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Dentofacial deformities as independent predictors of sleep disorders: a cross-sectional study of young adults

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Abstract

Background Sleep disorders (SDs), a public health concern, can lead to critical physiological conditions, and are associated with mental and behavior problems such as psychosocial stress, smoking, alcohol consumption, etc. This study aimed to investigate the cross-sectional associations between dentofacial deformities and sleep quality in young adults in China.

Methods Data were collected from 2,479 young adults (aged 17–25 years) enrolled at Fudan University across various regions of China. Participants completed a self-reported questionnaire that included general information and the Pittsburgh Sleep Quality Index (PSQI) under standardized guidance. Dentofacial characteristics were examined by experienced orthodontists. Data analysis employed one-way ANOVA, student's t-test, chi-square tests, and multivariable logistic regression models.

Results The study revealed a median PSQI score of 5.92 ± 1.66, with 16.3% of participants classified as SDs. Higher PSQI scores were reported by females, underweight individuals, and participants from southern regions. Among the subjects, 44.36% exhibited protruding profiles, 6.86% had concave profiles, and various dentofacial abnormalities were prevalent. Logistic regression analysis identified protruding lateral profiles (OR 1.93, 95% CI 1.18–3.16, $p = 0.008$) and anterior crossbite (OR 1.44, 95% CI 1.01–2.04, $p = 0.043$) as significant risk factors for SDs. Additionally, reduced anterior overbite was associated with a higher prevalence of SDs, while deep overbite acted as a protective factor. Moderate overbite demonstrated statistical significance (OR 0.51, 95% CI 0.35–0.76, $p = 0.001$).

Conclusion These findings suggest a significant association between dentofacial characteristics and sleep quality in young adults. Protruding facial profiles and anterior crossbites were identified as independent predictors for SDs. These findings underscore the importance of screening for SDs in individuals with dentofacial deformities and highlight the potential benefits of early correction of such dentofacial abnormalities to reduce the risk of SDs in adulthood.

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Keywords Sleep disorders, Dentofacial deformities, Young adults, Pittsburgh sleep quality index, Risk factors

Introduction

We spend about a third of our lives sleeping, a vital physiological function essential for maintaining good health [1]. Effective nighttime sleep and daytime alertness are associated with physical and psychological health, as well as living quality [2].

Accumulating evidence demonstrates that sleep disorders (SDs) lead to numerous adverse consequences [3], including headaches, academic difficulties, memory disorders, aggressive behaviors, and cognitive impairments, all of which detrimentally affect the physical, mental, and emotional well-being of young adults [4, 5]. Poor sleep quality is further associated with various adverse outcomes, including mental disorders [6], metabolic disease [7], cancer, and cardiovascular diseases [8].

Emerging adulthood is considered a distinct life stage for young adults [9]. During this period, they often experienced huge changes in lifestyle and behavior, such as variation of academic arrangements, greater social activities, increased autonomy and responsibility. However, an increasing number of young adults report experiencing sleep problems such as difficulty falling asleep, frequent nighttime awakenings, and poor daytime performance [10, 11]. The prevalence of SDs was estimated to range from 11 to 40% in adolescents or young adults [12]. One study surveyed 19,41719417 undergraduate students across 26 countries spanning Asia, Africa and the Americas, finding that 39.2% reported sleep durations of ≤6 h [13]. Additionally, over 60% of university students were categorized as poor sleepers based on the Pittsburgh Sleep Quality Index (PSQI) in an ethnically diverse sample [14]. Epidemiological studies have identified several associated risk factors for SDs, including psychosocial stress, smoking, and alcohol consumption. However, existing risk factors do not entirely explain the development of SDs [15]. Consequently, identifying additional risk factors is essential for developing effective strategies to lower the incidence of SDs and support timely intervention and treatment.

Sleep-disordered breathing (SDB) is a common type of SD characterized by recurrent upper airway (UA) dysfunction during sleep, leading to sleep disruption and ventilation abnormalities. It includes a range of clinical entities of varying severity, from primary snoring to obstructive sleep apnea (OSA) in children of all ages [16]. The prevalence of SDB in primary school students was strongly associated with mandible retrusion in our previous survey of the Chinese urban population [17]. Substantial evidence suggests that craniofacial abnormalities may be related to pediatric OSA. Since young adults have surpassed the peak of dentofacial growth and development—during which environmental factors exert the greatest influence—their dentofacial development is almost complete. Therefore, it is reasonable to hypothesize that dentofacial deformities could be related to SDs. Identifying a correlation between specific dentofacial characteristics and poor sleep quality may allow these features to serve as early indicators for SDs. Defining the dentofacial features of poor sleepers could facilitate the design of more targeted prevention and intervention measures.

Nevertheless, most of the current researches on the relationship between dentofacial features and SDs rely on X-ray cephalometric data in clinical settings, and lack large-scale epidemiological evidence. Accordingly, this study aimed to evaluate the relationship between dentofacial deformities and SDs in Chinese young adults, and to identify predictors of poor sleep quality.

Study design and participants

This cross-sectional study was conducted with young adults aged 17 to 25 years in September 2023. Using cluster sampling, all newly admitted undergraduate and graduate students at Fudan University were invited to participate. Students who declined participation or had a history of maxillofacial surgery or orthodontic treatment were excluded. This study was approved by the Ethical Committee of Shanghai Stomatological Hospital (Certificate Number 2023–011) and was initiated thereafter. Written informed consent was obtained from all participants. The study protocol conformed to the ethical guidelines of the Declaration of Helsinki.

Procedures and measurements

The research was mainly comprised of questionnaires completed by participants under guidance and oral examinations implemented by orthodontists. The questionnaire was about general information and sleep quality assessment on subjects.

The Chinese version of the Pittsburgh Sleep Quality Index (PSQI) [18], one of the most extensively used tools for assessing SDs, was employed in this study to evaluate sleep quality. The PSQI is a self-rated questionnaire reflecting sleep quality over the preceding month, comprising 19 questions categorized into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component score ranges from 0 to 3, producing a global PSQI score ranging from 0 to 21. Higher scores indicate indicates poorer sleep quality and greater SD severity of. The Chinese version of PSQI was proved to be valid and reliable in young adults, with a cutoff score of 8 or higher applied to identify SDs in this population [19].

Oral examinations were conducted by trained and certified orthodontists with over three years of clinical experience. Data were recorded by assistants using a standardized form. Before the examination, orthodontists and assistants underwent standardized training. Inter-examiner reliability was ensured by Cohen's kappa coefficient, achieving a value greater than 0.8.

The examination mainly included assessments of the lateral facial profile, space discrepancy of dentition, teeth alignment, and occlusion parts. Specific elements, such as the lateral profile, molar occlusion, and teeth alignment, were qualitatively evaluated as described in a previous study [17]. The lateral facial profile was categorized as concave, upright, or protruding based on the aesthetic plane (extending from the nasal tip to the pogonion of soft tissue). Molar occlusions were classified according to the relationship between the upper and lower first permanent molars, recorded as Angle's class I (neutral), II (distoclusion), or III (mesioclusion). Teeth alignment was noted as either irregular or regular. Additional assessments included measurements of anterior overbite, overjet, open bite and crossbite, maxillary and mandibular crowding, and space discrepancies.

Statistical analysis

All data were analyzed using SPSS Statistics 23 (SPSS Inc., Chicago, IL, USA) software package. A two-sided *P*-value of < 0.05 was considered statistically significant. Mean and standard deviation were obtained for normally distributed variables, while median and interquartile range (IQR) were used for non-normally distributed variables, and numbers and percentages for categorical variables. An independent sample t-test was used to compare PSQI scores between genders. Analysis of variance (ANOVA) was used to assess PSQI scores across groups with different BMI classifications and from various regions. Post hoc least significant difference (LSD) analysis was performed inter-group comparisons. Student's t-test and Chi-square test were applied to determine statistical associations among demographic and dentofacial development variables according to PSQI ≤ 7 or PSQI > 7. Multivariable logistic regression models were applied to evaluate the influence of dentofacial development variables on the probability of SDs, adjusting for age, sex, BMI and native region. Results were expressed as Odds Ratios (OR) along with their 95% Confidence Interval (95% CI) and *p*-values derived from Wald's tests.

Results

Among the 4822 students ,4674 agreed to participate in the survey and completed the oral examination. After the screening process (Fig. 1), 2479 subjects were involved in the final analysis, comprising 1487 males and 992 females (supplementary file). The median age of participants was 18 years, with an IQR of 18–22. The subjects represented 24 different ethnic groups in China, with 94.2% identifying as Han Chinese. The survey sample represented various provinces and cities across China, with their native regions illustrated in Fig. 2.

The global PSQI score for young adults in China was 5.92 ± 1.66. Figure 3 demonstrated the PSQI scores for different subgroups. Females exhibited higher PSQI scores (6.22 ± 1.65) compared to males (5.72 ± 1.64, $p < 0.001$). According to the normal BMI range for Chinese individuals (18.5–24.9 kg/m^2), underweight participants exhibited higher PSQI scores compared to those with normal BMI, while normal weight individuals had higher scores than overweight participants ($p < 0.001$). When categorized into seven groups based on native regions across China, a notable trend was observed: participants from more southern regions exhibited higher PSQI scores.

Among the subjects, 1093(44.36%) had protruding profiles, while 169 (6.86%) had concave profiles. Abnormal anterior overbite was observed in 46.35% of participants, while 51.11% exhibited abnormal overjet. The current prevalence of irregular alignment was about 64.15%. Maxillary/mandibular spacing or crowding were observed in 60.01% and 71.70% of subjects, respectively.

Participants were divided into two groups: 2075 individuals (83.7%) with a PSQI score ≤ 7 and 404 individuals (16.3%) with a PSQI score > 7. The demographic and dentofacial characteristics of both groups are summarized in Tables 1 and 2. Chi-square tests indicated no significant differences between the two groups in terms of height, BMI, sex, molar occlusion, anterior overjet and maxillary/mandibular spacing or crowding. Individuals with a PSQI score > 7 were more likely to be older aged ($p = 0.019$), lighter in weight ($P = 0.001$) and to exhibit a protruding profile ($p < 0.001$) and irregular alignment ($p = 0.036$). Interestingly, a deeper overbite was associated with a lower prevalence of SDs in this survey ($p = 0.012$).

To identify risk factors associated with a PSQI score > 7, logistic regression models were conducted (Table 3). After adjusting for sex, age, BMI and native region in the multivariate analysis, a protruding lateral profile (OR 1.93, 95% CI 1.18–3.16, $p = 0.008$) and anterior crossbite (OR 1.44, 95% CI 1.01–2.04, $p = 0.043$) were identified as significant risk factors for poor sleep quality. Additionally, a reduced anterior overbite was linked to a higher prevalence of SDs. Although anterior open bite was considered as a potential risk factor, the results were not statistically significant. Deep overbite was found to be a protective factor, with moderate overbite showing significant statistical relevance (OR 0.51, 95% CI 0.35–0.76, $p = 0.001$).

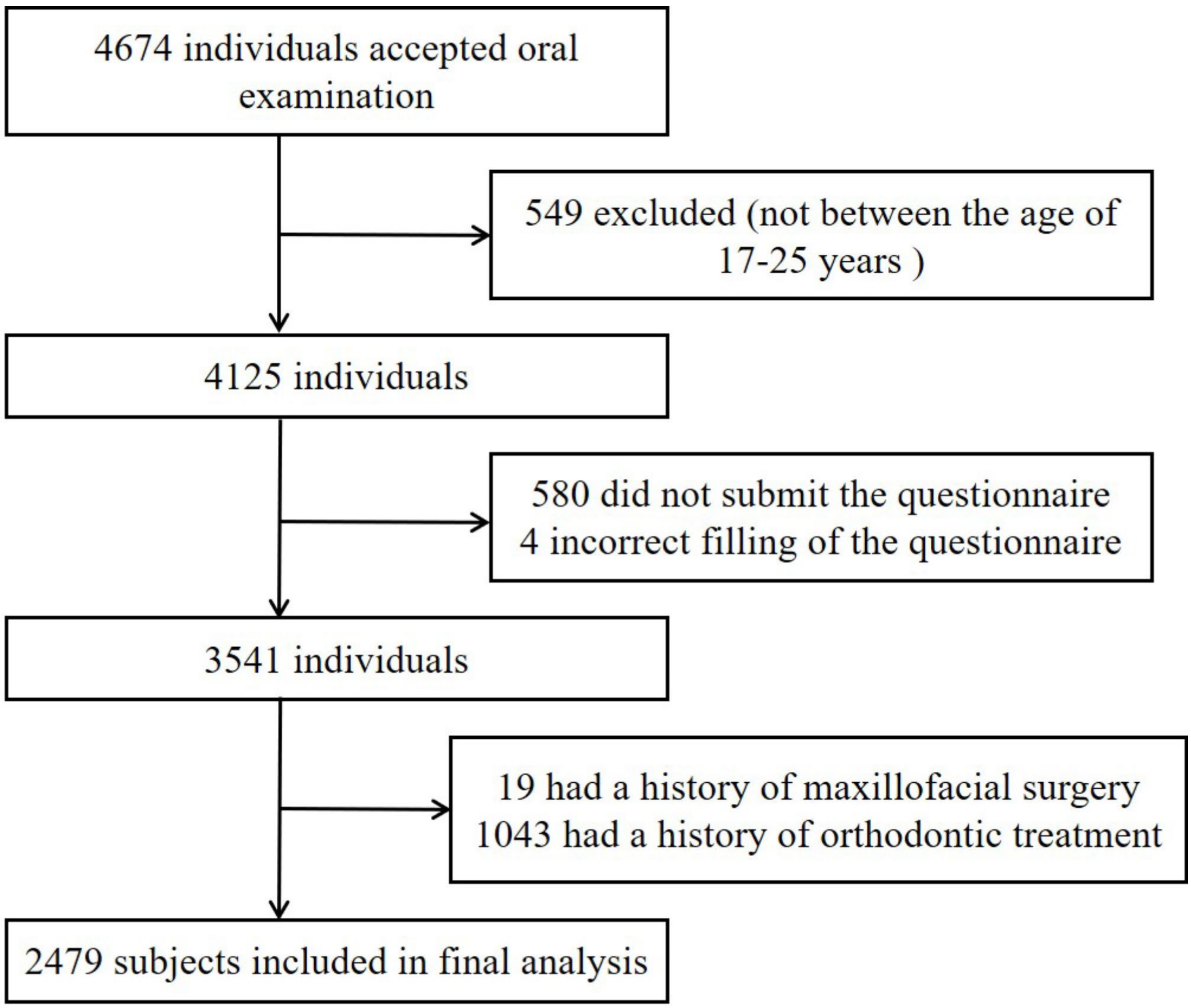

Fig. 1 Flow chat of the screening process

As displayed in Fig. 4, the median PSQI scores for both males and females with protruding profiles were 6 (IQR 5–7), compared to 5 (IQR 5–6) for males with concave or upright profiles. Figure 4B showed that the median PSQI score for males with an open bite was lower than that of those in the normal and deep overbite groups. Anterior crossbite was identified as an independent risk factor for SDs, however, there were no significant differences in the median or quartile PSQI scores among the various population groups.

Discussion

Youth is a diverse and dynamic period marked by various transformations and challenges. A 2024 study that tracked 526 individuals in early adulthood over 11 years, found that poor sleep quality during this phase was associated with diminished cognitive function in midlife [20]. Identifying risk factors and adjusting interventions accordingly can contribute to more effective strategies for improving health outcomes. However, both natural and social environmental factors are often internalized and difficult to measure, dental features are observable and can be assessed without the need for complex questionnaires or examinations.

The study represents the first investigation, to the best of our knowledge, of the relationship between dentofacial deformities and sleep quality among Chinese young adults in a large population sample. We explored the prevalence and associated factors of poor sleep quality among college students in China. With a cutoff score of 7 on the Pittsburgh Sleep Quality Index (PSQI), we found a mean total PSQI score of 5.92 (SD = 1.66) and a prevalence of SDs oof 16.3%. These figures are slightly higher than those reported in similar studies involving Chinese college students [19, 21]. Given the numerous negative health consequences associated with sleep disturbances

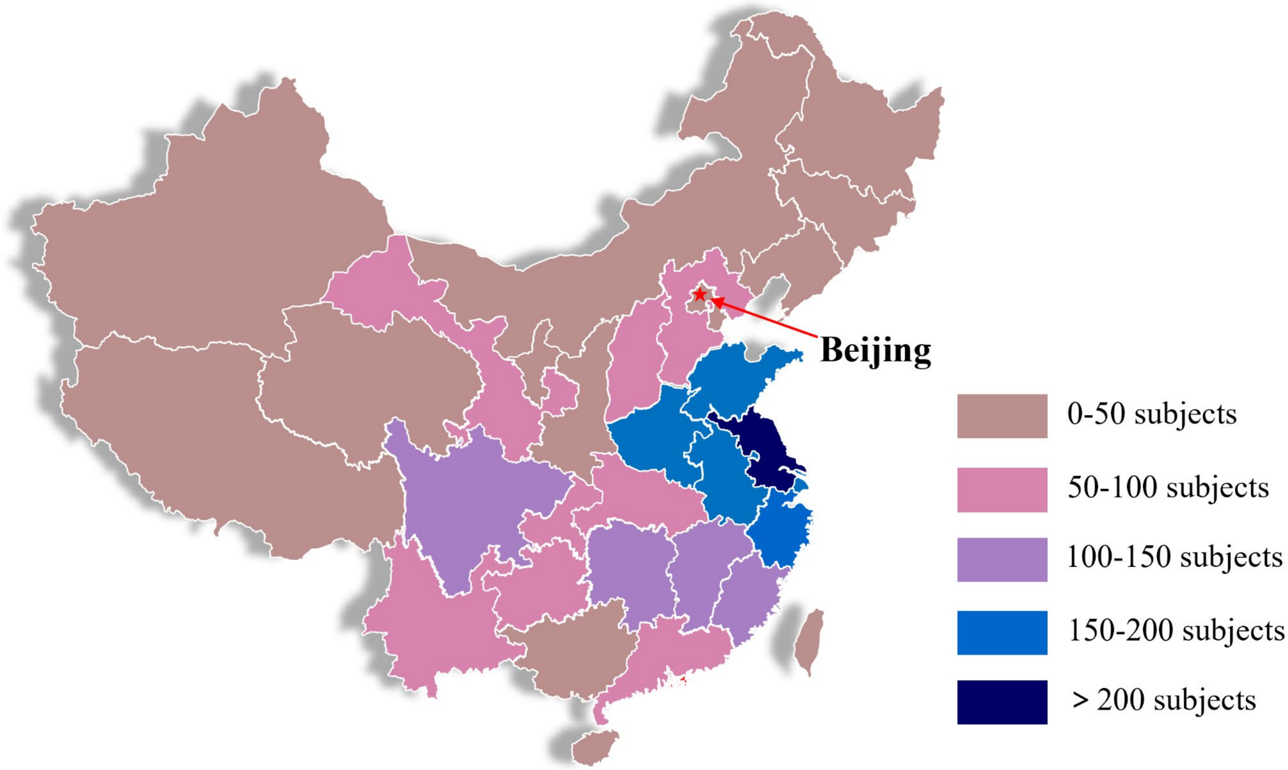

Fig. 2 The regional distribution of subjects

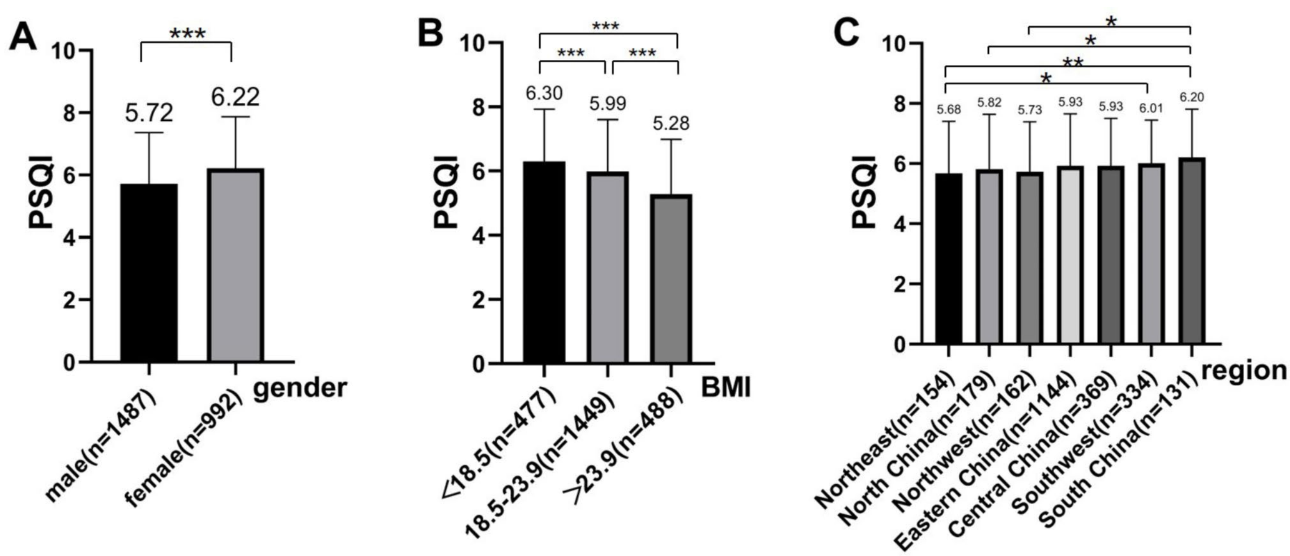

Fig. 3 The PSQI of subjects of different genders, BMI, and regions. (**A**) The PSQI of subjects of different genders. (**B**) The PSQI of subjects of different BMI. (**C**) The PSQI of subjects of different regions. * $p<0.05$, ** $p<0.01$ *** $p<0.001$

and the large number of Chinese college students, these results emphasize the importance of preventive measures and clinical attention to address sleep issues in this population.

Some risk factors were identified, including female sex, lower BMI, and residence in southern regions of China, all of which contributed to higher mean PSQI scores. Previous studies have shown that women exhibit a higher prevalence of SDs across various age groups, potentially due to hormonal or physiological changes [22–24]. Obesity is a well-established risk factor for SDB, with studies reporting significantly higher SDB risks in obese children compared to their non-obese peers [17, 25]. Interestingly, this study found that high sleep quality was significantly

Table 1 Demographic of the subjects

	PSQI ≤ 7(N = 2075)		PSQI > 7(N = 404)		
	N or median	% or IQR	N or median	% or IQR	P value
Age (years)	18	18–22	19	18–22	0.019*
Height (cm)	172	165–178	171	165–176	0.896
Weight (kg)	62	55–72	61	54–68	0.001***
BMI	20.82	18.93–23.46	20.65	18.81–22.43	0.151
Gender					
Male	1262	84.87%	225	15.13%	0.054
Female	813	81.96%	179	18.04%	

Abbreviation: BMI, body mass index; PSQI, Pittsburgh Sleep Quality Index. Independent sample T test or Chi-square test were used. *$p < 0.05$. ***$p < 0.001$

associated with increased BMI in young adults, corroborating a previous study by Gildner TE [26]. But other studies have suggested no link between BMI and sleep quality in young adults [19, 27]. Additionally, we found that geographic region plays a role in PSQI score variation, likely influenced by differences in socioeconomic status and lifestyle patterns.

In this cross-sectional study of 2479 Chinese young adults, we revealed that approximately 1093 individuals (44.36%) exhibited protruding profiles, and 169 (6.86%) had concave profiles. Abnormal anterior overbite was detected in 46.54% of subjects, and 51.11% exhibited abnormal overjet. In addition, our findings revealed associations between dentofacial deformities such as lateral facial profiles, anterior overbite and irregular alignment and poorer sleep quality. Protruding facial profiles (OR = 1.93, 95% CI 1.18–3.16) emerged as significant predictors of SDs in young adulthood after adjusting for age, sex, BMI and geographic regions by multivariate linear regression analysis. The results were not surprising given that many previous studies have linked the dentofacial deformities with SDB. Dentofacial deformities such as

Table 2 The relationship of dentofacial features and sleep quality

	PSQI ≤ 7(N = 2075)		PSQI > 7(N = 404)		
	N or median	% or IQR	N or median	% or IQR	P value
Lateral facial profile					
Concave	149	88.17%	20	11.83%	0.000***
Upright	1042	86.76%	159	13.24%	
Protruding	868	79.41%	225	20.59%	
Molar occlusion					
Class I	1540	84.15%	290	15.85%	0.639
Class II	279	83.53%	55	16.47%	
Class III	249	81.37%	57	18.63%	
Anterior overbite					
<1/3 crown	1093	82.55%	231	17.45%	0.012*
1/3 – 2/3 crown	694	85.78%	115	14.22%	
>2/3 crown	181	86.19%	29	13.81%	
Open bite	99	79.2%	26	20.8%	
Anterior overjet					
Crossbite	203	80.24%	50	19.76%	0.516
0–3 mm	992	84.71%	179	15.29%	
3–5 mm	488	83.28%	98	16.72%	
5–8 mm	215	83.98%	41	16.02%	
>8 mm	107	82.95%	22	17.05%	
Irregular alignment					
No	751	84.95%	133	15.05%	0.036*
Yes	1314	83.06%	268	16.94%	
Maxillary space or crowding					
Spacing	140	85.37%	24	14.63%	0.89
No space/crowding	815	83.59%	160	16.41%	
Mild/moderate crowding	1030	83.81%	199	16.19%	
Severe crowding	59	84.28%	11	15.71%	
Mandible space or crowding					
Spacing	143	85.11%	25	14.89%	0.857
No space/crowding	589	84.75%	106	15.25%	
Mild/moderate crowding	1249	83.16%	253	16.84%	
Severe crowding	76	83.52%	15	16.48%	

Abbreviation: PSQI, Pittsburgh Sleep Quality Index. Independent sample T test or Chi-square test were used. *$p < 0.05$. ***$p < 0.001$

Table 3 Multivariate regression analysis of risk factors for SDs

	PSQI>7(*N* = 404)		
	OR	**IC95%**	***p* value**
Lateral facial profile			
Concave	1.00	/	
Upright	1.10	0.67–1.81	0.703
Protruding	1.93	1.18–3.16	0.008**
Molar occlusion			
Class I	1.00	/	
Class II	1.03	0.75–1.42	0.850
Class III	1.29	0.94–1.77	0.119
Anterior overbite			
Open bite	1.30	0.82–2.05	0.262
<1/3 crown	1.00	/	
1/3 – 2/3 crown	0.75	0.59–0.96	0.022*
>2/3 crown	0.74	0.48–1.13	0.165
Anterior overjet			
0–3 mm	1.00	/	
3–5 mm	1.10	0.84–1.442	0.501
5–8 mm	1.05	0.72–1.53	0.786
>8 mm	1.24	0.76–2.02	0.393
Crossbite	1.44	1.01–2.04	0.043*
Irregular alignment			
No	1.00	/	
Yes	1.13	0.90–1.41	0.31
Maxillary space or crowding			
Spacing	1.00	/	
No space/crowding	1.13	0.70–1.82	0.615
Mild/moderate crowding	1.09	0.68–1.74	0.735
Severe crowding	1.13	0.52–2.48	0.753
Mandible space or crowding			
Spacing	1.00	/	
No space/crowding	0.92	0.46–1.86	0.824
Mild/moderate crowding	0.92	0.51–1.66	0.772
Severe crowding	0.98	0.55–1.74	0.950

Abbreviations: SDs, sleep disorders; PSQI, Pittsburgh Sleep Quality Index. Adjusted for age, gender, BMI and geographic region

maxillary constriction and mandibular retrognathia are believed to reduce UA dimensions and increase collapsibility, thereby increasing the risk of SDs [28, 29]. Class II skeletal malocclusion, tendencies toward the vertical type of growth, and posterolateral crossbites have been shown to directly decrease oral air space volume, further elevating the risk of OSA [30–32]. These characteristics, including vertical growth tendencies, mandibular retrognathia, Class II skeletal malocclusion, and elevated ANB angles, are generally represented as protruding profiles. Notably, our study found no significant correlation between PSQI scores and Angle's classification, which categorizes malocclusion based on the positional relationship of the first molars. Regarding anterior overjet, a known indicator of protruding profiles, a general trend was observed in which the odds ratios for SDs increased with greater overjet. However, these differences were not statistically significant, potentially due to the sample size limitations.

Growing evidence suggests a bidirectional relationship between sleep alterations and certain dentofacial features. On one hand, dentofacial deformities may be a primary cause of SDB. On the other hand, oral breathing, one of the main clinical signs of SDB, can affect oropharynx muscle tone, thereby influencing dentofacial growth [33, 34]. Numerous studies have reported a higher prevalence of malocclusion in children with SDB compared to healthy counterparts. While existing literature predominantly focuses on OSA in children and older adults, there is limited information regarding young adults. Although childhood and young adults OSA differ in certain respects [29], the potential continuum between these age groups and the overlap in risk factors remain unresolved [35]. Nevertheless, it is likely that some continuity exists in dentofacial features from childhood into young adulthood.

We also identified anterior crossbite (OR = 1.44, 95% CI 1.01–2.04) as a significant predictor of SDs in young adults. This association may stem from the fact that anterior crossbite is often linked to poor maxillary development, which can affect UA volume. A recent systematic review indicated that children with OSA may have shorter hard palates compared to their healthy peers [31] As for anterior overbite, our findings revealed that a reduced anterior overbite is associated with a higher prevalence of SDs. Deep overbite was identified as a protective factor, with only moderate overbite (OR 0.51, 95% CI 0.35–0.76, $p = 0.001$) showing statistical difference. While anterior open bite merged as a risk factor for SDs, the results were not statistically significant. We speculate that, beyond changes in mandibular position and growth direction, another explanation may involve the stomatognathic muscular chain in individuals with an open bite. In such cases, the muscular chain may exist in an abnormal state of balance, potentially influencing UA volume and compliance, and, consequently, affecting sleep breathing.

Of the 3,541 participants who completed both the examination and questionnaire, approximately 30% with a history of maxillofacial surgery or orthodontic treatment were excluded to avoid misleading results. Despite the strengths of our study, several limitations should be acknowledged. First, the cross-sectional design restricts the ability to establish a direct causal relationship between dentofacial deformities and sleep quality. Second, while this study utilized a large dataset from a nationally representative sample to ensure statistical robustness and broad applicability, the sample was not obtained through random sampling. Lastly, the use of the Pittsburgh Sleep Quality Index (PSQI) questionnaire, rather than more validated tools such as sleep

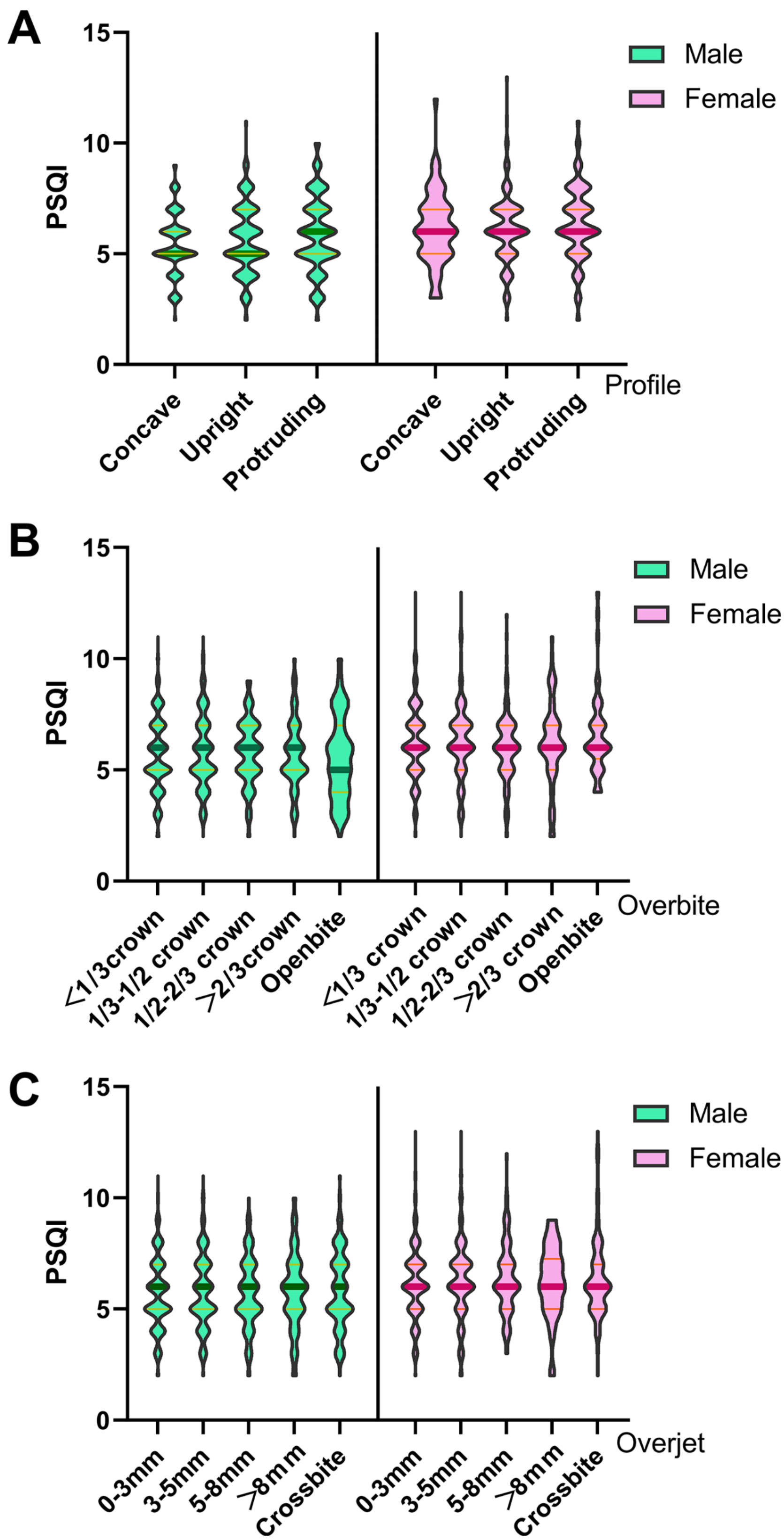

Fig. 4 The PSQI distribution of subjects of different sexes and dentofacial abnormalities. (**A**) The PSQI distribution of subjects of different profiles. (**B**) The PSQI distribution of subjects of different types of overbite. (**C**) The PSQI distribution of subjects of different types of overjet

monitoring devices, may introduce inevitably recall bias and limit our ability to ascertain the classification of SDs. Our study is exploratory, aiming to highlight the relationship between dentofacial deformities and SDs. Future research is needed to address these methodological limitations through prospective studies with larger and more diverse samples. Longitudinal and qualitative approaches will also be crucial to establish causality and clarify the potential mechanisms underlying these associations.

Conclusion

Our investigation extends prior research conducted on children to young adults, providing novel evidence of the correlation between SDs and specific types of dentofacial deformities. Our results indicate that a protruding facial profile and anterior crossbite were independent predictors of SDs in young adults. Further research is necessary to validate these findings and elucidate the underlying mechanisms. These results emphasize the importance of screening for SDs in individuals with dentofacial deformities, and suggest that addressing dentofacial abnormalities during childhood may help reduce the risk of SDs in adulthood.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12903-025-05497-2.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

YYL contributed to data analysis, manuscript writing, and oral examinations. YL contributed to data entry and analysis, as well as manuscript revisions. XFL and WYM handled questionnaire statistics and data entry. LXL provided resources, facilities, and oversight for the study. WZ contributed to data analysis and statistical guidance. BJZ and YHL managed project administration, funding acquisition and contributed to manuscript revisions. All authors have reviewed and approved the final version of the manuscript.

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Data availability

The datasets generated and analyzed during this study are included in the manuscript and its supplementary information files.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethical Committee of Shanghai Stomatological Hospital (Certificate Number 2023–011) and commenced thereafter. Written consent was obtained from all participants. The study protocol conformed to the ethical guidelines of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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