelihood**	**Chi-square**	**Df**	**Sig. (p-value)**
Intercept only	91.720			
Final	63.456	28.264	12	0.005
Molar dentition stages				
Intercept only	42.452			
Final	33.726	8.726	9	0.463

Df: Degrees of freedom; Sig: Significance

Table 8. Multinomial regression model explaining the impact of BMI-percentile on the dental development stages of anterior dentition stages

Dental stages	B	SE	p	OR	95% CI for OR	
					Lower	Upper
Deciduous dentition fully erupted	-1.299	0.651	0.046			
Intercept						
Underweight	0.952	0.724	0.188	2.597	0.628	10.743
Normal	0.282	0.685	0.681	1.325	0.346	5.077
At risk of overweight	-1.003	1.235	0.416	0.367	0.033	4.123
Overweight	O[b]					
Intermediate mixed						
Intercept	-1.012	0.584	0.083			
Underweight	-0.087	0.712	0.903	0.917	0.227	3.704
Normal	0.687	0.608	0.258	1.988	0.604	6.545
At risk of overweight	1.482	0.710	0.037	4.400	1.095	17.676
Overweight	O[b]					
Late mixed						
Intercept	-0.788	0.539	0.144			
Underweight	-0.087	0.658	0.895	0.917	0.253	3.327
Normal	0.007	0.574	0.990	1.007	0.327	3.101
At risk of overweight	0.788	0.701	0.260	2.200	0.557	8.686
Overweight	O[b]					
Adolescent						
Intercept	-0.318	0.465	0.493			
Underweight	-0.662	0.607	0.275	0.516	0.157	1.695
Normal	0.074	0.493	0.881	1.077	0.409	2.832
At risk of overweight	0.501	0.632	0.428	1.650	0.478	5.693
Overweight	O[b]					

B: Regression coefficient, SE: Standard error, OR: Odd ratio for the predictors, CI: Confidence interval. Overweight (O[b]) is the reference percentile for the body mass percentile groupings; Early mixed dentition was the reference category group for the dental stages: this was used because majority of the participants were in this particular group

Disease Control for children and teens. This could have impacted the outcome of their result.

In this present study, females mean BMI were higher in the intermediate mixed, late mixed and adolescent dentition compared to the male participants. However, statistical significance difference was only observed in the late mixed dentition stage. Raghavan et al[23] reported the eruption timing of the teeth to also be earlier in females compared to the males without specific focus on the dentition stage. This is because majority of the studies only considered the eruption of individual teeth instead of the dentition stage, which has been the focus of this current study.

In the interim, following the outcome of this current study, overweight and obese patients may require early orthodontic treatment intervention as against their peers with normal body mass. With the increasing trend of overweight and obesity among Nigerians,[35] orthodontists and pedodontists should consider it germane in clinical practice to always assess patients body mass in relation to dental emergence.

Table 9. Spearman's Correlation coefficient between body mass percentile and the dentition stage

Variable	R	p
BMI-percentile Vs Anterior dentition	0.136	0.005
BMI-percentile Vs Molar dentition	0.062	0.236

BMI: Body mass index, R: Correlation coefficient

Study limitation and recommendation

This study was cross-sectional research and it was not possible to determine the actual time for the emergence

of the teeth. That is, dental emergence may have occurred prior to the participants' presentation in the clinic. Participants could have switched from one category of BMI-percentile to another due to changes in lifestyle thereby obviating the true reflection of the dental emergence. Also, certain factors like socio-economic factors, dietary habits, genetic and endocrine factors that could independently affect BMI and dental emergence were not accounted for and these could affect the outcome of the study. The sample size of the study could have been larger to accommodate for variables that were tagged non-available.

Conclusion

The category of BMI-percentile significantly predicts the stages of the deciduous dentition and the permanent dentition anterior to the molars (p=0.005). On the contrary, the various categories of BMI-percentile were not significant predictors of the permanent molars' dentition.

Underweight participants were observed to be more likely to have a delayed dentition stage compared to overweight participants who were more likely to be in the advanced late mixed and adolescent dentition stages with greater odds of 0.788 and 0.501 respectively.

Disclosures

Ethics Committee Approval: The study was approved by the Hospital Management Ethics Committee (no: A732/T/5, date: 20/05/2022).

Informed Consent: Informed consent was obtained from all participants.

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Appendix 1. Bjork et al criteria for dental emergence staging (DES)

DES	Description	Stage of dentition	Teeth present
Grading for primary teeth and permanent anterior teeth and premolars			
DS01	Deciduous teeth erupting	Deciduous dentition erupting	
DS02	Deciduous teeth fully erupted	Deciduous dentition complete	
DS1	Permanent incisors erupting	Early mixed dentition	1-7 incisors
DS2	Permanent incisors fully erupted	Intermediate mixed dentition	All incisors
DS3	Permanent canine or premolar erupting	Late mixed dentition	1-11 canines and/or premolars
DS4	Permanent canine or premolar fully erupted	Adolescent dentition	All canines and premolars
Grading for molars			
M0	First permanent molar erupting	First molar not fully erupted	1-3 first molars
M1	First permanent molar fully erupted	First molar fully erupted	All first molars
M2	Second permanent molar fully erupted	Second molar fully erupted	All second molars
M3	Third permanent molar fully erupted	Third molar fully erupted	All third molars