Association of Hormonal Fingerprints and Body Mass Index with Dental Caries and Malocclusion: A Cross-Sectional Study

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Abstract:

Background: The second-to-fourth digit ratio (2D:4D) is a marker of prenatal hormonal exposure and has been studied as a potential biomarker for various health conditions, including oral diseases. Dental caries and malocclusion are common multifactorial oral health issues possibly influenced by hormonal factors and anthropometric measures such as body mass index (BMI).

Aim: This study aimed to evaluate the association of hormonal fingerprints (2D:4D ratio) and BMI with dental caries and malocclusion among dental students.

Materials and Methods: A cross-sectional study was conducted involving 200 dental students (158 females, 42 males; mean age approximately 20 years). BMI was calculated using standard anthropometry and classified according to WHO criteria. The 2D:4D ratio was measured using Vernier calipers. Dental caries experience was recorded using the DMFT index following ADA Type III clinical examination protocols. Malocclusion was classified clinically using standard

orthodontic criteria. Statistical analysis included chi-square tests for categorical variables and Pearson's correlation for associations between BMI, 2D:4D ratio, DMFT scores, and malocclusion, with a significance level set at $p < 0.05$.

Results: No significant association was found between gender and BMI categories ($p = 0.327$). BMI showed a significant positive correlation with DMFT scores ($r = 0.440$, $p = 0.032$) but not with malocclusion ($r = –0.163$, $p = 0.54$). The 2D:4D ratio correlated positively with DMFT scores ($r = 0.642$, $p = 0.032$), indicating higher ratios were linked to greater caries experience. No significant correlations existed between the 2D:4D ratio and malocclusion ($r = –0.005$, $p = 0.949$) or BMI ($r = –0.080$, $p = 0.257$).

Conclusion: Higher BMI and increased 2D:4D ratios were significantly associated with higher dental caries experience, suggesting their potential as non-invasive markers for caries risk. Neither BMI nor 2D:4D ratio showed significant relationships with malocclusion. Further studies with larger, more diverse samples are recommended.

Keywords: 2D:4D ratio, Hormonal fingerprints, Body mass index, Dental caries, Malocclusion, Biomarkers, Dental students.

Introduction:

Biological markers (biomarkers) are objectively measurable indicators of normal biological processes, pathogenic processes, or pharmacologic responses to therapeutic interventions. They play a central role in diagnosis, prognosis, and epidemiological research, guiding disease prevention, early detection, and management strategies. Common examples include physiological parameters like pulse and blood pressure, as well as molecular indicators such as hormone levels and genetic variations.[1,2]

Among the diverse array of biomarkers, the digit ratio of the second to the fourth finger (2D:4D), also termed the hormonal fingerprint, has garnered significant scientific interest. Established prenatally and largely stable throughout life, the 2D:4D ratio reflects the balance of androgen and estrogen exposure in utero.[3-5] This ratio exhibits marked sexual dimorphism—males typically present with lower 2D:4D ratios compared to females—and has been linked to a broad spectrum of behavioural, physiological, and disease traits. Accumulating evidence suggests that the 2D:4D ratio may correlate with oral health conditions, including dental caries and malocclusion, possibly due to the influence of sex hormones on craniofacial and dental development.[6-8]

Dental caries remains the most prevalent global oral infectious disease, characterized by the destruction of tooth hard tissues through multifactorial mechanisms that include behavioural, genetic, and environmental components (Centers for Disease Control and Prevention, 2022)[9]. Similarly, malocclusion—defined as the misalignment of teeth or jaws—represents a major oral health issue impacting both aesthetics and functionality. Identifying stable, early-life predictors for these conditions, such as non-invasive biomarkers, could significantly enhance screening and preventive strategies.[7,8]

Furthermore, the global increase in rates of overweight and obesity presents additional challenges to oral health. Overweight and obesity contribute to both systemic metabolic disturbances and are increasingly implicated in faster dental development, altered masticatory patterns, and greater susceptibility to dental diseases. Recent studies have begun to explore potential interrelationships between 2D:4D digit ratio, body mass index (BMI), dental caries, and malocclusion, but consensus remains elusive, and many questions persist regarding the underlying biological pathways.[10,11]

Despite advances, substantial gaps remain in understanding how hormonal fingerprints and BMI interact to affect oral health risk in young adults who are often subjected to early, modifiable risk factors. By investigating these associations, the present study seeks to provide novel insights that can inform both individualized risk assessment and potential preventive interventions.

Accordingly, this study aims to assess the implications of hormonal fingerprints (2D:4D ratio) and BMI on dental caries and malocclusion among dental students, offering a foundation for further research and clinical application in oral health sciences.

Materials and Methods

Study Design and Setting

A cross-sectional survey was conducted among dental students at Lenora Institute of Dental Sciences, Rajahmundry. The study was approved by the Institutional Ethical Committee (Ref: 34/IEC/LIDS/UG/2022).

Population and Sampling

A convenience sample of 200 dental students aged 18 years was recruited. *Inclusion criteria:* comprised participants without any congenital digital abnormalities or history of significant systemic diseases affecting hormonal levels or BMI. Students using medications affecting hormonal levels or BMI in the past six months, or those with digital deformities or recent systemic illness, were excluded from the study.

Data Collection and Variables

Demographic data, including age, gender, education, and basic health history, were recorded. BMI was calculated as weight (kg) divided by height squared (m^2).

Anthropometric data: a) Height was measured using a standard stadiometer scale and b) Weight was measured using a weighing machine with corrected zero error. The BMI score was categorized as underweight (<18.5), normal weight (18.5–24.9), overweight (25.0–29.9), and obese (≥30) according to WHO standards.

c) Hormonal Fingerprint (2D:4D Ratio): Both hands' index (2D) and ring (4D) fingers were measured from the midpoint of the proximal crease to the fingertip using standardized Vernier callipers. The ratio was computed as the length of 2D divided by the length of 4D on the same hand.

Dental Caries Assessment: A clinical oral examination following ADA Type III criteria was performed using mouth mirrors, WHO probes, with standard infection control measures. Dental caries status was recorded using the DMFT (Decayed, Missing, and Filled Teeth) index as per WHO oral health assessment guidelines (2022).

Malocclusion Assessment: Malocclusion was classified according to Angle's classification of malocclusion.

Ethical Considerations

Informed consent was obtained from all participants before data collection.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS version 26.0 (IBM, Chicago) Quantitative variables were summarized using means and standard deviations; categorical data were presented as frequencies and percentages. Associations between categorical variables were tested using Chi-square analysis; Means between groups were compared with independent-sample t-tests. Statistical significance was set at $p < 0.05$.

Results:

A total of 200 participants were included in this cross-sectional study, comprising 158 females (79%) and 42 males (21%). Analysis using the chi-square test revealed no statistically significant association between gender and body mass index (BMI) categories (p = 0.327), indicating that BMI distribution was comparable across genders in this sample.

Table 1: Association between Gender and BMI among study participants

Gender	BMI					P value
	underweight	healthy weight	overweight	obesity	Total	
Female	25	100	27	6	158	0.327
Male	10	20	10	2	42	
Total	35	120	37	8	200	

Pearson's correlation analysis was conducted to investigate relationships between BMI, dental caries experience as measured by the Decayed, Missing, and Filled Teeth (DMFT) index, and malocclusion. Results demonstrated a statistically significant positive correlation between BMI and DMFT score (r = 0.440, p = 0.032), suggesting that higher BMI values were associated with increased dental caries prevalence. Conversely, no statistically significant correlation was observed between BMI and malocclusion (r = –0.163, p = 0.54), indicating that BMI may not influence malocclusion status.

Test done: Chi-square test

Table 2: Correlation between DMFT score, malocclusion, and BMI

Variables	BMI(r*)	P value
DMFT Score	0.440	.032*
Malocclusion	-.163	0.54

Test done: Pearson's correlation

*P≤0.05 was considered statistically significant

Further analysis assessed the relationship between the hormonal fingerprint, represented by the second-to-fourth digit ratio (2D:4D), and oral health parameters. The 2D:4D ratio showed a significant positive correlation with DMFT score ($r = 0.642$, $p = 0.032$), implying that participants with higher digit ratios tend to experience a greater burden of dental caries. However, no significant correlations were found between the hormonal fingerprint ratio and either malocclusion ($r = –0.005$, $p = 0.949$) or BMI ($r = –0.080$, $p = 0.257$).

Table 3: Correlation between Malocclusion, DMFT Score, BMI, and Hormonal Finger Print ratio

Variables	Fingerprint ratio(r*)	P value
DMFT Score	0.642	0.032*
MALOCCLUSION	-.005	.949
BMI	-.080	.257

Test done: Pearson's correlation

*P≤0.05 was considered statistically significan

Discussion

Dental caries remains one of the most prevalent chronic diseases globally, characterised by its infectious, multifactorial aetiology and gradual progression, destroying dental hard tissues. The decayed, missing, filled teeth (DMFT) index, used for evaluating and comparing dental caries experiences in various populations due to its simplicity, validity, and reliability.

The present study utilised the DMFT index to comprehensively assess caries experience among 200 young adults, with a mean age of around 20 years. With a caries prevalence of 30.5% and a mean DMFT score of 0.88, these findings are indicative of a relatively moderate caries burden in this population, with decayed, missing, and filled teeth components reflecting a generally

positive oral health profile. This is consistent with reports from comparable young adults in both Indian and international studies, where DMFT values and caries prevalence often remain low to moderate, potentially due to improved oral health awareness.[12]

A noteworthy determinant in caries epidemiology is body mass index (BMI). In the present sample, most students (60%) fell within the healthy BMI category. Our observation of a negative correlation between BMI and dental caries supports several previous studies—including those by Gupta et al., Chen et al., Tuomi et al., Moreira et al., and Assi et al.—that reported no significant direct association between BMI and caries experience among young or adolescent populations.[13-17] These findings challenge the notion that overweight or obese status universally heightens caries risk, highlighting the complex interplay of dietary patterns, oral hygiene practices, and socioeconomic factors. Contrarily, some researchers like Elangovan et al.[17] have suggested a potential increase in caries with higher BMI, though these relationships often lack statistical significance—possibly reflecting confounding influences such as malnutrition, stunting from severe caries, or diverse dietary habits across socioeconomic strata.

The examination of malocclusion type revealed a predominance of Class I malocclusion (88%), similar for both genders and in agreement with prior epidemiologic reports on Indian dental students and young adults. Of particular interest, the present data showed an inverse relationship between BMI and malocclusion, in line with the findings of Stefan Van Dongen[19], who noted similar associations between somatic growth parameters and occlusal traits—potentially mediated by nutritional or developmental factors during growth[20].

A significant area of exploration was the digit ratio (2D:4D) as a hormonal biomarker. Our results indicate a negative correlation between lower 2D:4D ratios (reflecting higher prenatal androgen exposure, typically male) and malocclusion risk, supporting the observations by Priyanka et al.[21] and others, who found associations between digit ratios and craniofacial/dental

development. Conversely, a higher 2D:4D ratio was linked with an increased caries experience, suggesting a hormonal component to dental vulnerability and reinforcing the proposed predictive relevance of 2D:4D for oral health risk stratification. However, in agreement with prior studies, the association between BMI and 2D:4D ratios did not reach significance, further supporting the notion that these anthropometric and hormonally mediated parameters may act through distinct biological pathways.[22]

Taken together, the findings highlight the value of integrating stable, early-life biomarkers such as 2D:4D digit ratio alongside conventional anthropometric and clinical indices for more nuanced oral disease risk assessment in young adults. Further longitudinal and mechanistic studies are warranted to elucidate the biological underpinnings and predictive utility of these associations in oral health science.

Conclusion

This study underscores the interconnected nature of BMI, hormonal fingerprints (2D:4D ratio), and dental health outcomes, including caries and malocclusion. Although a negative relationship was observed between BMI and both caries experience and malocclusion, and a positive association was found between the 2D:4D ratio and caries, the multifactorial origins of dental diseases require further investigation. Hormonal fingerprints, as reflected in the 2D:4D digit ratio, show promise as an early risk marker for malocclusion and caries experience, but these findings should be interpreted cautiously due to potential confounding factors.

Limitations:

The sample size of 200, mainly female and around 20 years old, limits the generalizability of results. The multifactorial nature of dental diseases and potential confounders complicate

isolating hormonal fingerprint effects. The cross-sectional design also prevents causal conclusions. While the 2D:4D ratio is a promising biomarker, its accuracy may vary with genetic and ethnic differences. Future studies should use larger, more diverse, and longitudinal designs for stronger validation.

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