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Halitosis, Physical and Oral Health in German and International Sports Science Students

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Abstract

The purpose of this study was to assess the influence of oral and physical health and the prevalence of oral malodor among sports science students. Halitosis may indicate bacterial accumulation, which is a precursor of periodontitis, or even of whole body inflammation. This may result in an increased risk of systemic and metabolic diseases and may affect physical activity. Clinical examinations of 163 German and 144 international students included screenings of periodontal parameters (gingivitis, papillary bleeding, visible plaque, periodontal screening and recording, pocket depth), cardiovascular risk factors (C-reactive protein, interleukin-6, lipid-status), and a health check-up (electrocardiography, blood pressure, lung-function, and body composition). Oral malodor was found in 49% of German and 43% of international students and corresponded with insufficient oral hygiene and gingivitis, both of which are preconditions for future periodontitis in the participants' age range (from 18 to 41 years). While men had worse oral hygiene and periodontal status, no significant gender differences in halitosis were observed. Halitosis groups were found to have worse oral hygiene with regard to dental floss, mouthwash and tongue cleaning, as well as plaque and papillary bleeding. The comparison between national and international groups indicates a similar tendency. The main halitosis related factors are oral hygiene, inflammation and the presence of third molars.

Keywords: *Halitosis; Periodontal Disease; Oral Hygiene; Gender*

Introduction

Oral health is defined as the ability to chew a wide range of foods and to eat, to speak clearly, to have a socially acceptable smile and a corresponding dentofacial profile, to feel free of pain in the mouth and to have fresh breath [1]. Halitosis is a general term used to define an unpleasant or offensive odor that may decrease self-confidence and social interactions. Since most are adapted to their own smells, people with halitosis are often unaware of their problem [2]. Although people with halitosis cannot perceive their own malodor, people without halitosis can describe oral malodor with great accuracy [3]. According to the American Dental Association [4], 50% of adults suffer from an occasional oral malodor, including 25% experiencing chronic symptoms. The major cause for oral halitosis is poor oral hygiene due to gingivitis or periodontitis [5,6]. Non-oral factors of halitosis include tonsillitis, gastrointestinal and respiratory system problems, liver cirrhosis, chronic renal failure, diabetes mellitus, systemic or malignant diseases, and medication. Other possible extrinsic factors include a reduced salivary flow. The latter is observed in people who drink less than 0.5 liters of water daily resulting in a stronger coating on the tongue compared to subjects who drink up to 2 liters daily [7]. Further influences include smoking, mouth breathing, snoring, piercings, stress, antibiotics, alcohol and diet [7]. Halitosis regularly affects an estimated 10 - 30% of the population and people of all ages. It is clear that the proteolytic activity is mainly associated with anaerobic, gram-negative bacteria that resides on the tongue and teeth surfaces or in the periodontal pockets [8]. Malodor results from microbial breakdown of food debris, cells, saliva and blood. The agents that give rise to halitosis specifically include volatile sulphur compounds (VSC), diamines and short-chain fatty acids. Of these factors, only VSC can be detected in the clinical setting by using a halimeter [9-11].

Although halitosis has multifactorial origins, in nine out of ten cases the source can be found within the oral cavity. The most frequent intra-oral causes are tongue coating, gingivitis, and periodontitis, or a combination these [12].

Health promotion becomes increasingly important for nutrition, training and social components alike. However, although oral health may influence work efficiency, physical performance, and life quality, it often remains unconsidered. Dental health ailments include pain, effects on nutrition and mental wellbeing, in addition to increased systemic inflammatory stress. The aim of the current study was to determine the overall condition and perception of oral health, as well as to assess malodor levels. The latter was observed by measuring the volatile sulfur compounds (VSC) by using a halimeter in German and international students at the Sports Faculty in Leipzig/Germany. The prevalence of malodor/halitosis was investigated in relation to oral hygiene, oral and physical health, lifestyle, inflammatory and lipid markers, gender, and nationality (German/Non-German).

Materials and Methods

163 German students (88 females, 75 males; ages 18 to 32 years old) and 144 international students (42 females, 102 males; ages 21 to 41 years old, including Arabic, African, and South American nationalities) from the Faculty of Sports Science Leipzig participated in this study. Prior to the study, all subjects were given an explanation of the study and signed the research consent forms. This investigation was approved by the Ethics Committee of the University of Leipzig. The exclusion criteria were: acute/chronic infections, current antibiotic therapy, piercings, pregnancy, diet and chronic/systemic diseases.

All participants underwent a physical health check-up, including a lung function test, electrocardiography (ECG), anthropometric and body composition measurements, blood sampling for inflammatory parameters (interleukin-6 (IL-6), C-reactive protein (CRP), triglycerides, cholesterol, high density protein (HDL), and low-density protein (LDL)). Laboratory analyses were performed at 8:00 in the morning after a 10-hour period of overnight fasting.

The clinical dental examination was done by a single dentist to avoid inter-observer effects. None of the participants had ever been patients in the institute before. The intraoral examination, which payed special attention to periodontal tissues and plaque accumulation, was done after the halimeter measurement. The following examinations were performed: periodontal screening and recording (PSR), probing pocket depth (PPD), papillary bleeding index (PBI), visible plaque index (VPI), and gingival index (GI). The number and extent of dental restorations were also registered.

Halitosis Measurements

Breath odor was measured in the 307 students using the Halimeter RH-17, which detects volatile sulphur compounds (VSC) known to be the main components of breath odor in expired breath. VSCs include hydrogen sulphide (H_2S), methyl mercaptan (CH_3)SH, dimethyl sulphide (CH_3)2S, and dimethyl disulphide ((CH_3)S)$_2$. Calibration was focused on the main component hydrogen sulphide (H_2S). The concentration of all volatile sulphur compounds in expired breath was summarized without any precise distinctions (Ansyco GmbH). All subjects refrained from any oral cleaning activity for at least 2 hours prior to the measurement. The subjects were instructed to close their mouth for 3 minutes, breathing only through the nose before each measurement, after which a straw connected to the halimeter was placed 4 cm into their mouth for the measurement. The mean value of three consecutive measurements was used for analysis.

Values higher than 100 ppb are related to an unpleasant or offensive breath odor. An objective halitosis was defined as > 100 ppb of VSCs concentration measured by the halimeter [13-15].

Halitosis Measurements

For the 163 German students, the oral odor was assessed in combination with a specific self-reported questionnaire. All questionnaires were filled out before the oral examination to determine self-reported halitosis and other possibly linkable variables: presence of self-perceived halitosis, presence of halitosis perceived by others, presence or absence of medical and dental pathologies, allergies, oral hygiene practices, experience with oral malodor, medication, stress level, smoking, physical discomfort, psychological discomfort, physical disability and social disability. No questionnaire was performed on the international groups due to language barriers.

Statistical analyses

All data are presented as means ± SD. The group analyses were done using the Mann-Whitney U-test. Additionally, independent Student's t-tests were used for determining the significance of mean differences between the groups. A p-value of $p < 0.05$ was considered to indicate significance, and $p < 0.005$ as very significant.

Results

Gender differences in German students

88 female and 75 male students were enrolled in the study. Biometric data, inflammatory parameters, blood lipid and periodontal parameters are shown in table 1. Male participants had a higher BMI and lower values of s-CRP, cholesterol, and HDL than female participants ($p < 0.0001$). The systolic blood pressure and fat mass in males were both lower ($p < 0.009$ and $p < 0.0001$) and weight, height, and cell mass were higher ($p < 0.0001$). No differences were found in the lung function parameters. Halimeter measurements showed no significant gender differences. Females had a value of 136.19 ± 120.63 ppb, and males of 132.56 ± 96.05 ppb. Values above 100 ppb indicate oral malodor. The male students had significantly more present teeth and calculus ($p < 0.0005$; $p < 0.005$), a higher PSR ($p < 0.01$), visible plaque index ($p < 0.0004$) and gingival index ($p < 0.0001$). Concerning papillary bleeding, the male group had a higher number of teeth with a papillary bleeding score of 3 ($p < 0.009$) (Table 1). No gender dependent differences were found regarding the number of fillings, filling material, and filling extent. No periodontal disease was found in the groups. However, notable gender dependent differences were found in oral hygiene behavior: daily teeth-brushing and weekly use of dental floss was reported at a higher rate in the female group ($p < 0.0006$ and $p < 0.01$).

	Females	Males	p-value
N	88	75	
Age, years	22.58 ± 2.81	22.05 ± 3.17	n.s.
Height, cm	169 ± 0.06	181 ± 0.07	***
Weight, kg	61.29 ± 7.17	74.99 ± 7.03	***
Cell mass, %	39.05 ± 2.82	46.72 ± 2,78	***
Fat mass, %	24.87 ± 4.37	16.04 ± 3.97	***
BMI, kg/m^2	21.53 ± 1.91	22.98 ± 1.63	***
Heart rate, bpm	65.4 ± 10.3	62.1 ± 10.7	n.s.
Systolic blood pressure, torr	122 ± 12.7	125 ± 11.5	**
Diastolic blood pressure, torr	77 ± 8.81	75 ± 9.11	n.s.
C-reactive protein, mg/l	1.87 ± 3.56	0.55 ± 0.40	***
Interleukin-6, pg/l	2.48 ± 2.55	1.98 ± 0.80	n.s.
Triglycerides, mmol/l	0.91 ± 0.44	0.79 ± 0.30	n.s.
Cholesterol, mmol/l	4.64 ± 0.76	4.10 ± 0.67	***
High density lipoprotein, mmol/l	1.95 ± 0.44	1.48 ± 0.27	***
Low density lipoprotein, mmol/l	2.53 ± 0.69	2.42 ± 0.68	n.s.
Halimeter value, ppb	136.19 ±120.63	132.56 ± 96.05	n.s.
No. of teeth	28.33 ± 1.61	29.34 ± 1.75	***
Calculus, %	33	53	**
Mean PSR	0.11 ± 0.18	0.17 ± 0.16	**
Visible plaque index	1.09 ± 0.69	1.53 ± 0.75	***
Visible plaque on all teeth, %	35	47	n.s.
Gingival index	0.26 ± 0.51	0.66 ± 0.72	***
Papillary bleeding score 1, average no. of teeth	1.68 ± 2.08	2.22 ± 2.25	n.s.
Papillary bleeding score 2, average no. of teeth	3.24 ± 3.63	3.68 ± 3.16	n.s.
Papillary bleeding score 3, average no. of teeth	0.30 ± 0.81	0.74 ±1.34	**
Papillary bleeding score 4, average no. of teeth	0.05 ± 0.27	0.22 ± 0.69	n.s.

Table 1: Baseline characteristics and periodontal status of the German sports science students according to gender; *p < 0.05, **p < 0.01, ***p < 0.005, n.s.= Not Significant.

No differences were found in the history of diseases or discomfort (sinusitis: females (F): 18.2% (n = 16), males (M): 25.3% (n = 19); lung diseases: F: 23.9% (n = 21), M: 26% (n = 20); stomach complaints: F: 18.2% (n = 16), M: 16% (n = 12).

Differences between the German students groups with or without oral malodor

80 German students (49%, mean age: 22.64 ± 3.1 years) had halimeter values higher than 100 ppb (197.60 ± 128.73 ppb) and 5 female and 7 male participants had halimeter values higher than 250 ppb (mean average: 414.83 ± 216.63 ppb). The remaining 83 students (mean age: 22.45 ± 2.85 years) had an average value of 73.72 ± 13.47 ppb. No significant differences were found in age, weight or inflammatory markers between the German groups with or without oral malodor. The German group with halimeter values above 101 had a significantly higher BMI ($p < 0.01$) and lower triglycerides ($p < 0.05$) (Table 2). No differences were found in the body composition,

	Halitosis	No halitosis	p-value
N	80 (43 F, 37 M)	83 (45 F, 38 M)	
Age, years	22.63 ± 3.12	22.05 ± 2.85	n.s.
Halimeter value, ppb	197.6 ± 128.7	73.7 ± 13.5	***
BMI kg/m^2	22.52 ± 1.9	21.89 ±1.9	**
Height, cm	1.74 ± 0.09	1.74 ± 0.08	n.s.
Weight, kg	68.53 ± 9.80	66.7 ± 9.94	n.s.
Cell mass, %	42.12 ± 4,81	43.02 ± 4.70	n.s.
Fat mass, %	21.73 ± 6.10	19.94 ± 5.99	n.s.
C-reactive protein mg/l	1.26±3.27	1.26±2.03	n.s.
Interleukin-6, pg/l	1.96 ± 0.76	2.53 ± 2.64	n.s.
Triglyceride, mmol/l	0.80 ± 0.38	0.91 ± 0.39	*
Cholesterol, mmol/l	4.38 ± 0.68	4.41 ± 0.85	n.s.
High density lipoprotein, mmol/l	1.78 ± 0.4	1.69 ± 0.48	n.s.
Low density lipoprotein, mmol/l	2.42 ± 0.56	2.54 ± 0.79	n.s.
No. of teeth	29.1 ± 1.9	28.4 ± 1.5	**
Tooth 1	0.36 ± 0.48	0.21 ± 0.41	*
Tooth 16	0.36 ± 0.48	0.23 ± 0.43	n.s.
Tooth 17	0.33 ± 0.47	0.2 ± 0.4	n.s.
Tooth 32	0.33 ± 0.47	0.17 ± 0.38	*
Mean PSR	0.14 ± 0.19	0.13 ± 0.16	n.s.
Gingival index	0.43 ± 0.62	0.45 ± 0.65	n.s.
Self detected tongue coating, %	23	31	n.s.
Dental flossing, n per week	1.01 ± 2.08	1.75 ± 3.02	n.s.
Tooth cleaning, n per day	1.99 ± 0.41	2.09 ± 0.38	n.s.
Tongue cleaning, %	23	41	**
Mouthwash, n per week	0.83 ± 1.82	2.28 ± 3.95	*
Stress at university, %	16.3	23	n.s.
Stress frequency	1.84 ± 0.58	1.90 ± 0.62	n.s.
Gingival bleeding, %	11	11	n.s.
Stomach trouble, %	18.8	16.9	n.s.
Xerostomia, %	6.3	7.2	n.s.
Rhinitis, %	38	30	n.s.
Allergy, %	29	31	n.s.
Self detected halitosis, %	20	12	n.s.
Sinusitis, %	29	18	n.s.
Pulmonary complaints, %	23.8	26.5	n.s.
Social problems due to halitosis, %	3.8	2.4	n.s.

Table 2: Inflammatory, blood lipid, dental and oral hygiene parameters, and complaints from the German sports science students according to halitosis F: Females, M: Males, *p < 0.05, **p < 0.01, ***p < 0.005, n.s.= Not Significant, Stress Frequency: 1= Little, 2= Average, 3= Much, 4= Very Much.

respiratory parameters, heart rate or blood pressure. No students were on a diet. 6 of the 80 German students with oral malodor were smokers (less than 7 cigarettes per day). In the German group without oral malodor, 6 students smoked less than 7 cigarettes daily, and 3 less than 13 cigarettes. The group with oral malodor had a significantly higher number of teeth ($p < 0.006$) and the presence of the third molar 1 ($p < 0.04$) and 32 ($p < 0.02$). The results for the other two third molars were not significant (Table 2). No differences were seen in the gingival index, plaque amount and plaque index, papillary bleeding index, mean of periodontal screening and recording, number of fillings, filling material, filling extent, former orthodontic treatment, or presence of calculus. A significant number of German students without malodor had a retainer after a former orthodontic treatment ($p < 0.03$).

The German students without oral malodor reported significantly more frequent use of mouthwash ($p < 0.04$) and daily tongue cleaning ($p < 0.01$) than the other group. No statistical differences were seen in the mean frequency of teeth-brushing or the use of dental floss (Table 2). The rate of self-reported halitosis was 20% (n = 16) in the German halitosis group and 12% (n = 10) in the German group without halitosis.

Gender differences in international students

42 female and 102 male students were enrolled in the study. Biometric data, inflammation, blood lipid and periodontal parameters are shown in table 3.

	Females INT	Males INT
N	42	102
Age, years	29.91 ± 5.23	31.85 ± 4.48
Height, cm	166 ± 0.07	176 ± 0.08
Weight, kg	63.84 ± 9.61	77.81 ± 11.71
Cell mass, %	35.80 ± 3.69	41.30 ± 3.63
Fat mass, %	29.32 ± 6.17	22.97 ± 5.02
BMI, kg/m^2	23.05 ± 3.25	25.22 ± 3.16
Heart rate, bpm	66.48 ± 11.14	66.48 ± 9.11
Systolic blood pressure, torr	117 ± 8.91	125 ± 12.23
Diastolic blood pressure, torr	76 ± 6.76	81 ± 8.69
C-reactive protein, mg/l	1.15 ± 1.47	1.75 ± 2.06
Triglycerides, mmol/l	0.86 ± 0.64	1.16 ± 0.55
Cholesterol, mmol/l	3.98 ± 0.64	4.31 ± 0.81
High density lipoprotein, mmol/l	1.54 ± 0.37	1.29 ± 0.32
Low density lipoprotein, mmol/l	2.19 ± 0.52	2.63 ± 0.77
Halimeter value, ppb	99.67 ± 66,19	159 ± 146.66
No. of teeth	29.68 ± 1.91	29.79 ± 2.17
Calculus, %	58	67
Mean PSR	0.82 ± 1.16	0.92 ± 1.03
Visible plaque index	1.85 ± 0.81	2.03 ± 0.82
Visible plaque on all teeth, %	51	55
Gingival index	0.86 ± 1.06	1.14 ± 1.09
Papillary bleeding score 1, average no. of teeth	0.79 ± 1.41	0.68 ± 1.26
Papillary bleeding score 2, average no. of teeth	3.38 ± 3.25	4.03 ± 3.77
Papillary bleeding score 3, average no. of teeth	1.53 ± 2.84	1.53 ± 2.77
Papillary bleeding score 4, average no. of teeth	0.74 ± 2.08	0.65 ± 1.56

Table 3: Baseline characteristics and periodontal status of the international sports science students according to gender.

Differences between the international groups with or without oral malodor

A total of 60 international students (43%) had halimeter values higher than 100 ppb (236.4 ± 160.01 ppb), while 1 female and 15 male international participants had halimeter values higher than 250 ppb (mean average: 443.94 ± 180.79 ppb). The remaining 80 students had an average value of 74.10 ± 17.4 ppb. No significant differences were found in age, weight, cell and fat mass, level of high density lipoprotein, or the number of teeth between the international groups with or without oral malodor. The international group with halimeter values above 101 had a significantly higher BMI ($p < 0.03$), heart rate ($p < 0.04$), blood pressure (systolic: $p < 0.01$; diastolic: $p < 0.003$), level of C-reactive protein ($p < 0.02$), triglycerides ($p < 0.01$), cholesterol ($p < 0.02$), low density protein ($p < 0.003$), more calculus ($p < 0.001$), visible plaque ($p < 0.0001$), a significantly higher mean of periodontal screening and recording ($p < 0.0003$), gingival index ($p < 0.0001$), papillary bleeding index (from $p< 0.01$ up to $p < 0.0007$) and the number of broken teeth ($p < 0.04$) (Table 4). The international group with oral malodor had a significantly higher number of participants with a present third molar 1 ($p < 0.02$) and 16 ($p < 0.03$). The results for the other two third molars were not significant (Table 4).

	Halitosis INT	No halitosis INT	p-value INT	p-value GER
N	60 (10 F, 50 M)	84 (32 F, 52 M)		
Age, years	31.72 ± 4.42	31.05 ± 5	n.s.	n.s.
Height, cm	174 ± 0.09	172 ± 0.09	n.s.	n.s.
Weight, kg	76.84 ± 12.49	71.58 ± 12.62	***	n.s.
Cell mass, %	39.91 ± 4.53	39.53 ± 4.38	n.s.	n.s.
Fat mass, %	24.85 ± 5.85	24.80 ± 6.33	n.s.	n.s.
BMI	25.32 ± 3.4	24.09 ± 3.1	*	*
Heart rate, bpm	68.18 ± 8.91	65.24 ± 3.07	*	n.s.
Systolic blood pressure, torr	125.23 ± 11.50	120.30 ± 11.75	*	n.s.
Diastolic blood pressure, torr	82.23 ± 8.92	78.24 ± 7.78	***	n.s.
C-reactive protein, mg/l	1.9 ± 2.12	1.34 ± 1.74	*	n.s.
Triglycerides, mmol/l	1.16 ± 0.53	1.01 ± 0.63	*	*
Cholesterol, mmol/l	4.43 ± 0.83	4.07 ± 0.71	*	n.s.
High density lipoprotein, mmol/l	1.32 ± 0.34	1.39 ± 0.36	n.s.	n.s.
Low density lipoprotein, mmol/l	2.74 ± 0.83	2.34 ± 0.62	***	n.s.
Halimeter value, ppb	236.4 ±160	74.10 ± 17.4	***	***
No. of teeth	29.33 ± 2.29	29.64 ± 1.96	n.s.	**
Calculus, %	80	54	***	n.s.
Mean PSR	1.27 ± 1.14	0.65 ± 0.95	***	n.s.
Visible plaque index	2.30 ± 0.78	1.76 ± 0.77	***	n.s.
Visible plaque on all teeth, %	64	48	n.s.	n.s.
Gingival index	1.54 ± 1.07	0.72 ± 0.97	***	n.s.
Papillary bleeding index 2, average no. of teeth	5.10 ± 3.73	3.01 ± 3.34	***	n.s.
Papillary bleeding index 3, average no. of teeth	2.37 ± 3.4	0.96 ±2.10	**	n.s.
Papillary bleeding index 4, average no. of teeth	1.06 ± 2.11	0.41 ± 1.32	*	n.s.
No. of broken teeth	0.34 ± 0.76	0.22 ± 1.03	*	n.s.
Tooth 1	0.78 ± 0.43	0.59 ± 0.49	*	*
Tooth 16	0.78 ± 0.42	0.61 ± 0.49	*	n.s.
Tooth 17	0.74 ± 0.44	0.63 ± 0.48	n.s.	n.s.
Tooth 32	0.72 ± 0.45	0.57 ± 0.50	n.s.	*

Table 4: Baseline characteristics, periodontal and dental status of the international students (INT) according to halitosis and the significances (p-value INT) in comparison to the significances between the German groups (p-value GER). F: Females, M: Males, *p < 0.05, **p < 0.01, ***p < 0.005, n.s.= Not Significant.

The international students without malodor had significantly more amalgam fillings ($p < 0.02$) and single-faced fillings ($p < 0.02$) than the international students with oral malodor. No significances were found in these groups concerning multi-surface and composite fillings. No differences were found in the pulmonary/ventilatory parameters.

Differences between the international and German students with halitosis

No notable differences between the international and German students with halitosis were found in the number of teeth, halimeter values, systolic blood pressure, or cholesterol. All other measured parameters showed significant or very significant differences (Table 5).

	Halitosis INT	Halitosis GER	p-value
N	60	80	
Ceight, kg	76.84 ± 12.49	68.52 ± 9.74	< 0.0001
BMI	25.52 ± 3.39	22.51 ± 1.90	< 0.0001
Fat mass, %	24.85 ± 5.85	21.73 ± 6.10	< 0.002
Cell mass, %	39.91 ± 4.53	42.12 ± 4.80	< 0.007
Heart rate, bpm	68.18 ± 8.91	62.79 ± 10.87	< 0.0007
Systolic blood pressure, torr	125.23 ± 11.5	128.29 ± 52.51	n.s.
Diastolic blood pressure, torr	82.23 ± 8.92	75.62 ± 9.53	< 0.0001
C-reactive protein, mg/l	1.9 ± 2.12	1.26 ± 3.27	< 0.0001
Triglycerides, mmol/l	1.16 ± 0.53	0.80 ± 0.38	< 0.0001
Cholesterol, mmol/l	4.43 ± 0.83	4.38 ± 0.68	n.s.
High density lipoprotein, mmol/l	1.32 ± 0.34	1.78 ± 0.95	< 0.0001
Low density lipoprotein, mmol/l	2.74 ± 0.82	2.42 ± 0.56	< 0.02
Halimeter value, ppb	236.4 ± 160.01	197.60 ± 128.73	n.s.
No. of teeth	29.33 ± 2.29	29.07 ± 1.88	n.s.
Calculus, %	0.80 ± 0.38	0.39 ± 0.48	< 0.0001
Mean PSR	1.27 ± 1.14	0.14 ± 0.19	< 0.0001
Visible plaque index	2.30 ± 0.78	1.36 ± 0.80	< 0.0001
Gingival index	1.54 ± 1.07	0.43 ± 0.62	< 0.0001
Papillary bleeding index 2, average no. of teeth	5.10 ± 3.73	3.57 ± 3.36	< 0.02
Papillary bleeding index 3, average no. of teeth	2.37 ± 3.40	0.56 ± 1.15	< 0.0009
Papillary bleeding index 4, average no. of teeth	1.06 ± 2.11	0.19 ± 0.61	< 0.001
Tooth 1	0.78 ± 0.43	0.36 ± 0.48	< 0.0001
Tooth 16	0.78 ± 0.42	0.36 ± 0.48	< 0.0001
Tooth 17	0.74 ± 0.44	0.33 ± 0.47	< 0.0001
Tooth 32	0.72 ± 0.45	0.33 ± 0.47	< 0.0001

Table 5: Baseline characteristics, periodontal and dental status of the international (INT) and German students (GER) with halitosis.

Differences between the international and German students without halitosis

No significant differences between the international and German students without halitosis were found in the following parameters: heart rate, halimeter value, diastolic blood pressure, C-reactive protein, triglycerides, low density protein, presence of calculus, gingival and papillary bleeding index. All other measured parameters showed significant differences (Table 6).

	No halitosis INT	No halitosis GER	p-value
N	84	83	
Weight, kg	71.58 ± 12.62	66.70 ± 9.94	< 0.02
BMI, kg/m^2	24.09 ± 3.07	21.89 ± 1.91	< 0.0001
Fat mass, %	24.80 ± 6.33	19.94 ± 6.0	< 0.0001
Cell mass, %	39.53 ± 4.38	43.02 ± 4.70	< 0.0001
Heart rate, bpm	65.24 ± 10.12	64.87 ± 10.08	n.s.
Systolic blood pressure, torr	120.30 ± 11.75	123.93 ± 11.29	<0.03
Diastolic blood pressure, torr	78.24 ± 7.78	76.43 ± 8.50	n.s.
C-reactive protein, mg/l	1.34 ± 1.74	1.26 ± 2.03	n.s.
Triglycerides, mmol/l	1.01 ± 0.62	0.91 ± 0.39	n.s.
Cholesterol, mmol/l	4.07 ± 0.70	4.41 ± 0.84	< 0.01
High density lipoprotein, mmol/l	1.39 ± 0.36	1.69 ± 0.48	< 0.0001
Low density lipoprotein, mmol/l	2.34 ± 0.61	2.54 ± 0.79	n.s.
Halimeter value, ppb	74.10 ± 17.34	73.72 ± 13.47	n.s.
No. of teeth	29.64 ± 1.96	28.44 ± 1.48	< 0.0001
Calculus, %	0.54 ± 0.49	0.42 ± 0.48	n.s.
Mean PSR	0.65 ± 0.95	0.13 ± 0.16	< 0.004
Visible plaque index	1.76 ± 0.77	1.22 ± 0.70	< 0.0001
Gingival index	0.72 ± 0.97	0.45 ± 0.65	n.s.
Papillary bleeding score 2, average no. of teeth	3.01 ± 3.34	3.15 ± 3.29	n.s.
Papillary bleeding score 3, average no. of teeth	0.96 ± 2.10	0.37 ± 0.86	n.s.
Papillary bleeding score 4, average no. of teeth	0.41 ± 1.32	0.07 ± 0.42	n.s.
Tooth 1	0.59 ± 0.49	0.21 ± 0.41	< 0.0001
Tooth 16	0.61 ± 0.49	0.23 ± 0.43	< 0.0001
Tooth 17	0.63 ± 0.48	0.20 ± 0.40	< 0.0001
Tooth 32	0.57 ± 0.50	0.17 ± 0.38	< 0.0001

Table 6: Baseline characteristics, periodontal and dental status of the international and German students without halitosis.

Discussion

The prevalence of halitosis has been studied in different populations all over the world with a variety of techniques and cut-offs, but it is still not well established. Most of the prevalent studies are based on self-perceived breath odor and do not correlate well with other halitosis measurements [16]. Instrumental measurements of halitosis may give an objective and exact value for halitosis, but it is important to note that different studies have used various threshold levels for halitosis. Values higher than 100 ppb indicate an unpleasant or offensive odor emanating from the breath. An objective halitosis was defined as > 100 ppb of VSCs concentration measured by halimeter. In the current study the threshold of VSC values ≥ 101 ppb was chosen. The group of participants with VSC values ≤ 97 ppb was defined as no halitosis. People with VSC values from 98 to 101 were excluded from the evaluation.

Fitness, leisure and professional athletes as well as trainers must pay special attention to oral health. Isotonic and sweet drinks as well as food influence oral hygiene and can be responsible for the development of plaque, halitosis and inflammation. According to the Food and Agriculture Organization of the United Nations [17,18], increasing urbanization and lifestyle changes lead to increasingly unhealthy dietary habits in the population. Such poor habits include the consumption of food with low micronutrient and fiber values and the intake of too much sugar, fat and energy. This also has an effect on the mouth and tooth flora, oral hygiene and mouth odor.

In the current study the rate of self-reported halitosis was 20% in the German students with halitosis and 12% in the group without halitosis. Based on these numbers, the results indicate that there is no relevant relationship between self-reported halitosis and objective measurements. It appears that self-reported halitosis is an insufficient measurement of objective oral malodor. Halitosis measurements should always be performed together with the usual questionnaires for scientific purposes.

Clinical investigations in patients with halitosis revealed that in 90% of cases the source for malodor can be found within the oral cavity. The main sources were tongue coating, gingivitis/periodontitis or a combination of those two. Periodontal diseases affect around half of the adult population all over the world.

Periodontal diseases are characterized by inflammation, bacteremia, a strong immune response, and progressive destruction of connective tissue attachments and bones. It is speculated that a continuous, long-term exposure of oral bacteremia and bacterial toxins induce immune responses which may contribute to atherosclerosis, and, in conjunction with other risk factors, may lead to coronary heart disease and myocardial infarction. Periodontal disease may initiate pathological changes in blood vessel walls and act as a precursor for atherosclerosis in susceptible hosts. Periodontal disease may represent one of several possible causal factors for heart diseases to occur. The role of periodontal disease in the etiology of cardiovascular disease (CVD) has recently received more attention. The link between inflammation and CVD appears to be firmly established [19-21].

Cardiovascular diseases (CVD) are the leading cause of mortality in the United States, the Western World, and in developing and developed countries. Inflammation is currently recognized as a common pathway for the major complications of atherosclerosis, strokes, and ischemic heart disease [22].

Health care often neglects the aspect of dental health and the chronic effects of oral diseases and their long-term systemic effects. For example, clinical trials suggest a threefold increase in stroke risk and double myocardial infarction risk in people with periodontal disease. Oral hygiene/oral health is the third pillar of the otherwise primarily movement-/nutrition-oriented and psychological health promotion.

In the current study, halitosis was measured in comparison to inflammation and general and oral/periodontal health parameters. The results for halitosis and oral status in sport science students are discussed on the base of CVD modifiable risk factors, which are inflammation, hyperlipidemia, hypertension, and obesity (BMI).

Differences between the international and German students without halitosis

The German group with halitosis showed no significant difference in the C-reactive protein values (CRP) when compared to the no halitosis group, but had a higher mean score of periodontal screening and recording (PSR, $p < 0.009$). The group with oral malodor had a higher number of teeth ($p < 0.006$) due to a higher number of participants with a present third molar 1 ($p < 0.04$) and 32 ($p < 0.02$), cleaned their tongue less ($p < 0.01$), and used less mouthwash ($p < 0.04$). In the case of an incomplete or obliquely perforated wisdom tooth, niches, which are difficult to reach and clean, are present. Generally, wisdom teeth may be a cause of oral malodor. Bacteria and food debris can be deposited there and lead to inflammation. Inflammatory swelling of the gingiva increases the depth of the tissue, which in turn results in an increase in the odor-forming anaerobic bacteria and thus promotes halitosis. In addition, brushing the teeth on the right side of the upper and lower jaws is more difficult for right-handed people because they must turn their wrist, and in general the posterior mouth area is more difficult to access. This indicates the importance of a proper cleaning of the posterior pharynx.

Though there was no difference in the mean use of dental floss, 39.7% of the students without halitosis used floss 4.58 ± 3.96 times per week, vs 27.5% with halitosis 3.83 ± 2.68 times per week. This indicates that the use of dental floss is one factor related to oral malodor.

The international group with halitosis had higher levels of CRP values ($p < 0.02$), calculus ($p < 0.001$), mean average of PSR ($p < 0.0003$), visible plaque ($p < 0.0001$), gingival index ($p < 0.0001$), papillary bleeding and broken teeth when compared to the international students without halitosis. The third molars 1 and 16 were significantly more present in the international halitosis group, whereas the

total number of teeth showed no significant difference. In total, the signs of inflammation were more frequent and severe. The higher plaque index ($p < 0.0001$) revealed a worse oral hygiene performance. Although the moderately increased CRP levels, halitosis, and gingival inflammation in the current study coincide, the absolute CRP values were clinically not significant. However, this coincidence may be an early sign of developing periodontitis and chronic inflammation. Inflammation and bacteria at a systemic low-grade level, when repeated acutely and aggravated chronically over many years, can theoretically provide severe cumulative damage to systemic health. It is suggested that even mild increases in CRP enhance cardiac risk, the small elevations in CRP elicited by periodontal disease might be considered as a potential cardiac risk factor [23-27].

Lipid status and blood pressure

The international group with halitosis and a worse oral and periodontal status showed significantly higher triglyceride, cholesterol, and LDL levels than the international group without halitosis. The ratio LDL : HDL was 2.08 and 1.68 in the subjects with and without halitosis, respectively. The increase of lipid factors was significant in the halitosis group, though not clinically significant [28]. The international halitosis group had increased systolic and diastolic blood pressure values. Yet these values had no clinical significance.

Differences between all groups concerning the BMI and oral status

Poor oral health has previously been related to high body mass index (BMI). Plaque index, reflecting dental plaque, and probing pocket depth closely linked with periodontal inflammation and infection, were statistically associated with high BMI and obesity [29].

The factors which may be related to halitosis are compared in table 7 between the German and international groups.

	Halitosis GER	No halitosis GER	Halitosis INT
Halitosis INT	BMI, weight, fat mass: ↑↑ Cell mass: ↓↓ PSR, VPI, GI, PBI: ↑↑	BMI, weight, fat mass: ↑↑ Cell mass: ↓↓ PSR, VPI, GI, PBI: ↑↑	_____
No halitosis INT	BMI, fat mass: ↑↑ Cell mass: ↓↓ PSR, VPI: ↑↑	BMI, fat mass: ↑↑, weight: ↑ Cell mass: ↓↓ PSR, VPI: ↑↑	Weight: ↓↓ BMI: ↓ PSR,VPI,GI,PBI: ↓↓

Table 7: BMI and oral status - comparison between the groups (GER: German Group; INT: International Group). Significant differences concerning BMI, weight, fat and cell mass, and the oral/periodontal parameters: PSR: Mean Periodontal Screening and Recording; VPI: Visible Plaque Index; GI: Gingival Index; PBI: Papillary Bleeding Index. The direction of the arrows refers to the international groups (left column); one arrow= significant, two arrows= very significant.

The subjects in the current study were not obese, but the international students with halitosis had a higher BMI, weight, and fat mass together with a lower cell mass than the German students with or without halitosis. Additionally, the international students with halitosis had a higher BMI, fat mass and lower cell mass than the international group without halitosis. This corresponds with Rosenberg., *et al.* [30] who found a correlation between BMI and oral malodor. Considering all factors together, it appears that indicators of inflammation such as GI and PBI are the main determining factors for halitosis.

Plaque index, reflecting dental plaque, and probing pocket depth, closely linked with periodontal inflammation and infection, were statistically associated with high BMI and obesity [29].

Health care often neglects the aspect of dental health and the chronic effects of oral diseases and their long-term effects, performance impairment and systemic effects on organs. Together with periodontal inflammation and halitosis, an increase in systemic risk factors was found.

Age

There are contradictory reports on the influence of age on halitosis: some studies showed a correlation with increasing age [16,31], whereas others did not [32,33]. In the current study the mean age between the German and international groups differed significantly: the mean age of the international students was 31 years old and of the German students 22 years old. Despite the age difference of about 9 years, the measured parameters between the international and German students without halitosis were similar.

On the other hand, significant differences in the measured parameters were found between the international and German groups with halitosis. The international students with halitosis who were 9 years older had significantly worse values in their general health status, although the measured CVD risk parameters were not in a pathological range.

Gender differences in oral hygiene, halitosis and health

Breath odor may be influenced by many factors such as periodontitis, gingivitis, dental hygiene, tongue coating, smoking, nutrition, medication, and stress.

Oral hygiene: The current study aimed to evaluate the statement that men care less for oral hygiene [34,35]. The frequency of daily teeth-brushing and weekly use of dental floss was higher in the female group ($p < 0.0006$ and $p < 0.01$).

23% of all German male participants used dental floss 3.1 times per week; while 42% of German women used dental floss 3.65 times per week. 49% (n = 43) of females had halitosis and 42% of these used dental floss 3.38 times per week. 53.3% of the females without halitosis used dental floss 3.85 times per week. Regarding the male subjects, 49% (n = 37) had halitosis and 30% of these used dental floss 1.73 times per week. 29% of the males without halitosis used dental floss 6.1 times per week. These results indicate that more frequent use of dental floss is related to less halitosis.

Of the 49% (n = 43) of females with halitosis, 25.6% used mouthwash 3.7 times per week, while 33.3% of the females without halitosis used mouthwash 5.5 times per week. Regarding the 49% (n = 37) of the males with halitosis, 27% used mouthwash 3.25 times per week, while 42% of the males without halitosis used mouthwash 7.7 times per week.

In general, men exhibited worse oral hygiene and had a worse periodontal status compared to women. Nevertheless, no differences in malodor were found between men and women in the German group.

According to DMS IV [36], 84% of the 35 to 44-year-old subjects brushed their teeth twice a day, 40% used dental floss, and 46% used mouthwash. In a survey on dental floss by DenTek Germany [37] a reported 19.7% of the people in Leipzig use dental floss daily, while 19.5% reported no use. Therefore, the observed poor oral hygiene in sports students is similar to the behavior of the general population in that area. In Germany, 58% of people do not care about using dental floss. It is a surprising result that young, physically active people do not exhibit better oral hygiene than the average. Apparently no relation exists between high interest in whole-body-appearance and local (oral) hygiene.

Halitosis: Halitosis has been reported to be similarly prevalent in females and males [16,32,33]. The current study also showed no gender specific differences in the presence of halitosis in German students, whereas less female (25%, n = 10 from 42 females) than male (50%, n = 50 from 102 males) international students had halitosis. This is in line with other studies done in the countries represented in this study [31]. Concerning both the results of the current and previous studies [34,38], the most reasonable conclusion is that women exhibit significantly better oral hygiene, regardless of the respective country of origin.

General health: Regarding general health, higher values were found in German females for hsCRP, cholesterol, HDL ($p < 0.0001$), and lower systolic blood pressure ($p < 0.009$).

The LDL: HDL in women was 1.3 and 1.6 in men. The overall cardiovascular risk parameters were better in women, although these differences have no clinical relevance.

The gender related results lead to the following conclusions: although halitosis was similar in both groups, oral hygiene was better in women. Halitosis groups performed worse in the use of dental floss, mouthwash and tongue cleaning, as well as plaque and papillary bleeding. The comparison between German and international groups indicates a similar tendency. The main halitosis related factors are oral hygiene, inflammation and the presence of third molars.

In comparison to other literature, no relevant differences in oral hygiene and halitosis were found between athletes and the general population.

Conclusion

Oral hygiene is the most relevant factor in halitosis in athletes regardless of nationality. Education on oral hygiene is therefore necessary to decrease oral malodour. No obvious cause-and-effect relationship was found between blood pressure, lipid status or body composition and halitosis. It appears that gingivitis and moderately increased CRP-values may correlate with halitosis in the international groups. A higher grade of gingivitis and the presence of the third molars or halitosis with even slightly increased CRP-values may therefore be an early sign of a low grade chronic inflammation.

Bibliography

1. Sheiham A and Spencer J. "In Pine CM-Community oral health". Oxford (1997): 39-54.
2. Rosenberg M., *et al*. "Self-assessment of oral malodor 1 year following initial consultation". *Quintessence International* 30.5 (1999): 324-327.
3. Iwakura M., *et al*. "Clinical characteristics of halitosis: differences in two patient groups with primary and secondary complaints of halitosis". *Journal of Dental Research* 73.9 (1994): 1568-1574.
4. ADA Council on Access, prevention and Interprofessional Relations, and ADA Council on Scientific Affairs. "Using mouthguards to reduce the incidence and severity of sports-related oral injuries". *Journal of the American Dental Association* 137.12 (2006): 1712-1720.
5. Oho T., *et al*. "Characteristic of patients complaining of halitosis and the usefulness of gas chromatography for diagnosing halitosis". *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology* 91.5 (2001): 531-534.
6. Van den Velde S., *et al*. "Halitosis associated volatiles in breath of healthy subjects". *Journal of Chromatography. B, Analytical Technologies in the Biomedical and Life Sciences* 853.1-2 (2007): 54-61.
7. Kurmann M and Filipp A. "Diagnostik von Halitosis - Ein Vergleich unterschiedlicher Messverfahren". Medical Dissertation, Basel (2007).
8. Quirynem M., *et al*. "Review of the treatment strategies for oral malodour". *Clinical Oral Investigations* 6.1 (2002): 1-10.
9. Hughes FJ and McNab R. "Oral malodour -a review". *Archives of Oral Biology* 53.S1 (2008): S1-S7.
10. Rodriguez-Fernández J., *et al*. "A sorbent tube for malodour monitoring". *Talanta* 62.2 (2004): 421-426.

11. Thrane PS., *et al*. "A new mouthrinse combining zinc and chlorhexidine in low concentrations provides superior efficacy against halitosis compared to existing formulations: a double-blind clinical study". *The Journal of Clinical Dentistry* 18.3 (2007): 82-86.

12. Zürcher A., *et al*. "Diagnosis, prevalence, and treatment of halitosis". *Current Oral Health Reports* 1.4 (2014): 279-285.

13. Bollen CM and Beikler T. "Halitosis: the multidisciplinary approach". *International Journal of Oral Science* 4.2 (2012): 55-63.

14. Porter SR and Scully C. "Oral malodour (halitosis)". *British Medical Journal* 333.7569 (2006): 632-635.

15. Snel J., *et al*. "Volatile sulphur compounds in morning breath of human volunteers". *Archives of Oral Biology* 56.1 (2011): 29-34.

16. Miyazaki H., *et al*. "Correlation between volatile sulphur compounds and certain oral health measurements in the general population". *Journal of Periodontology* 66.8 (1995): 679-684.

17. FAO. Food and Agriculture Organization of the United Nations. World Agriculture: towards 2015/2030. An FAO Perspective, London, Earthscan (2003).

18. FAO. Food and Agriculture Organization of the United Nations. World Agriculture: towards 2030/2050. Global Perspective Studies Unit, Rom (2006).

19. Ross R. "Atherosclerosis-an inflammatory disease". *New England Journal of Medicine* 340.2 (1999): 115-126.

20. Libby P. "Inflammation in atherosclerosis". *Nature* 420.6917 (2002): 868-874.

21. Dutta P., *et al*. "Myocardial infarction accelerates atherosclerosis". *Nature* 487 (2012): 325-329.

22. Husain K., *et al*. "Inflammation, oxidative stress and renin angiotensin system in atherosclerosis". *World Journal of Biological Chemistry* 6.3 (2015): 209-217.

23. Ridker PM., *et al*. "Inflammation, aspirin, and the risk of cardiovascular disease in apparently healthy men". *New England Journal of Medicine* 336.14 (1997): 973-979.

24. Ridker PM., *et al*. "C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease in women". *New England Journal of Medicine* 342.12 (2000): 836-843.

25. Ridker PM., *et al*. "Measurement of C-reactive protein for the targeting of statin therapy in the primary prevention of acute coronary events". *New England Journal of Medicine* 344.26 (2001): 1959-1965.

26. Ridker PM., *et al*. "C-reactive protein levels and outcomes after statin therapy". *New England Journal of Medicine* 352.1 (2005): 20-28.

27. Ridker PM., *et al*. "Number needed to treat with rosuvastatin to prevent first cardiovascular events and death among men and women with low low-density lipoprotein cholesterol and elevated high-sensitivity C-reactive protein: justification for the use of statins in prevention: an intervention trial evaluating rosuvastatin (JUPITER)". *Circulation: Cardiovascular Quality and Outcomes* 2.6 (2009): 616-623.

28. Awano S., *et al*. "Correlations between health status and OralChromaTM-determined volatile sulfide levels in mouth air of the elderly". *Journal of Breath Research* 5.4 (2011): 046007.

29. Benguigui C., *et al*. "Evaluation of oral health related to body mass index". *Oral Diseases* 18.8 (2012): 748-755.

30. Rosenberg M., *et al*. "Association among bad breath, body mass index, and alcohol intake". *Journal of Dental Research* 86.10 (2007): 997-1000.

31. Nadanovsky P., *et al*. "Oral malodour and its association with age and sex in a general population in Brazil". *Oral Diseases* 13.1 (2007): 105-109.

32. Bornstein MM., *et al*. "Prevalence of halitosis in the population of the city of Bern, Switzerland: a study comparing self-reported and clinical data". *European Journal of Oral Sciences* 117.3 (2009): 261-267.

33. Liu XN., *et al*. "Oral malodor-related parameters in the Chinese general population". *Journal of Clinical Periodontology* 33.1 (2006): 31-36.

34. Azodo CC and Unamatokpa B. "Gender difference in oral health perception and practices among Medical House Officers". *Russian Open Medical Journal* 1.2 (2012): 0208.

35. Schulze A and Busse M. "Gender Differences in Periodontal Status and Oral Hygiene of Non-Diabetic and Type 2 Diabetic Patients". *The Open Dentistry Journal* 10 (2016): 287-297.

36. Deutsche Mundgesundheitsstudie (DMS IV) (2006).

37. DenTek ORAL CARE (2013).

38. Alsadhan SA. "Self-perceived halitosis and related factors among adults residing in Riyadh, Saudi Arabia. A cross sectional study". *Saudi Dental Journal* 28.3 (2016): 118-123.

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