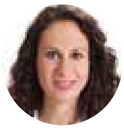
Dental health, halitosis and mouth breathing in 10-to-15 year old children: A potential connection



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Abstract

Aim The relationship between mouth breathing and dental caries, gingival inflammation, and halitosis in children is contentious with studies reporting positive and negative associations; this study aimed at investigating the effect of mouth breathing on dental, gingival health status, and halitosis.

Materials and methods An observational cross-sectional study was carried out involving 785 randomly selected children and adolescents between the ages of 10 and 15 in the city of Leipzig, Germany (LIFE Child cohort). Caries levels and gingival health status for the upper-right and the lower-left central incisors were assessed by evaluating ICDAS scores and CPI scores, respectively. A standardised questionnaire was used to assess self-reported mouth-breathing habit and halitosis.

Results This study showed a statistically significant association between halitosis and mouth breathing (OR=3.0; 95% CI: 1.5-6.2), and a significant increase in mouth breathing habit in males compared to females (59.7% vs. 40.3%; $p<0.05$). There were no statistically significant differences in ICDAS scores, orthodontic treatment, CPI scores, or socioeconomic status between the mouth and nasal-breathing groups.

Conclusion Mouth breathing habit has no effect on the prevalence of caries or gingivitis based on examining the upper-right central incisor (11) and the lower-left central incisor. However, mouth breathers showed a significant increase in halitosis compared to nasal-breathing individuals.

KEYWORD Dental caries; Gingivitis; Halitosis; Mouth breathing.

Introduction

Nasal breathing is the primary source of air intake in human beings and improves the quality of the inspired air by filtering, warming and humidifying the air leading to the protection of the airways. Mouth breathing is considered a pathological condition and could be the result of upper airway obstruction, sagging facial muscles, or just habit [Emslie et al., 1952; Hitos et al., 2013]. The prevalence of mouth breathing among children is still controversial but has so far been reported at >50%. The nose is always involved to some extent during the breathing process [Abreu et al., 2008; Yamaguchi et al., 2015], so breathing exclusively through the mouth is not covered in this study.

The effect of bacterial plaque on oral health status has been well established as it is the main cause of carious lesions, gingivitis, and halitosis. However, there are suggestions in the literature that the loss of continuous salivary flow over the marginal tissues and teeth as a result of mouth breathing may reduce local antibacterial effects of saliva or reduce the salivary cleansing action of the area leading to possible increase in dental caries, gingivitis, and halitosis [Jacobson, 1973]. It has been shown that there is no difference in salivary flow rates or the buffering capacity of saliva between nasal and mouth breathing individuals; the only difference is the evaporation of saliva leading to halitosis [Weiler et al., 2006].

Halitosis or malodor is any unpleasant odor emerging from the mouth that is detected by others [Nalçacı and Sönmez, 2008]. Halitosis may be either primary, referring to the respiration exhaled by the lungs; or secondary, originating in the mouth or upper airways [Motta et al., 2011]. Accumulation of plaque on interdental surfaces, posterior dorsum of the tongue, and subgingival areas cause bacteria to grow with odoriferous volatiles produced as the oxygen level drops to zero, leading to bad odor [Pratibha and Bhat, 2006].

The anterior segments of the mouth are the areas most often suggested for testing due to the hypothesis of increased probability of salivary evaporation causing a decrease in the buffering action of saliva, which in turn leads to an increase in caries levels and gingival irritation.

There have been many attempts to determine a causal relationship between mouth breathing and increased dental decay, gingivitis and halitosis, but this relationship has so far remained controversial [Bhatia et al., 2015, Gulati et al., 1998].

The aim of the study was to investigate the effect of mouth breathing on oral cavity by comparing the levels of dental caries, gingival inflammation, and the presence or absence of halitosis when controlling for confounders (age, gender, socioeconomic factors and orthodontic treatment) between nasal and mouth breathing children.

Materials and methods

Sample and study design

Subjects were randomly selected and recruited from the population of the German city of Leipzig. All children in the area of Leipzig were eligible to participate in the LIFE Child study. This sample is supposed to represent the population of the city of Leipzig. The LIFE Child study is part of "Leipzig research center for civilisation diseases", a prospective longitudinal population-based cohort study with the purpose of understanding the effect of environmental, metabolic, and genetic factors on growth, development, and health from foetal life to adulthood. Children and adolescents were mainly recruited through a community-based collaborative network of university hospitals, local clinics, public health centers, schools, and partner study centers; the registration office of Leipzig also sent letters to randomly selected families with children and young adolescents.

Fully informed written consent was obtained from all participants and their parents after a thorough briefing on the purpose and aim of the study. Written consent was also obtained from the children themselves at age twelve and above. The measurements were performed in a well-equipped research center located on the premises of the Leipzig University Hospital.

All assessments were based on documents outlining the standard operating procedures (SOPs) [Quante et al., 2012]. The study was designed in accordance with the Declaration of Helsinki, and the practical dental examination was reviewed by the Ethics Committee of the University of Leipzig (A2: 354-10-13122010) [WMA, 2008].

The study collected detailed information from clinical examination, questionnaires, and interviews between July 2011 and July 2014. A sample of 785 children and adolescents aged 10 to 15 years was included in the study. The number of subjects was judged to be adequate for the various categories of response expected.

Mouth breathing has been hypothesised as an aggravating factor in the development of marginal gingivitis as well as caries especially in the anterior region of the mouth, so the upper right central incisor and the lower left central incisor (teeth 11 and 31) were included and examined in this study [Jacobson, 1973]. Following visual examination of the upper right central incisor and the lower left central incisor, two groups were created depending on ICDAS scores. The first group had ICDAS score of 0 indicating sound tooth structure, and the second group showed ICDAS scores ranging between 2 and 6 indicating enamel or dentine alterations.

Examiners' briefing

Prior to the examination, the reference examiner from the Department of Conservative Dentistry at Leipzig University Hospital briefed three other examiners in a two-hour session according to a standard operating procedure (SOP). The briefing consisted of a thorough explanation of ICDAS and CPI criteria. The three examiners were given sixty clinical images to assess for smooth surfaces according to ICDAS. Based on the results of the assessment, intra-examiner reliability tests (0.87) and inter-examiner reliability (0.81–0.90) were calculated to ensure the accuracy of the examination. This briefing was held once a year for all the examiners to ensure inter-examiner reliability.

Gingival status

As for the assessment of the gingival status, probing pocket depth (PPD) was performed on the upper right central incisor and lower left central incisor. CPI criteria were used in making a generalisation on periodontal and oral hygiene status. It also gave an estimation of the periodontal treatment needs [Lewis et al., 1994]. The World Health Organization (WHO) probe was inserted into the sulcus; community periodontal Index scores (CPI) were assessed accordingly using codes varying between 0 and 4 as follows.

- Code 0: PPD <3.5 mm, no bleeding, no calculus.
- Code 1: PPD <3.5 mm, bleeding on probing.
- Code 2: no pockets >3 mm, calculus present.
- Code 3: a pocket 3.5-5.5 mm deep.
- Code 4: a pocket >5.5 mm deep.

Dental status

The distribution of carious lesions was assessed visually using modified international caries detection and assessment system (ICDAS II), and a consensus score for each site was achieved. The international caries detection and assessment system (ICDAS) is a clinical scoring system for use in dental education, clinical practice research, and epidemiology [Jablonski-Momeni et al., 2008]. The ICDAS codes are as follows.

- 0 sound tooth structure.
- 1 First visual change in enamel (seen after prolonged air drying).
- 2 First visual change in enamel (seen without air drying).
- 3 Localised enamel breakdown (without clinical visual signs of dental involvement).
- 4 Underlying dark shadow from dentine.
- 5 Distinct cavity with visible dentine.
- 6 Extensive (more than half the surface) distinct cavity with visible dentine.

Initial carious lesions (ICDAS code 1) were not considered in the analyses due to the lack of facilities to dry the teeth.

The study excluded any candidates where one or both of the teeth to be tested were missing or restored.

Self-reported questionnaire

A questionnaire consisting of objective, close-ended questions was used to gather information on age, gender, socioeconomic status (SES), and presence or absence of any type of orthodontic appliance at the time of examination. This study used the Winkler Index, which combines different socioeconomic information (household income, parent education, and occupational prestige) based on the "Adaptation of the social index for use in the child and youth health survey" [Lampert et al., 2013].

The questionnaire was standardised, validated, published, computerised and piloted. It was completed by the parents, and by the child itself at age eight or over. Whenever possible, the mother, father or even the teacher of the child were asked to answer the questionnaire separately [Quante et al., 2012].

Questions from the Child Perceptions Questionnaire (CPQ-G) were used in assessing the presence or absence of oral breathing pattern and halitosis for the last three months (options: never, scarcely, occasionally, often, and very often) [Jokovic et al., 2006].

Accuracy of the mouth breathing assessment

In order to evaluate the accuracy of assessing the mouth breathing pattern, ten mouth breathers and ten nasal breathers (a total of 20) attending Leipzig University Hospital were selected, observed, and examined first-hand by the researcher. Each subject was then tested using the mirror test [Wagaiyu and Ashley, 1991] and asked to self-report their breathing pattern to confirm the observation. This assessment was performed to calculate sensitivity and specificity giving the values of 1 and 0.87 respectively, showing a high correlation between self-report and objective mirror test.

Statistical evaluation

Data analysis was performed using the SPSS 21 Program involving chi-square test for categorical variables, and t-test for continuous variables; the level of significance was set to 5% (p<0.05). Multivariable logistics regression was used to test for an association between mouth breathing and dental caries, gingivitis, and halitosis controlling for the effects of age, gender socioeconomic status, and orthodontic treatment (OT) as possible confounders.

Results

Of the 785 children evaluated, 646 (82.3%) were categorised as nasal breathers and 139 (17.7%) as mouth breathers. Table 1 shows differences in individuals with and without a mouth breathing pattern regarding carious levels, gingivitis or halitosis. Potentially confounding variables were also considered when comparing between nasal and mouth breathing patterns among individuals.

More males were shown to suffer from a mouth breathing habit than females; this observation was statistically significant (p=0.015). No statistically significant difference was seen when performing the chi-square test in ICDAS scores, orthodontic treatment (OT), or CPI scores for the upper right central incisor and the lower left central incisor and SES between the mouth and nasal breathing groups.

Table 2 shows the statistical difference in increased ICDAS scores for the lower left central incisor in individuals undergoing OT 29.4% vs. 44.9% (p=0.002). Individuals with increased CPI scores for the upper right central incisor were shown to have a significant increase in ICDAS scores for the same tooth being tested, and individuals with increased CPI scores for tooth 31 showed a significant increase in ICDAS scores for both teeth 11 and 31 (p=0.006). There was no statistically significant difference between the two ICDAS groups for both teeth 11 or 31 regarding mean age, gender, mouth breathing pattern, halitosis or SES (p>0.05 for all correlations tested).

The multivariable logistic regression analysis for ICDAS scores for teeth 11 and 31 is presented in Table 3. Intriguingly, individuals with increased local gingivitis at the lower left central incisor showed increased ICDAS scores for both upper right central incisor and lower left central incisor at an odds ratio of 1.70 and 2.75, respectively. There was a significant increase in ICDAS scores for the lower left central incisor in individuals with OT (OR=1.72) (Table 3).

	Nasal breatwhing (n=646)	Mouth breathing (n=139)	p
Mean age (SD)	12.2 (1.54)	12.0 (1.44)	0.288
Male % (n)	48.4 (312)	59.7 (83)	0.015
11 ICDAS (score >1) % (n)	25.7 (158)	27.6 (35)	0.662
31 ICDAS (score >1) % (n)	13.5 (83)	13.4 (17)	0.979
OT % (n)	29.7 (187)	33.8 (47)	0.338
11 CPI (score 1+) % (n)	35.1 (215)	33.3 (42)	0.700
31 CPI (score 1+) % (n)	64.8 (397)	63.5 (80)	0.786
Halitosis % (n)	3.4 (22)	10.1 (14)	0.001
High SES % (n)	84.6 (428)	85.5 (94)	0.141
OT=orthodontic treatment, ns=not significant, SES=socio-economic status			

TABLE 1 Comparisons between nasal and mouth-breathing groups.

	Tooth 11 ICDAS 0 (n=596)	Tooth 11 ICDAS >1 (n=224)	p	Tooth 31 ICDAS 0 (n=704)	Tooth 31 ICDAS >1 (n=117)	p
Mean age (SD)	12.3 (1.5)	12.3 (1.5)	0.821	12.3 (1.5)	12.3 (1.4)	0.983
Male % (n)	51.1 (305)	44.4 (99)	0.088	49.2 (348)	50.0 (57)	0.877
Mouth br. % (n)	16.8 (92)	18.1 (35)	0.662	17.1 (110)	17.0 (17)	0.979.
OT % (n)	30.4 (165)	34.9 (66)	0.248	29.4 (187)	44.9 (44)	0.002
11 CPI 1+ % (n)	32.0 (189)	40.4 (90)	0.025	33.2 (233)	41.2 (47)	0.096
31 CPI 1+ % (n)	62.2 (368)	69.5 (155)	0.051	62.3 (437)	75.4 (86)	0.006
Halitosis % (n)	4.7 (26)	3.1 (6)	0.339	4.5 (29)	3.0 (3)	0.489
High SES % (n)	84.3 (397)	81.1 (150)	0.172	83.9 (473)	80.6 (75)	0.898
OT=orthodontic treatment, ns=not significant, SES=socio-economic status						

TABLE 2 Descriptive analysis for ICDAS scores for teeth 11 and 31.

	OR	95% CI	p
ICDAS 11 (>1)			
Mouth breathing	1.16	0.72 - 1.88	0.532
11 CPI 1+	1.20	0.79 - 1.80	0.391
31 CPI 1+	1.70	1.11 - 2.61	0.015
OT	1.23	0.82 - 1.84	0.310
Age	0.92	0.81 - 1.05	0.228
Male	0.83	0.57 - 1.21	0.334
Halitosis	1.14	0.71 - 1.84	0.588
SES	0.82	0.55 - 1.22	0.326
ICDAS 31 (>1)			
Mouth breathing	0.88	0.46 - 1.69	0.703
11 CPI 1+	1.25	0.74 - 2.09	0.400
31 CPI 1+	2.75	1.48 - 5.14	0.001
OT	1.72	1.03 - 2.86	0.037
Age	0.91	0.77 - 1.08	0.294
Male	1.02	0.62 - 1.67	0.930
Halitosis	0.75	0.29 - 1.90	0.703
High SES	1.09	0.66 - 1.80	0.742
OT=orthodontic treatment, ns=not significant, SES=socio-economic status			

TABLE 3 Multivariable logistic regression on ICDAS scores for teeth 11/31.

	11 CPI=0	11 CPI ≥1	p	31 CPI=0	31 CPI ≥ 1	p
Mean age (SD)	12.3 (1.5)	12.4 (1.4)	0.161	12.0 (1.5)	12.5 (1.5)	0.001
Males % (n)	46.7 (250)	54.8 153)	0.028	45.7 (134)	51.5 (269)	0.112
Mouth breathing % (n)	17.5 (84)	45.2 126)	0.70	17.6 (46)	16.8 (80)	0.786
11 ICDAS >1 % (n)*	24.9 (133)	32.3 (90)	0.025	23.3 (68)	29.6 (155)	0.051
31 ICDAS >1 % (n)*	12.5 (67)	16.8 (47)	0.096	9.6 (28)	16.4 (86)	0.006
Halitosis % (n)*	4.4 (21)	3.9 (10)	0.759	4.6 (12)	4 (19)	0.699
OT % (n)*	32.7 (155)	28.9 (73)	0.287	36.3 (95)	28.8 (134)	0.036
High SES % (n)	38.9 (169)	30.7 (67)	0.040	35.4 (86)	36.6 (150)	0.759
*Not all information was available for the whole study population of 785 children aged 10 to 15 years.						
OT=orthodontic treatment, ns=not significant, SES=socio-economic status						

TABLE 4 Summary statistics for age, gender, mouth-breathing habit, OT, gingivitis, halitosis, and SES between the two CPI groups (CPI score 0 and CPI scores ≥1) for teeth 11 and 31.

Table 4 shows a descriptive analysis for CPI scores for both teeth tested. A significant increase in CPI scores for the upper right central incisor was seen more in males (p=0.028). A significant increase in CPI scores was also observed for both teeth 11 and 31 in individuals with increased ICDAS scores for tooth 11 (p=0.025 and 0.051, respectively). CPI scores were significantly increased for the lower left central incisor in individuals with increased ICDAS scores for the same tooth. Interestingly, individuals undergoing OT showed a significant increase in CPI scores for the lower left central incisor (p=0.036).

Multivariable logistic regression (Table 5) on CPI scores for tooth 11 shows a significant increase in CPI scores for tooth 11 in individuals with increased local gingivitis for tooth 31 at an odds ratio of 4.36 (p=0.001). Multivariable logistic regression for CPI scores for tooth 31 shows that individuals with increased ICDAS for tooth 31 also had a significant increase in CPI scores for the same tooth tested at an odds ratio of 2.32 (p=0.001). An increase in CPI scores for tooth 31 showed an increase in CPI scores for tooth 11 at an odds ratio of 4.31 (p=0.001).

Table 6 shows descriptive analysis between individuals reporting halitosis and those who did not. The table shows a significant increase in halitosis levels in individuals breathing through the mouth (p=0.001).

Multivariable logistic regression for CPI scores for halitosis shows that individuals who had a mouth breathing habit also reported significantly increased levels of halitosis [Akinkugbe et al., 2016] (Table 7).

	OR	95% CI	p
CPI (1+) for tooth 11			
Mouth breathing	0.92	0.57 - 1.48	0.724
11 ICDAS >1	1.14	0.74 - 1.75	0.546
31 ICDAS >1	1.20	0.70 - 2.07	0.496
31 CPI 1+	4.36	2.80 - 6.78	0.001
Age (per year)	1.09	0.96 - 1.24	0.183
Male gender	0.73	0.51 - 1.06	0.100
Halitosis	1.43	0.56 - 3.61	0.454
OT	0.89	0.57 - 1.33	0.577
SES (high)	0.65	0.44 - 0.96	0.029
CPI scores (1+) for tooth 31			
Mouth breathing	1.20	0.74 - 1.94	0.467
11 ICDAS >1	1.46	0.94 - 2.28	0.095
31 ICDAS >1	2.32	1.25 - 4.37	0.001
11 CPI 1+	4.31	2.77 - 6.70	0.001
Age (per year)	1.29	1.14 - 1.46	0.000
Male gender	0.83	0.57 - 1.20	0.324
Halitosis	0.75	0.29 - 1.90	0.546
OT	0.74	0.49 – 1.10	0.135
SES (high)	0.31	0.27 - 0.70	0.001
OT=orthodontic treatment, ns=not significant, SES=socio-economic status			

TABLE 5 Multivariable logistic regression for CPI scores for tooth 11/31.

	No halitosis	Halitosis	p
Mean age (SD)	12.2 (1.5)	12.3 (1.7)	0.494
Male gender % (n)	50.3 (376)	52.8 (19)	0.769
Mouth breathing % (n)	16.7 (125)	38.9 (14)	0.001
11 ICDAS >1 % (n)	26.3 (187)	18.8 (6)	0.339
31 ICDAS >1 % (n)	13.6 (97)	9.4 (3)	0.489
11 CPI 1+ % (n)	34.9 (247)	32.3 (10)	0.759
31 CPI 1+ % (n)	64.7 (458)	61.3 (19)	0.699
OT % (n)	29.9 (219)	41.7 (15)	0.133
High SES % (n)	38.3 (227)	29.2 (7)	0.364
OT=orthodontic treatment, ns=not significant, SES=socio economic status			

TABLE 6 Summary statistics for individuals with and without halitosis.

	OR	95% CI	p
Mouth breathing	3.05	1.50 - 6.17	0.002
OT	1.58	0.79 - 3.18	0.196
Age	1.08	0.86 - 1.35	0.519
Male Gender	0.92	0.46 - 1.83	0.817
OT=orthodontic treatment, ns=not significant			

TABLE 7 Multivariable logistic regression for Halitosis

Discussion

There are some limitations that need to be acknowledged and considered in interpreting the results of the present study; the findings of our study were limited by the self-reporting questionnaire on breathing patterns and the presence or absence of halitosis, but not confirmed by a specific test after filling out the questionnaire. Individuals may also have been inaccurate when reporting their breathing pattern, for example, one individual may be breathing normally during the day and through the mouth at night. However, we did manage to use questions from a standardised protocol (CPQ-G) to make the results comparable even with these limitations in mind.

The findings from this study indicate that mouth breathing pattern does not influence gingival or dental health status, but already existing low oral hygiene status will increase the prevalence of having gingivitis or caries among mouth breathers. Mouth breathers also reported a significant increase in halitosis levels compared to nose breathers in this study.

Research on the effect of mouth breathing on the oral cavity has yielded conflicting results in the past. This study evaluated dental, gingival health status, and halitosis in comparison between mouth and nose breathers. The study did not confirm the hypothesis of increased carious lesions or change in periodontal status in mouth breathing individuals. ICDAS scores for the upper right central incisor and the lower left central incisor tested showed insignificant results between mouth and nasal breathing individuals, indicating no changes in carious levels or periodontal status between the two groups tested. This agrees with the results of Koga-lto et al. [2003] that mouth breathing cannot be considered a risk factor in dental caries. The methodology in our study is different from the study by Koga-Ito et al. [2003] comparing numbers of lactobacilli, Streptococcus mutans and yeasts in saliva between mouth breathers, treated mouth breathers and controls; however, both studies conclude in two different ways that mouth breathing is not a risk factor for dental caries [Koga-Ito et al., 2003].

Few studies have addressed the topic of correlation between mouth breathing and gingivitis, and even fewer studies have addressed the relationship between mouth breathing and caries. Our results are in agreement with Nascimento Filho et al. [2004] in that neither study found any statistically significant differences in caries levels between mouth and nasal breathing groups [Nascimento Filho et al., 2004]. Findings from the present study describing the lack of correlation between mouth breathing and gingivitis (CPI scores) replicate Sutcliffe's findings [1968] as there was no correlation between mouth breathing and gingivitis in children aged 13 to 14 years. Remarkably, this study included a total of 785 subjects, which is very close to Sutcliffe's study that included 870 subjects [Sutcliffe, 1968].

There is a significant association between halitosis and mouth breathing in our study. This finding is consistent with Motta et al. [2008], who suggests by way of explanation that the oral cavity becomes dry due to the evaporation of saliva when the mouth remains open causing halitosis [Motta et al., 2011]. The results from the study agree with de Menezes et al. [2007] by not showing any differences in age or socio-economic status between nose and mouth breathers. It did however show a difference in gender, as more males suffered from an oral breathing pattern than females [de Menezes et al., 2007].

The strengths of our study lie in the large representative sample size and consideration for the effect of confounders such as periodontal status and orthodontic treatment (OT) on gingival and dental health status in mouth breathing individuals. The upper right central incisor and the lower left central incisor teeth (11 and 31) were chosen to be examined as in other studies [Alexander, 1970] on the hypothesis that surface dehydration on the mucosa in the anterior part of the mouth occurs as a result of exposure to air causing a lowering of local resistance.

Our recommendation for future research is that all participants be examined by an otorhinolaryngiologist to confirm the mouth breathing pattern and more teeth in different segments in the oral cavity be tested for an accurate overview of general dental and periodontal status. The use of an oral halimetry to detect halitosis with the self-reporting question could also give more precise results [Motta et al., 2011].

In summary, the results of the present study indicate that mouth breathing does not particularly increase the prevalence of gingival inflammation or dental caries levels in the anterior segment of the mouth. It does however increase susceptibility to halitosis in children and adolescents according to our findings.

Conclusion

The effect of mouth breathing on the oral cavity in children remains controversial, and research about this topic is scarce.

This study investigated the effect of mouth breathing on the levels of dental caries, gingival inflammation, and halitosis, while controlling many cofounders such as age, gender, socioeconomic status, and orthodontic treatment, indicating a significant association between halitosis and mouth breathing but no effect on the prevalence of caries and gingivitis based on assessing two regions of the mouth by studying the upper right central incisor (11) and lower left incisor (31).

Further studies are recommended on this topic after examining the individuals by an otorhinolaryngiologist or by using halimetry to accurately diagnose the mouth breathing pattern, while possibly assessing more segments of the mouth to give an overview of the general dental and periodontal status as these were the main limitations in this study [Motta et al., 2011].

Conflict of interests

The authors declared no conflict of interest.

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