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Original Article

Oral health and physical performance in Asian military males: The cardiorespiratory fitness and health in armed forces

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Abstract *Background/purpose:* It is unclear about whether the oral health has impact on physical performance. Therefore, this study aimed to examine the association between oral health and physical performance in 300 military adults in Taiwan.

Materials and methods: Oral health was assessed by the presence of periodontitis and dental caries. The status of cardiorespiratory and muscular endurance capacity was respectively assessed by tertiles of time for a 3000-m run and 2-min push-up numbers. Multivariable logistic and linear regression analyses with adjustments for age, smoking, alcohol drinking, blood pressure, anthropometric variables, lipid profile, fasting glucose and physical activity were used to determine the association.

Results: Participants with periodontitis were more likely to have worse 3000-m running performance classified in the lowest tertile [odds ratio (OR) and 95% confidence interval: 1.94 (1.03, 3.66)]. Participants with any dental caries were more likely to have worse push-ups performance classified in the lowest tertile [OR: 2.50 (1.27, 4.92)]. In linear regression analyses,

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dental caries numbers were inversely correlated with 2-min push-ups numbers [$\beta = -1.04$ ($-2.07, -0.01$)].

Conclusion: This study suggests that oral health is crucial to maintain physical fitness, and dental caries and periodontitis may affect differently on aerobic and muscular endurance capacities.

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Introduction

The World Health Organization (WHO) defines oral health as the state of the mouth, teeth and orofacial structures that enables people to perform essential functions, e.g., eating, breathing and speaking, and encompasses psychosocial dimensions such as self-confidence, well-being, and the ability to socialize and work without discomfort and embarrassment.¹ Poor oral health is an important issue because it can cause pain, negative effects on life quality and psychosocial effects on confidence, along with having long-term consequences for treatment burden.² In addition, oral pathology is not always confined in the mouth, a link between oral health and systemic diseases is emerging in recent decades.^{3–12} In some instances, it is even a bidirectional relationship.^{13,14}

Poor oral health is prevalent among athletes.^{2,15} In the 2012 London Summer Olympic Games, oral disorder was the second common issue for elite athletes to seek medical assists.¹⁶ Poor oral health status may affect physical fitness not only directly through pain from the oral diseases but also indirectly through increased systemic inflammation or psychosocial impacts associated with the oral diseases.¹⁷ Although several studies have reported the association of oral health with physical fitness, the strength of evidence was generally low.^{2,15,17} For instance, the status of oral health and physical fitness in most studies were limited to self-report for oral health rather than objective measurements. In addition, most of the recent literature on the association between poor oral health and physical fitness among young adults were inconclusive.^{15,17} Therefore, the aim of this study was to investigate the association of poor oral health with physical fitness among a population of physically active military young adults in Taiwan.

Materials and methods

Study population

Participants were recruited from the ancillary study of the cardiorespiratory fitness and health in eastern armed forces (CHIEF) study for oral health which has been described in detail previously.^{3–12} All military personnel underwent both oral and physical fitness in the same year in 2018–2020. The study protocol has been reviewed and approved by the Ethics Committee of the Mennonite Christian Hospital (No. 16-05-008) in Hualien City of Taiwan, and this study was conducted in accordance with the Helsinki Declaration of

1975, as revised in 2013. Participants were informed the nature of the study, and all gave written informed consent to provide the ability to opt out without consequence.

Measurement of systemic health

Each participant responded to a questionnaire including personal information, lifestyle behavior, e.g., smoking and alcohol intake status (active vs. nonactive), medical history and physical activity (minutes per week). Physical examination for body height, weight, and waist circumference (WC) were measured at standing position. Body mass index (BMI) was calculated as body weight (in kilograms) divided by the square of body height (in meters). Hemodynamic parameters of systolic blood pressures (SBP)/diastolic blood pressures (DBP) were assessed over the right upper arm and automatically measured by the machine (Parama-Tech Co Ltd, Fukuoka, Japan) at sitting position, after a rest for 15 min or longer. Blood tests for total cholesterol, triglycerides and fasting glucose (FPG) were checked in the Hualien Armed Forces General Hospital where is the only military referral center eastern Taiwan.

Measurement of oral health

The 2017 world workshop on the classification of periodontal diseases was used for the definition of periodontitis.¹⁸ As the study was aimed at physically active adults, the extent of periodontitis was merely restricted to the localized (<30% of teeth involved).¹⁸ On another respect, dental caries were assessed by recording the decayed, missing, or filled tooth (DMFT) indices according to the WHO criteria.¹⁹ All participants were asked to return to outpatient department for a re-evaluation and receiving treatment for the oral pathologies within one month. The inter-examiner agreement (kappa coefficient) was estimated 90.6% for verifying the periodontitis and 92.5% for DMFT indices.

Measurement of physical fitness

The outdoor 3000-m none weight-bearing run test and indoor 2-min push-ups test were used to evaluate cardiorespiratory fitness (CRF) and muscular endurance fitness (MusF), respectively.^{20,21} Both tests were scored objectively and supervised during the whole course. The 3000-m run test was only allowed to be held at 16:00 pm when the risk coefficient of heat stroke, the product of outdoor temperature (°C) and relative humidity (%) $\times 0.1$, was

lower than 40 or it was not raining. Each participant wore an induction bracelet, and the infrared sensors were installed at the start and end points to record the running time. With regard to the push-ups test, there were three detectors next to the shoulders, hips and knees. The number would not be calculated either if the upward position lower than initial resting height of shoulders and hips, or knees touched the detector. The whole course of both tests was recorded by the video.

Statistical analysis

The oral pathologies on the impacted teeth and third molars were not counted in the analysis. Poor performance of each exercise test was defined as the lowest tertile. Multivariable logistic regression models were used to estimate the odds ratio (OR) and 95% confidence interval (CI) of periodontitis and dental caries for poor 3000-m running performance (≥ 879 s) and poor 2-min push-ups (≤ 47 numbers) with adjustments for age, smoking, alcohol drinking, BMI WC, SBP, DBP, total cholesterol, serum triglycerides, FPG and physical activity (PA). Multivariable linear regression analysis was further used to examine the association of dental caries numbers and DMFT indices with time for a 3000-m run and 2-minute push-ups numbers. The analysis was carried out using SPSS software (Version 26.0. Armonk, New York: International Business Machines Corporation), and a two-sided P value < 0.05 was considered to be statistically significance.

Results

Of the 1289 military participants who were included in the CHIEF oral health study, 300 men underwent physical fitness tests in the same year with their oral examination in 2018–2020 and included for analysis. The mean age of the study participants is 33.0 years, and other clinical characteristics of the participants are shown in Table 1.

Table 2 reveals the multivariable logistic regression analysis for poor physical fitness performance with periodontitis and dental caries. In univariate model, those with periodontitis were more possibly to have poor 3000-m running time ≥ 879 s (OR = 1.82, $P = 0.02$), while the association for poor 2-min push-ups performance was not significant. In contrast, those with dental caries were more likely to have poor 2-min push-ups numbers ≤ 47 (OR = 2.06, $P = 0.01$), while the association for poor 3000-m running performance was not significant. In multivariate model, the associations remained significant for periodontitis with poor 3000-m running time (OR = 1.94, $P = 0.04$) and for dental caries with poor 2-min push-ups numbers (OR = 2.50, $P = 0.008$).

Table 3 shows the results of multivariable linear regression analysis for time for a 3000-m run and 2-min push-ups numbers with dental caries numbers and DMFT index. With regard to 3000-m running performance, the associations for dental caries numbers and DMFT indices were not significant in univariate and multivariate analyses. In contrast, dental caries numbers were inversely correlated with 2-min push-ups numbers in univariate analysis (β : -1.03 , $P = 0.04$) and in multivariate analysis (β : -1.04 ,

Table 1 Baseline characteristics of military males.

	Total Cohort (N = 300)
Age (years)	32.97 $\pm$ 4.52
Tobacco smoking, active (%)	112 (37.3)
Alcohol consumption, active (%)	142 (47.3)
Systolic blood pressure (mmHg)	122.41 $\pm$ 11.63
Diastolic blood pressure (mmHg)	74.27 $\pm$ 9.61
Waist circumference (cm)	86.98 $\pm$ 7.63
Body mass index (kg/m ²)	26.06 $\pm$ 3.03
Blood test	
Total cholesterol (mg/dL)	182.16 $\pm$ 34.88
Triglycerides (mg/dL)	142.00 $\pm$ 97.32
Fasting glucose (mg/dL)	94.18 $\pm$ 16.77
Oral health status	
Periodontitis (%)	156 (52.0)
Dental caries (%)	72 (24.0)
Decayed teeth (numbers)	0.65 $\pm$ 1.37
DMFT indices	7.28 $\pm$ 4.64
Physical activities (%)	
<150 min/week	54 (18.0)
150–200 min/week	124 (41.3)
≥ 200 min/week	122 (40.7)
Physical fitness	
Time for a 3000-m run (s)	863.11 $\pm$ 61.61
2-min push-ups (numbers)	47.95 $\pm$ 11.87

Continuous variables are expressed as mean $\pm$ SD (standard deviation), and categorical variables as N (%).

Abbreviations: DMFT: decayed, missing, or filled tooth.

$P = 0.04$). In addition, DMFT indices were inversely correlated with 2-min push-ups in univariate analysis ($\beta = -0.27$, $P = 0.07$) and in multivariable analysis ($\beta = -0.32$, $P = 0.04$).

Discussion

The main findings in this study were that poor oral health may be associated with lower physical fitness in physically active military men. Periodontitis may be an independent risk factor for lower levels of CRF. In contrast, there were inverse associations of dental caries numbers and DMFT indices with muscular endurance capacity, implying that increased dental caries burden might lower muscular endurance capacity.

Mechanisms for oral disorders development among athletes may be caused by repeated episodes of dry mouth which was related to mouth breathing as well as fluid loss during training,^{2,15} leading to modification of oral microbiota and increasing the oral diseases risk.²² There are several epidemiological studies for an association between periodontitis and CRF. Two large studies demonstrated a link between periodontitis and peak oxygen uptake.^{23–25} The European Federation of Periodontology (EFP) and American Academy of Periodontology (AAP) joint workshop in 2012 recommended a potential link between periodontitis and atherosclerotic cardiovascular disease.²⁶ Periodontal pathogens might directly invade bloodstream, or indirectly increase systemic inflammatory mediators,^{3–12} and thereby impair the cardiorespiratory system. Elevated

Table 2 Multiple logistic regression analysis for low physical fitness (the bottom tertile) with periodontitis and dental caries.

	3000-meter run						2-minute push-ups					
	Univariate			Multivariate			Univariate			Multivariate		
	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Periodontitis	1.82	1.08–3.07	0.02	1.94	1.03–3.66	0.04	1.50	0.92–2.44	0.10	1.25	0.69–2.28	0.45
Dental caries	1.41	0.76–2.62	0.27	1.48	0.72–3.03	0.28	2.06	1.15–3.69	0.01	2.50	1.27–4.92	0.008

Data are presented as OR (odds ratio) value and 95% CI (confidence intervals) using multiple logistic regression analysis with age, smoking, drinking, systolic blood pressure, diastolic blood pressure, waist circumference, body mass index, total cholesterol, triglycerides, fasting glucose and physical activities adjustment.

Table 3 Multiple linear regression analysis for physical fitness with decayed teeth numbers and DMFT indices.

	Time for a 3000-meter run						Numbers of 2-minute push-ups					
	Univariate			Multivariate			Univariate			Multivariate		
	β	95% CI	P	β	95% CI	P	β	95% CI	P	β	95% CI	P
Decayed teeth numbers	4.00	−1.81–9.80	0.17	3.57	−2.20–9.35	0.22	−1.03	−2.06–0.10	0.04	−1.04	−2.07–0.01	0.04
DMFT indices	0.74	−1.21–2.69	0.45	0.94	−0.98–2.85	0.33	−0.27	−0.58–0.03	0.07	−0.32	−0.63–0.01	0.04

Abbreviations: DMFT: decayed, missing, or filled tooth.

Data are presented as β value and 95% CI (confidence intervals) using multiple linear regression analysis with age, smoking, drinking, systolic blood pressure, diastolic blood pressure, waist circumference, body mass index, total cholesterol, triglycerides, fasting glucose and physical activities adjustment.

proinflammatory cytokines can modify the metabolism in muscle and magnify the fatigue symptoms, resulting in reduced cardiorespiratory fitness.^{17,27} A cross-sectional study demonstrated that periodontitis was associated with a lower VO₂ peak in middle-aged adults,²⁸ which was consistent with our study finding in young adults. In contrast, a recent study using the National Health and Nutrition Examination Survey reported that such a link was not significant among young adults.²⁹ The conflicting results among studies indicate that age might be a possible moderator for the association of periodontitis with physical fitness. Longer exposure to periodontitis and its related systemic inflammation may promote the reduction in CRF.

Oliveira et al. found an inverse association between periodontitis severity and muscular endurance capacity among young male military police officers.²⁷ In addition, periodontitis was associated with reduced handgrip strength in middle- and old-aged individuals.^{30–32} However, in this study, the association of periodontitis with muscular endurance capacity in young adults was null, possibly due to lower severity and exposure time of periodontitis among young adults, which reduced the impact of systemic inflammation of periodontitis on muscular endurance capacity.¹⁷ With regard to dental caries, an observational study revealed a negative effect of dental caries on push-ups performance in 13,564 Finnish male conscripts,³³ which was consistent with our study finding. The mechanisms for the inverse association in young adults remained unclear. Further studies are required to clarify the association between dental caries and muscular endurance capacity in young adults.

There were some strengths in this study. First, the CRF and MusF, laboratory tests, systemic and oral examinations were all performed in a strict manner, and all procedures were standardized. Second, since the daily life of military personnel, such as nutritional intake, diet consumption and exercise training program were unified; many unmeasured confounders would be controlled. On the other hand, this study also had some limitations. First, this study was a cross-sectional design which was difficult to draw causal inferences between oral health problems and physical fitness. Second, the results were obtained from men and might not be generalized to women. Third, the behavior for smoking and alcohol intake and PA was based on self-report, which might potentially introduce bias into the analyses.

In summary, this study suggests that oral health is crucial to maintain physical fitness. In addition, dental caries and periodontitis may have different effects on aerobic and muscular endurance capacities in young adults. Both CRF and MusF may have major protective effects for primary and secondary prevention of cardiovascular diseases.^{34–36}

Declaration of competing interest

The authors declare no conflicts of interest.

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