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Association Between BMI-for-Age and Eruption Status of Permanent Premolars Among Children Aged 8-10 Years

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Abstract

To assess the association between body mass index for age (BMI-for-age, WHO 2007 reference) and the eruption status of the permanent premolars in children aged 8–10 years in Al-Najaf, Iraq, with attention to age and sex. In this cross-sectional study, 497 schoolchildren aged 8–10 years with complete weight and height measurements were examined for eruption of the right permanent premolars. BMI-for-age z-scores were derived from the WHO 2007 reference and used to classify each child as thinness, normal weight, overweight, or obesity. Associations with eruption status were tested using chi-square and Fisher exact tests, and multivariable logistic regression with BMI-for-age z-score, age, and sex as predictors. Thinness occurred in 5.4% of children, normal weight in 65.0%, overweight in 15.3%, and obesity in 14.3%. Higher BMI-for-age was associated with greater odds of eruption of the maxillary second premolar (adjusted OR per SD 1.18, 95% CI 1.01–1.37, $p = 0.033$) and the mandibular second premolar (1.18, 95% CI 1.0–1.39, $p = 0.045$). Age was the strongest predictor (maxillary 2.63, 95% CI 1.92–3.61, $p < 0.001$), and girls had higher odds than boys for the maxillary second premolar (1.7, 95% CI 1.08–2.68, $p = 0.023$) but not the mandibular one. Thin children did not differ from non-thin children, and the first premolars were not associated with BMI-for-age. Higher BMI-for-age was modestly associated with greater odds of second premolar eruption, with age the dominant correlate and thinness not associated with reduced eruption. These cross-sectional findings implicate adiposity rather than undernutrition and support the use of age-appropriate BMI standards.

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Introduction

Tooth eruption is a complex biological process that reflects the interaction between genetic and environmental factors, and it is a useful indicator of growth and development in children. Because it marks biological maturity, it is widely used in pediatric dentistry, orthodontics, and forensic science. The timing of permanent tooth eruption, and of the premolars, has clinical relevance for occlusal development, the early recognition of eruption disturbances, and orthodontic treatment planning [1-3].

Although chronological age is the primary determinant of tooth eruption, the timing varies considerably between individuals. This variation has been linked to several factors, including nutritional status, genetic background, systemic health, socioeconomic conditions, and hormonal regulation [4-6]. Among these, nutritional status has drawn particular attention because of its direct role in skeletal maturation and somatic growth.

Body mass index for age is the standard indicator of nutritional status in children. It has been linked to dental development: some evidence suggests that greater adiposity accompanies earlier eruption through endocrine pathways, whereas the influence of low nutritional status appears less consistent [7-13]. Across study designs and populations, the findings remain mixed [14-16].

BMI has also been related to skeletal maturation and to oral biological processes [17,18]. In addition, the eruption path of permanent teeth can be obstructed by local conditions such as

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odontomas, which may impede emergence [19].

Sex-related differences in eruption are also documented, with girls generally showing earlier dental development than boys, attributed to earlier pubertal and hormonal maturation [20-22].

Despite a growing literature, population-specific analytical data on nutritional status and tooth eruption remain limited for Middle Eastern populations, including Iraq. This cross-sectional study therefore assessed the association between BMI-for-age and the eruption status of the permanent premolars among children aged 8–10 years in Al-Najaf, Iraq, while accounting for age and sex.

Material and Methods

Study Design and Setting

An analytical cross-sectional study was carried out to evaluate the association between BMI-for-age and the eruption status of the permanent premolars among schoolchildren aged 8–10 years in Al-Najaf, Iraq. The study was conducted in a school-based setting between October 2025 and January 2026.

Study Population and Sampling Technique

In all, 647 children aged 8–10 years were examined at the outset, recruited by cluster sampling in which schools served as the clusters and children were taken proportionally. Once the anthropometric data had been cleaned and checked 150 children with incomplete records were set aside. The final analytic set comprised 497 children, and every analysis reported here rests on it.

Sample Size and Power Consideration

The sample size was not fixed by a formal a priori calculation. A sensitivity power analysis was run instead: with 497 children and a two-sided significance level of 0.05, the study had about 80% power to detect a small effect (Cohen's w of about 0.15; df = 3) in the chi-square comparison of BMI-for-age category and premolar eruption, and similar sensitivity for the age (w of about 0.14) and sex (w of about 0.13) comparisons. This size also sits within the range of earlier studies of nutritional status and tooth eruption.

Inclusion and Exclusion Criteria

Eligible children were aged 8 to 10 years and clinically healthy. Anyone with a congenital anomaly affecting tooth formation, a systemic illness, prior orthodontic treatment, or an earlier extraction of a permanent premolar was not enrolled.

Clinical Examination and Assessment of Tooth Eruption

Examinations were done at the schools in natural daylight, with standard sterile mouth mirrors, disposable gloves, and tongue depressors. A single examiner assessed every child and, to keep intra-examiner variation low, scored only the right-sided premolars. A premolar was taken as erupted once any part of the crown had broken through the gingival mucosa into the mouth, and as unerupted otherwise.

Anthropometric Measurement and BMI Assessment

Weight was recorded to the kilogram on a calibrated electronic scale, with the child in light clothing and no shoes, and 0.5 kg was deducted to allow for the clothing. Standing height was then measured in meters, the child upright and barefoot with heels and back against a vertical surface and the head held in the Frankfort plane. BMI followed as weight divided by height squared (kg/m²). These values were converted to BMI-for-age z-scores against the WHO 2007 growth reference for school-aged children and adolescents, using its sex-specific L, M, and S parameters. Because age was recorded only in completed years, each child was placed at the mid-point of the age band in months (102, 114, and 126 months at ages 8, 9, and 10); a sensitivity analysis then repeated the z-scores at the lower and upper month of each band. The WHO cut-offs separated thinness ($z < -2$ SD), normal weight (−2 to +1 SD), overweight (> +1 to +2 SD), and obesity (> +2 SD). Missing values were not imputed, and because only children with both measurements were kept (complete-case analysis), 497 remained.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp., Armonk, NY, USA), with BMI-for-age z-scores derived from the WHO 2007 reference. Categorical variables are summarized as frequencies and percentages. Associations between eruption status and age, sex, and BMI-for-age category were examined with the Pearson chi-square test, using the Fisher exact test where expected counts were small. Multivariable binary logistic regression estimated the independent association of BMI-for-age (z-score), age (years), and sex with the eruption status of each second premolar (erupted = 1, unerupted = 0); adjusted odds ratios (AOR) with 95% confidence intervals (CI) are reported. All analyses were performed on the 497-child analytic sample, with tooth-specific valid totals used for teeth with invalid eruption codes. A two-sided $p < 0.05$ was considered statistically significant. Because several comparisons were made, isolated borderline results are interpreted conservatively.

Results

The analytic sample comprised 497 children aged 8–10 years with complete anthropometric data. Of these, 214 (43.1%) were boys and 283 (56.9%) were girls; 128 (25.8%) were aged 8 years, 201 (40.4%) 9 years, and 168 (33.8%) 10 years (Table 1).

By WHO BMI-for-age, 27 children (5.4%) had thinness, 323 (65.0%) normal weight, 76 (15.3%) overweight, and 71 (14.3%) obesity (Table 1); the mean z-score was +0.29. Thinness was uncommon, whereas overweight and obesity together accounted for about three in ten children.

Eruption of the second premolars differed across BMI-for-age categories (Table 2). For the maxillary second premolar, the proportion erupted rose from 18.6% in normal-weight children to 36.8% in overweight and 29.6% in obese children ($\chi^2 = 13.47$, $p = 0.004$), and a similar pattern was seen for the mandibular tooth ($\chi^2 = 10.45$, $p = 0.015$). This gradient was driven by the overweight and obese groups (overweight or obese versus the rest: maxillary 33.3% vs 18.9% erupted, $p < 0.001$), and thin children did not differ from non-thin children for either tooth (maxillary Fisher $p = 1.00$; mandibular $p = 0.80$). Because this unadjusted comparison does not account for age, and older children tend to be both heavier and further advanced in eruption, the adjusted models below provide the primary estimate.

Age was associated with the eruption status of all four premolars (all $p < 0.001$), with the proportion erupted increasing with age (Table 3).

Sex was associated with the eruption status of the maxillary second premolar, with a higher proportion erupted in girls than boys ($\chi^2 = 4.63$, $p = 0.031$), but not of the mandibular second premolar ($\chi^2 = 1.68$, $p = 0.19$) (Table 4). For the first premolars, the proportion erupted was higher in boys, so a uniform sex pattern was not observed.

In multivariable logistic regression (Table 5), higher BMI-for-age was independently associated with greater odds of eruption of the maxillary second premolar (AOR per SD 1.18, 95% CI 1.01–1.37, $p = 0.033$) and the mandibular second premolar (AOR 1.18, 95% CI 1.00–1.39, $p = 0.045$). Age was the strongest predictor (maxillary AOR 2.63, 95% CI 1.92–3.61, $p < 0.001$), and girls had higher odds of maxillary second premolar eruption (AOR 1.70, 95% CI 1.08–2.68, $p = 0.023$) but not of the mandibular tooth (AOR 1.41, 95% CI 0.86–2.31, $p = 0.17$). Results were materially unchanged when BMI was modelled as a continuous measured value (maxillary AOR per unit 1.06, $p = 0.043$; mandibular 1.06, $p = 0.044$), and a thinness-versus-non-thinness contrast was not significant (maxillary AOR 0.87, $p = 0.78$). The first premolars were not associated with BMI-for-age (maxillary AOR per SD 1.00, $p = 0.97$; mandibular 1.09, $p = 0.18$). Placing all children at the lower or upper month of their age band

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changed the thinness count only between 23 and 32 and did not alter these conclusions.

Discussion

This cross-sectional study examined the association between BMI-for-age and the eruption status of the permanent premolars. Eruption was most strongly related to chronological age, with an additional and modest association with BMI-for-age that was specific to the second premolars, and a sex difference confined to the maxillary second premolar.

The strong association between age and eruption across all premolars is consistent with established emergence patterns [1-5,23] and confirms chronological age as the principal correlate of premolar eruption status. The residual variation among children of the same age indicates that age does not fully explain eruption and leaves room for biological and environmental modifiers [3,4].

Higher BMI-for-age was associated with greater odds of second premolar eruption, whereas the first premolars showed no such association. This tooth-specific pattern fits the idea that the later-developing second premolars are more responsive to growth-related influences, and it agrees with studies relating body size and nutritional indices to permanent tooth eruption [5,14-16,24]. The first and second premolars were assessed in the same children at the same recorded ages; the association surfacing only in the second premolars therefore argues against it being a by-product of age alone, since imprecise age recording would have biased both teeth rather than one. Importantly, this association was driven by the overweight and obese children rather than by delay among the thin: thin children did not differ from normal-weight children in eruption status, and thinness was uncommon (5.4%). This is consistent with reports that low nutritional status has little effect on the timing of tooth formation [10], and it indicates that, in this population, the relevant nutritional dimension is higher adiposity associated with earlier eruption rather than undernutrition associated with delay.

A plausible mechanism is that greater adiposity accompanies advanced skeletal and somatic maturation, mediated in part by leptin and insulin-like growth factors acting on skeletal and dental development [11,12,17]. The effect was nevertheless modest and attenuated after adjustment for age, so adiposity is best regarded as a secondary correlate operating against the dominant influence of chronological age.

The earlier eruption of the maxillary second premolar in girls is in keeping with the generally earlier dental maturation reported for girls, attributed to earlier pubertal and hormonal changes [20-22]. The absence of a consistent sex difference in the other premolars suggests that this effect was tooth-specific in the present sample and should not be overgeneralized.

Clinically, these findings support incorporating simple growth assessment into pediatric dental evaluation, while recognizing that chronological age remains the main reference for expected eruption. The cellular and molecular processes underlying eruption are complex and only partly explained by the factors measured here [25,26].

A methodological point also follows. In children, nutritional status must be classified with age- and sex-specific BMI references rather than fixed adult thresholds, which misrepresent the distribution at these ages. Under an age appropriate WHO classification, most children fell within the normal range, and overweight and obesity were more common than thinness, a pattern that fixed adult cut-offs would obscure.

This study has several limitations. Being cross-sectional, it captures eruption status at a single examination and cannot speak to eruption timing or to cause and effect, which is why the results are framed as associations with eruption status. Only the 497 children with both weight and height entered the analysis; the rest were dropped rather than imputed, and although that exclusion was unrelated to age or sex, it may still introduce some selection bias. Because age came in completed years rather than exact months, the z-scores relied on an age-band approximation, though a sensitivity analysis showed this did not change the conclusions. Only right-sided teeth were scored. The thinness, overweight, and obesity groups were small, which limited power for the category-by-category comparisons, and with several tests run, an isolated borderline result is best read with caution. BMI, finally, says nothing about body composition or micronutrient status. Even so, the multivariable modelling gives the findings reasonable internal validity.

Conclusion

Within this cross-sectional sample of 497 children aged 8–10 years in Al-Najaf, higher BMI-for-age was modestly associated with greater odds of permanent second premolar eruption, while chronological age was the dominant correlate and girls reached maxillary second premolar eruption earlier than boys. Thinness was uncommon and was not associated with reduced eruption. These findings indicate that adiposity rather than undernutrition is the relevant nutritional dimension for premolar eruption status in this population, and they point to the need for age-appropriate BMI-for-age standards when assessing nutritional status in children. Longitudinal studies with complete anthropometry and exact ages are needed to confirm these associations and to examine true eruption timing.

Ethics Approval

The study protocol was reviewed and approved by the Research Ethics Committee, Faculty of Dentistry, Islamic University in Najaf, Iraq (approval number IS25DEC10001). Written informed consent was obtained from the parents or legal guardians of all participating children, and assent was obtained from children when appropriate.

Competing Interests

The author has no competing interests to declare.

Data Availability

The data behind these findings can be obtained from the corresponding author on reasonable request.

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Table 1. Demographic characteristics and WHO BMI-for-age nutritional status of the analytic sample (n = 497).

Variable	Category	n	%
Demographic characteristics			
Age	8 years	128	25.8
	9 years	201	40.4
	10 years	168	33.8
Sex	Male	214	43.1
	Female	283	56.9
WHO BMI-for-age			
Nutritional status	Thinness (z < −2)	27	5.4
	Normal (−2 to +1)	323	65.0
	Overweight (> +1 to +2)	76	15.3
	Obesity (> +2)	71	14.3

n: frequency; %: percentage.

Table 2. Association of WHO BMI-for-age categories with eruption status of the permanent second premolars.

BMI-for-age category	Maxillary 2nd premolar erupted, n/N (%)	Mandibular 2nd premolar erupted, n/N (%)
Thinness	6/27 (22.2)	4/27 (14.8)
Normal	60/323 (18.6)	46/322 (14.3)
Overweight	28/76 (36.8)	22/76 (28.9)
Obesity	21/71 (29.6)	16/71 (22.5)

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Table 3. Association between age and eruption status of permanent premolars

Tooth	Age (years)	Unerupted	Erupted	Total	χ^2	p-value
Upper 5	8	113	15	128	49.44	<0.001
	9	171	30	201		
	10	98	70	168		
Upper 4	8	104	24	128	45.46	<0.001
	9	91	110	201		
	10	83	85	168		
Lower 5	8	120	8	128	25.5	<0.001
	9	168	32	200		
	10	120	48	168		
Lower 4	8	100	28	128	24.64	<0.001
	9	107	93	200		
	10	88	79	167		

Table 4. Association between sex and eruption status of permanent premolars.

Tooth	Sex	Unerupted	Erupted	Total	χ^2	p-value
Upper 5	Male	175	39	214	4.63	0.031
	Female	207	76	283		
Upper 4	Male	99	115	214	13.59	<0.001
	Female	179	104	283		
Lower 5	Male	182	32	214	1.68	0.194
	Female	226	56	282		
Lower 4	Male	115	98	213	4.48	0.034
	Female	180	102	282		

Table 5. Logistic regression analysis of factors associated with second premolar eruption.

Predictor	Maxillary AOR (95% CI)	p	Mandibular AOR (95% CI)	p-value
BMI-for-age z (per +1 SD)	1.18 (1.01–1.37)	0.033	1.18 (1.0–1.39)	0.045
Age (per year)	2.63 (1.92–3.61)	<0.001	2.29 (1.63–3.22)	<0.001
Sex (female vs male)	1.7 (1.08–2.68)	0.023	1.41 (0.86–2.31)	0.168

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.