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Effect of poor oral health on respiratory functions and hence sportive performance

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SUMMARY

This study aimed to determine the effect of periodontal disease and dental decay, which deteriorated oral health in athletes, on the respiratory system and hence sports performance.

The athletes were divided into 3 groups: group 1: no periodontal disease or dental health problem (age: 16.8 ± 4.72 years; 10 male and 15 female); group 2: DMFT 1.7 and 13 athletes with periodontal disease (age: 18.2 ± 4.88 years; 22 male and 22 female); and group 3: DMFT 6.7 and periodontal disease (age: 20.8 ± 4.60 years; 19 male and 23 female). The mean prevalence value, DMFT index, gingival index (GI), forced expiratory volume in 1 s/forced vital capacity (FEV1/FVC) ratio, and FVC mean value were evaluated.

The mean FEV1/FVC% value of group 1 was 84.8 ± 2.26, and the mean body mass index (BMI) was 20.8 ± 4.56. The DMFT index of group 2 was found to be 1.7. Based on the GI assessment, 13 athletes were diagnosed with acute gingivitis. The mean BMI of this group was 22.2 ± 3.49. Based on the respiratory test, the mean value of FEV1/FVC% was 85±2.22. The DMFT index of group 3 was 6.7. No significant correlation was found between FEV1/FVC% and oral health problems of group 2. However, a significant correlation was observed between FEV1/FVC% and oral health status of group 3.

FEV1/FVC% decreased with poor oral health, indicating that respiratory values were affected when oral health was bad, influencing the athlete's performance negatively.

Key words: Athlete, periodontal disease, poor oral health, respiratory system, sportive performance

INTRODUCTION

Pulmonary capacity varies with factors such as age, sex, being healthy, body mass index (BMI), habits, and exercising (1). Simple allometric relationships between body structure and lung rates have indicated that the rate estimates are quite high in the youngest age group and quite low in the oldest adolescents. In addition, younger males have greater lung function values than younger females for standing body measurements. Tidal volume and respiratory minute volume increase with exercise. The increase in inspiration is derived from the inspiratory reserve volume. Vital capacity is an important indicator, but in recent years, forced vital capacity (FVC) measurements have become more accepted. FVC is close to VC in healthy individuals. Forced expiratory volume in 1 s (FEV1) has the advantage of being the most reproducible lung function parameter and is normally 75%–80% (2). A decrease indicates large airway obstruction. Oral health is a part of general health and its integrity is impaired by diseases that develop on dental or periodontal tissue. Periodontal diseases are specific infections characterized by the progression of the infections in the gingival connective tissue, periodontal ligament, and alveolar bone, destruction of the dental support tissues, and eventual tooth loss (3). These diseases are caused by complex relationships between pathogenic microorganisms and hosts, and are the most common chronic diseases known to the World Health Organization (WHO) data (4). Recent studies have focused on periodontal health and shown that many systemic and periodontal diseases are related. These are diabetes, cardiovascular diseases, respiratory system diseases, metabolic syndrome, kidney diseases, and negative consequences (preterm delivery, low-birth-weight

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infant, and preeclampsia) in pregnancy (5-7). Relationships between oral conditions such as periodontal disease and various respiratory tracts have been noted. For example, recent evidence suggests a central role of the oral cavity in the course of the respiratory tract infection. Oral periodontopathic bacteria may be aspirated into the lung to cause aspiration pneumonitis. The teeth may also serve as a reservoir for respiratory pathogen colonization followed by nosocomial pneumonia. Once established in the mouth, these pathogens can be aspirated into the lungs to cause infection. Other epidemiological studies have indicated a relationship between poor oral hygiene or periodontal bone loss and chronic obstructive pulmonary disease.8 When periodontal diseases are not treated, the alveolar bone and attachment system are destroyed. The amount of destruction depends on the severity of periodontal disease, local etiological factors, subgingival flora, response of the immune system to the environment, and genetic characteristics of the location (5). Recent studies on humans and animals have reported relationships between physical activity and periodontal health (9,10). These relationships are affected by different variables, such as eating frequency, eating a variety, and, most importantly, oral hygiene care, although physical activity has a positive effect on periodontal health. Eberhard et al. (2014) associated periodontal health with VO2max and reported the adverse effect of poor periodontal health on cardiorespiratory fitness (11). In addition, individuals with clinical attachment loss (CAL) ≥3 have been reported to have a poor diet and low physical activity (12,13). The effect of physical activity on periodontal disease has been shown to be altered by inflammatory biomarkers, particularly serum reactive protein (CRP) levels. The same study reported that physical activity lowered the CRP level and, accordingly, the risk of periodontal disease disappeared with favorable conditions (14). Diseases that develop on tooth tissue include tooth decay. A relationship has been reported between oral health and pneumonia. Also, periodontal pathogens and caries makers are potential risk factors for pneumonia formation. Terpenning et al. reported that some other risk factors, such as tooth decay and caries bacteria, are important risk factors for aspiration pneumonia (Fig. 1) (15). The composition of the plaque is different in dentures with a microbial dental plaque. Plaque and poor prosthetic hygiene in dental prostheses can also serve as a reservoir for potential infectious pathogens. Microorganisms accumulating in prostheses are likely a reserve for dental decay, periodontitis, bacterial endocarditis, aspiration

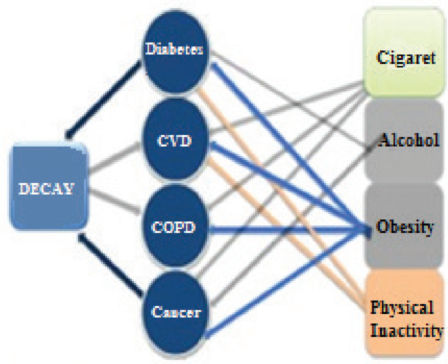

FIGURE 1: The relationship between the most common risk factors and caries in noncommunicable chronic patients.

pneumonia, gastrointestinal infections, and respiratory system diseases. It is important to control plaque biofilm in prostheses with effective oral hygiene practice. Teeth and periodontics are a focus for respiratory infections. Dental plaque is thought to be an important local source for anaerobic pathogens having a role in the etiology of pneumonia and other respiratory infections (16). The enzymes associated with periodontal disease enhance colonization of respiratory pathogens by modifying mucosal surfaces. A reduction in the levels of salivary enzymes associated with periodontal disease can reduce nonspecific host defense against respiratory pathogens.

In addition, cytokines [interleukin (IL)-1a, IL-1b, IL-6, IL-8, and tumor necrosis factor (TNF)-α] make periodontal tissues prone to respiratory pathogen colonization. One of the body systems important to athletes is "respiratory system." A strong cardiorespiratory system affects the athlete's performance positively. The ability to use oxygen, one of the most important criteria to determine success during physical activity, particularly during aerobic metabolism, indicates the ability of the skeletal muscle mitochondria to function. The high VO2max, which is the determinant of aerobic capacity, allows athletes to exercise longer under homeostatic conditions (17). Some studies have reported the adverse effects of periodontal and dental diseases on athletic performance. A relationship has been found between the performance of swimmers and the decay of teeth even if the relationship is weak (18). High caries score and periodontal disease negatively affect performance and may be associated with athlete muscle, tendon, and bone injuries (19). The aim of this study was to detect the influence of periodontal disease and tooth decay on the respiratory system, causing sports health problems and hence affecting sports performance.

MATERIALS AND METHODS

This study was performed between July and November 2017 within the routine examination standards applied by the Ministry of Youth and Sports, General Directorate of Sports, Directorate of Health Affairs, Ankara Sports Education Health and Research Center Policlinics. The study group consisted of a total of 111 athletes (51 males and 60 females) with a mean age of 18.8 ± 4.78 years. In accordance with the Helsinki Declaration principles, "Informed Consent" and "General Consent" forms were signed for the athletes' group. Caries prevalence value, caries, loss, restored tooth index (DMFT index), and gingival index (GI: 0: gum healthy, no inflammation; 1: gingival edema, inflammation, color change, and bleeding on probing; 2: inflammation, redness, edema in middle gingiva, and hemorrhage in the gland; and 3: inflammation, redness, edema, and spontaneous bleeding) were determined. According to the WHO criteria, the presence of hyperopia, edema, and hemorrhage was evaluated by the same dentist using a mirror, a catheter, and periodontal touch (20,21). Athletes were divided into 3 groups: group 1: no periodontal disease or dental health problem (age: 16.8 ± 4.72 years; 10 male and 15 female); group 2: DMFT 1.7 and 13 athletes with periodontal disease (age: 18.2 ± 4.88 years; 22 male and 22 female); and group 3: DMFT 6.7 and periodontal disease in 15 athletes (age: 20.8 ± 4.60 years; 19 male and 23 female). Also, oral health problems were observed in group 1: caries tooth (D), 2; missing tooth (M), 3; and fillet tooth (F), 4. Periodontal disease findings were also included. The results showed that group 1 had no periodontal disease or dental health problem, group 2 had mouth health problems <4, and group 3 had oral health problems >4. The respiratory function and respiratory muscle strength of the athletes were measured using a portable digital spirometer (Pony FX Cosmed, Italy) and the American Thoracic Society/European Respiratory Society acceptability criteria. FEV1/FVC% ratio and FVC mean value were measured by the dietitian on the same day after oral examination.

All statistical data were evaluated using the SSPS 14.0 Windows Evaluation Version analysis system. Pearson correlation statistical method was used. A *P* value of less than 0.05 indicated statistical significance.

RESULTS

The number of rotten, missing, and filled teeth and DMFT values for different groups of athletes are shown in Table 1. Group 1 had no caries, incomplete, or filled teeth. Group 2 had 37 caries teeth, 4 missing teeth, and 33 filled teeth. Group 3 had 87 bruised teeth, 54 missing teeth, and 139 filled teeth. The poor rate of change in the oral health of groups 2 and 3 was 2.5 times for caries, 13.5 times for missing teeth, and 4.2 times for filled teeth. The DMFT value was also about four times higher (Table 1).

The mean value of the FEV1/FVC% for the first group of 25 athletes was 84.8 ± 2.26, and the mean value of body mass index (BMI) was 20.8 ± 4.56. The DMFT index of 44 athletes in group 2 was found to be 1.7.

Based on the GI assessment, 13 athletes were diagnosed with acute gingivitis. The mean BMI of this group was 22.2 ± 3.49. Based on the respiration test, the mean value of FEV1/FVC% was determined as 85 ± 2.22. The DMFT index of 42 athletes in group 3 was found to be 6.7. Based on the GI assessment, 15 athletes were diagnosed with acute gingivitis. The mean BMI of the group was 23.3 ± 2.23, and the mean value of FEV1/FVC% was 84.5 ± 2.19 (Table 2).

The increase in FVC with an increase in age ratio in athletic groups does not reflect the FEV1/FVC % ratio. The FEV1/FVC% value in group 3, comprising athletes with a higher DMFT index value, was

TABLE 1: Athlete oral health status and FEV1/FVC % relationship according to DMFT.

Athlete	DMFT value	Tooth decay	Missing teeth	Filled teeth	FEV1/FVC % average
Group 1	<1	0	0	0	84.8 ± 2.26
Group 2	1.7	37	4	33	85 ± 2.22
Group 3	6.7	87	54	139	84.5 ± 2.19

DMFT: Decayed missing filled teeth, FEV1/FVC: forced expiratory volume in 1 s/forced vital capacity.

Table 2: DMFT measurement values according to the oral health of athletes.

Athlete	Male	Female	Average age	Average BMI	DMFT	Gingivitis	FEV1/FVC% average	FVC average
Group 1	10	15	16.8 ± 4.78	20.8 ± 4.56	< 1	0	84.8 ± 2.26	3.7 ± 1.32
Group 2	22	22	18.2 ± 4.88	22.2 ± 3.49	1.7	13	85 ± 2.22	4.3 ± 1.21
Group 3	19	23	20.8 ± 4.60	23.3 ± 2.23	6.7	15	84.5 ± 2.19	4.9 ± 1.30

BMI: Body mass index, FEV1/FVC: forced expiratory volume in 1 s/forced vital capacity%, FVC: forced vital capacity.

Table 3: Correlation between missing teeth and FEV1/FVC%.

Athlete group	FEV1/FVC% Average	Missing teeth (M)	*P*	Filled teeth (F)	*P*
Group 1	84. 8 ± 2.26	0	>0.05	0	0.05
Group 2	85 ± 2.22	4	>0.05	33	>0.05
Group 3	84.5 ± 2.19	54	0.018*	139	0.038*

FEV1/FVC: Forced expiratory volume in 1 s/forced vital capacity

lower than the value in group 2, comprising athletes with a low DMFT index value; however, the difference was not statistically significant ($P = 0.058$, $P > 0.05$). No statistically significant relationship was observed between the results of group 1 and the results of groups 2 and 3 (Table 2).

The statistical analysis revealed no significant correlation between oral health problems of group 2 and FEV1/FVC% ($P > 0.05$). However, a significant correlation was found between FEV1/FVC% and oral health status of group 3. This significant correlation was found to be between FEV1/FVC % and filling ($P = 0.038$, $P < 0.05$) (Table 3).

No correlation was found between FEV1/FVC values and FEV1/FVC% values of athletes who had no or fewer problems than 4 when they were evaluated according to their numerical status of poor oral health (multiple bruises, incomplete, filled teeth). However, a significant negative correlation ($P = 0.038$, $P < 0.05$) was observed between filled teeth and FEV1/FVC athlete with more than four mouth problems. At the same time, these athletes had a positive correlation ($P = 0.018$, $P < 0.05$) between incomplete teeth and FEV1/FVC%.

DISCUSSION

In the WHO 2013 declaration, oral health is reported to be a part of general health. In addition, WHO emphasized that the target value of diseased teeth per person (DMFT) <1 and the proportion of non-cirrhosis (POF) <50% should be 2020 targets (22). In the present study, the DMFT values of athlete groups were found and the relationship between these values and FEV1/FVC% value was shown. Increasing DMFT value is also a sign of poor oral health. Hence, the FEV1/FVC% value of group 3 decreased with the increasing DMFT value compared with the value of group 2. The decline was thought to be the result of poor oral health. This result supports the findings in the literature. Studies investigating the effects of oral health on respiratory tract diseases have shown that improved oral health reduces the incidence of nosocomial pneumonia by up to 40% (23). Also, a positive relationship has been found between the development of respiratory tract diseases and oral health in the high-risk group of patients treated in the intensive care unit or care homes. Reduction of respiratory tract diseases using a ventilator is also an effective method of good oral care (24,25). As a result of a 5-year follow-up program in Finland, three categories of patients were formed according to oral health status, and the lowest FEV1 was determined in individuals using a missing tooth denture prosthesis (26). In a different study, relationships between lung function and dental health were investigated. CAL, periodontal disease, and missing tooth volume were found to be related to reduced lung volume, airflow limitation, and hyperinflammation (27,28).

Also, in the present study, the increase in the number of filled teeth was found to be significantly correlated with decreased FEV1/FVC%. This relationship was consistent with findings in the literature.

Recent studies have demonstrated dental decay, cariogenic bacteria, and periodontal pathogens as risk factors for pneumonia as a result of respiratory aspiration (29). Periodontal diseases are infectious diseases. The riskiest of these diseases is periodontitis. It is characterized by CAL and is closely related to systemic diseases. In a study in Germany, CAL with periodontal disease was shown to be associated with lung volume and airflow limitation. In particular, severe negative effects of CAL ≥4 mm on FVC, FEV1, and FEV1/FVC have been reported. In the same study, the relationship between the presence of dental plaque triggering periodontal disease and low lung volume has also been reported. Low-grade systemic inflammation may provide a more plausible link (28).

High levels of cytokines, such as CRP and fibrinogen, and circulating inflammatory markers are associated with not only periodontal disease but also decreased lung function (30). Again, a study in Norway supported the findings of the present study. It examined the periodontal index (CPI) value of the population and showed that in the case of CPI 4–5 mm or ≥6 mm, the FEV1/FVC% was inversely related to the negative direction.30 Although the present study did not involve the measurement of CAL, periodontal assessment was performed. According to this evaluation, although gingivitis, the first stage of periodontal disease, was observed in groups 2 and 3, it was not statistically significantly correlated with the FEV1/FVC% values of the athletes. Hence, it was considered that periodontal disease and loss of clinical attachment had not yet developed in the athletes in the study groups. The results of a different study also supported the present findings. The study emphasized that asthmatic patients had a higher incidence of caries and periodontal disease (gingivitis) and lower intraoral pH compared with nonasthmatic participants (8). The present study also showed a low FEV1/FVC% in group 3 compared with group 2 with a high incidence of caries and gingivitis and high DMFT, although pH was not assessed. Animal studies also support the findings of the present study. In asthmatic mice, an increase in the number of macrophages, lymphocytes, neutrophils, and eosinophils was found after conventional periodontal therapy. These results indicated that photodynamic therapy could induce a cellular immune response as shown by some other studies (31). Several studies have been performed to explain the role of oral bacteria in the pathogenesis of respiratory tract infections. The findings include the following:

1. Aspiration of oral pathogens (e.g., Porphyromonas gingivalis, Actinobacillus actinomycetemcomitans, and so on) causes infection in the lung
2. The salivary enzymes associated with periodontal disease may be modified by adherence to the mucosal surface to promote colonization by respiratory pathogens aspirated into the lungs
3. The enzymes associated with periodontal disease may destroy salivary pellets on pathogenic bacteria to prevent their clearing from the mucosal surface
4. Cytokines (IL-1α, IL-1β, IL-6, IL-8, and TNF-a) from periodontal tissues have been reported to alter the respiratory epithelium to promote infection by respiratory pathogens (32).

Pro-inflammatory cytokines, such as interleukin-1β (IL-1β) and tumor necrosis factor-α (TNF-α), are released primarily by macrophages after bacterial infection or tissue injury When released in high concentrations, these cytokines can stimulate the production and release of other inflammatory mediators such as IL-6, matrix metalloproteinases (MMPs), and prostaglandin E2 (PGE2). IL-1β and TNF-α are also potent inducers of bone resorption and inhibitors of bone formation (33). Moreover, oral bacteria stimulate inflammatory periodontal tissues to release cytokines into the saline via sulcular fluid. The salivary biomarker load is higher in patients with periodontal disease than in healthy participants. Aspirated cytokines may support the adhesion and growth of respiratory pathogens in the lower airway tract. Later, respiratory epithelium can secrete cytokines and attract neutrophils, which leak into the airway parenchyma and release toxic oxygen radicals that damage proteolytic enzymes and epithelium. As a result, the resulting inflamed mucosal epithelium can be particularly prone to infection (32). In addition, periodontal therapy has been reported to cause decreased cytokine levels (34).

The physiological determinants of top endurance performance include oxygen transport capacity to the working muscle, deliberate mitochondrial diffusion, energy production, and force production, all of which are influenced by signals from the central nervous system. In general, the capacity of the pulmonary system far exceeds the requirements for ventilation and gas exchange during exercise. Endurance training initiates major and meaningful adaptations in cardiovascular, musculoskeletal, and hematological systems. However, the structural and functional characteristics of the lungs and airways do not change in response to recurrent physical activity and may be a limiting factor for elite athletes, pulmonary system, and exercise at sea level and height. As a result of this respiratory paradox, athletes may develop intra- and extrathoracic obstruction, expiratory flow limitation, respiratory muscle fatigue, and exacerbated hypoxemia. All these can affect their performance (35).

CONCLUSION

Increased restored teeth, increased DMFT value, and periodontal disease pathogens not only affect FEV1/FVC% values but are one of the risk factors negatively influencing the functions of the respiratory system, indicating poor oral health and affecting sportive performance.

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