Periodontal Disease as a Risk Indicator for Poor Physical Fitness: A Cross-Sectional Observational Study

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Background: Physical inactivity has been associated with poor oral health. The aim of this study is to assess whether periodontal disease is a risk indicator for poor physical fitness.

Methods: This cross-sectional study included 111 males who performed a physical fitness test (PFT) composed of four exercises: 1) push-ups conducted by pushing the body up and lowering it down using the arms; 2) pull-ups with the body suspended by the arms gripped on a bar; 3) sit-ups in which the upper and lower vertebrae are lifted from the floor; and 4) running for 12 minutes. A PFT score (range of 1 to 300) was determined for each participant, with higher scores indicating better physical fitness. One periodontist assessed attachment loss (AL) and probing depth (PD). Physical fitness was dichotomized according to whether the highest PFT score was "achieved" or "not achieved." Multivariable logistic models were fitted adjusting for age, overweight (body mass index of 25 to 29.9 kg/m^2), and frequency of daily exercise.

Results: The mean age of the sample was 34.8 ± 10.3 years. Overweight individuals demonstrated significantly lower PFT scores (276.9 ± 24.1 points) than normal-weight individuals (289.3 ± 16.8 points). Individuals presenting at least one tooth with AL ≥4 mm had significantly lower PFT scores (277.8 ± 23.6 points) compared with those without this status (285.9 ± 20.2 points). A 1-mm increment in PD or AL significantly decreased the chance of reaching the highest PFT score by 69% or 75%, respectively.

Conclusion: Periodontal disease may be considered a risk indicator for poor physical fitness in males. *J Periodontol 2015;86:44-52.*

KEY WORDS

Periodontal diseases; physical fitness; risk factors.

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Periodontal disease has been indicated as a possible risk factor for various systemic conditions, including cardiovascular diseases,[1] adverse events in pregnancy,[2] and diabetes.[3] One possible biologic explanation for these associations is that periodontal disease can lead to a low-grade inflammatory process, characterized by elevated blood concentrations of biomarkers[4,5] related to systemic conditions.

The association between periodontal disease and obesity has been studied and consolidated in the past years.[6] It has been demonstrated that obesity, mainly assessed by increased body mass index (BMI), causes a cascade of proinflammatory events that is related to various chronic diseases, such as cardiovascular diseases and diabetes.[7] In this scenario, obesity has been considered one of the major risk factors for periodontitis, and it may also be part of the biologic plausibility linking periodontal diseases with systemic conditions.

Physical fitness is defined as a set of attributes related to the ability to perform a physical activity.[8] The theoretical construct of physical fitness comprises various dimensions, including body composition and muscle performance.[9] Consequently, physical fitness is directly affected by body fat accumulation and muscle metabolism. Damage to the muscles, which may lead to

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decreased physical fitness, induces a chain of events involving leukocytes and increased serum levels of proinflammatory cytokines, such as interleukin (IL)-1β, IL-6, and tumor necrosis factor (TNF)-α.[10,11] This inflammatory response in the muscle may lead to secondary damage to the healthy muscle structures, thereby lengthening the muscle repair process, increasing muscle soreness, and making the individual more reluctant to contract his or her skeletal muscles.[12,13]

Considering that the same proinflammatory biomarkers are involved in both periodontal disease and muscle metabolism,[14] it is plausible that the systemic challenge generated by periodontal disease could also influence physical fitness. Additionally, it also has to be considered that body fat accumulation is involved in both physical fitness[15] and periodontal disease. Nevertheless, to the best of the authors' knowledge, no study has used a systematic methodology to evaluate periodontal disease as a risk indicator of poor physical fitness. There is limited evidence suggesting an association between poor oral health and decreased physical fitness in professional soccer players and Olympic athletes.[16,17] Partial loss of occlusion was also suggested to be associated with loss of muscular strength in older individuals.[18]

The aim of the present study is to assess whether periodontal disease is a risk indicator for poor physical fitness. The hypothesis was that poor periodontal health is a risk indicator for decreased physical fitness.

MATERIALS AND METHODS

Study Design and Sample

The target population of this cross-sectional observational study comprised military police officers from the city of Porto Alegre, Brazil. This population was chosen because of the availability of records of regular fitness assessments. All officers in this local police force regularly undergo comprehensive health and fitness evaluations. Specifically, the physical strength and cardiorespiratory fitness of all officers are assessed twice each year with the physical fitness test (PFT).

This study was conducted from June 2012 to March 2013. Male police officers of any age were eligible for the study, as long as they previously performed or were willing to perform the PFT. The most recent PFT results, not exceeding 3 months from the time of the study, were retrieved from the military police files for each study participant. Smokers, female officers, and individuals with <20 teeth were excluded from the study (Fig. 1). General health issues were not considered as exclusion criteria because all officers underwent the standard clinical examination of the Military Police Health Department before taking the PFT. Officers presenting any general health problem were not allowed to perform the PFT. In total, 154 officers from two garrisons were eligible and invited to participate in the study. Of them, 138 agreed to participate. After exclusions, 111 male police officers (aged 20 to 56 years; mean age: 34.8 years) were included in the study sample.

Ethical Considerations

The study protocol was reviewed and approved by the Committee of Ethical Affairs of the Federal University of Rio Grande do Sul and by the Research Institute of the Military Police of Rio Grande do Sul, Brazil. The privacy and confidentiality of the personal information of the research participants were protected. All officers read and signed an informed consent form before participation.

Power of the Sample

A power calculation was performed by using a logistic regression model of the binary outcome of physical fitness with 111 individuals. The estimation was made considering an odds ratio (OR) of 2.0 for any periodontal parameter and α and β errors equal to 0.05 and 0.20, respectively. This model is similar to those fitted in the present study and yielded a power of 83%.

PFT

The PFT was the primary outcome of the present study. The PFT[19] comprised four physical performance exercises. 1) Push-up exercises begin with the participant lying on his stomach on the floor. With his palms flat on the floor and using his arms as leverage, the participant pushes his body up and lowers his body down to the floor. The maximum number of repetitions is recorded. 2) Pull-up exercises are conducted with the body suspended by the hands from a bar. Using his arms, the participant lifts and lowers his body until his chin is level with the bar. The maximum number of repetitions is recorded. 3) Sit-up exercises begin with the person lying with his back on the floor. The participant lifts his upper and lower vertebrae from the floor until his upper body (above the buttocks) does not touch the ground. The maximum number of repetitions in 1 minute is recorded. 4) For the running exercise, the participant is asked to run for 12 minutes on an athletics track. This fitness test is similar to those performed in national armies and police departments from other countries.[20-22]

The participant earns a score for each of the four exercises, according to his age, the number of repetitions (exercises 1 to 3), and distance run in 12 minutes (exercise 4). The sum of these four component scores determines the individual's total PFT

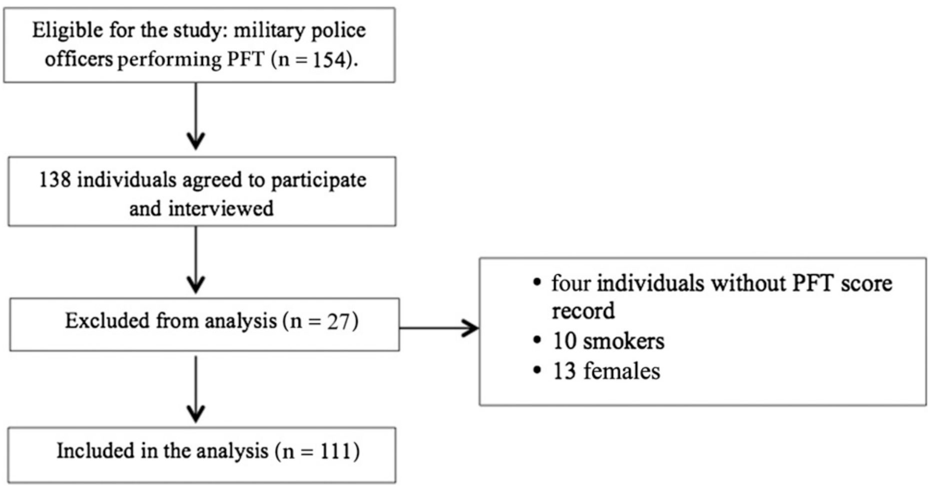

Figure 1.
Flowchart of the study sample.

score (range of 1 to 300). Higher PFT scores indicate better physical fitness. In the multivariable risk assessment, individuals were classified according to whether the highest PFT score (300) was "achieved" or "not achieved."

Questionnaire
Participants answered a structured, self-administered questionnaire on the same day as the clinical periodontal examination. The questionnaire included information about age, frequency of daily exercise, height, weight, and oral hygiene practices. Daily physical activity was assessed as the number of days per week that the individual engaged in physical exercise. Oral hygiene practices included the frequencies of toothbrushing and interproximal cleaning. Individuals were divided into age groups of 20 to 29 years and ≥30 years. Toothbrushing was categorized into two or less times per day and three or more times per day. Interproximal cleaning was categorized into less than one time per day and at least one time per day. Regular exercise was dichotomized into one or less time per week and at least two times per week.

BMI and Percentage Body Fat
BMI was obtained by dividing the self-reported weight (in kilograms) by the square of the self-reported height (in meters). Individuals were classified into "normal weight" and "overweight" categories by using the World Health Organization cutoff points for BMI (18.5 to 24.9 kg/m^2 for normal weight and 25 to 29.9 kg/m^2 for overweight). Obese (BMI ≥30 kg/m^2) individuals were not observed in the study.

The percentage of body fat (% BF) was obtained by a portable bioimpedance monitor,[§] according to the specifications of the manufacturer. After entering the individual's age, height, weight, and sex into the monitor, measurements were taken with the person standing, holding the metallic sensors, with elbows extended and the arms at 90° relative to the body. The % BF range registered by the monitor was 4% to 50%. Individuals were classified into low and high % BF, according to the bioimpedance cutoff points and age.[23]

Periodontal Measurements
Periodontal examinations were performed at dental offices located in the two garrisons of the military police. One calibrated periodontist (JAPO) conducted all measurements using a dental chair with a light reflector, mouth mirror, and manual periodontal probe.[‖] All permanent teeth were assessed, excluding the third molars. A partial recording protocol[24] of three sites per tooth (mid-buccal, mesiobuccal, and disto-lingual/palatal) was used because of time constraints. Probing depth (PD), clinical attachment loss (AL), and bleeding on probing (BOP) were assessed using standardized protocols.[25] PD was defined as the distance from the free gingival margin to the bottom of the pocket/sulcus. AL was defined as the distance from the cemento-enamel junction to the bottom of the pocket/sulcus. Measurements were made in millimeters and were rounded to the nearest millimeter. BOP was assessed as "present" or "absent" after the PD measurement.

The intraexaminer reproducibility of the PD and AL measurements was assessed before the study. Repeated measurements were performed in seven periodontal patients (486 sites). Duplicate measurements were with intervals of 30 to 60 minutes between each examination. The weighted κ coefficients for PD and AL were 0.94 and 0.91, respectively.

Statistical Analyses
Means of PD, AL, and BOP were calculated for each individual. Participants were categorized according to the number of teeth with PD ≥5 mm and AL ≥4 mm (no teeth and at least one tooth). Individuals were divided into two BOP categories, using the median value (15% of sites). Individuals were classified as having "moderate periodontitis" with the presence of at least two interproximal sites with AL ≥4 mm and at

§ HBF-306, Omron, Lake Forest, IL.
‖ Newmar, São Paulo, São Paulo, Brazil.

least one interproximal site with PD ≥5 mm in non-adjacent teeth.[26]

The PFT was analyzed as a continuous variable only in unadjusted comparisons. Means ± SDs were used as descriptive statistics. Because of the skewed distribution of the data, the PFT results were compared across categories of the independent periodontal variables by the Mann-Whitney *U* test.

Binary logistic regression models were used to assess the association between periodontal variables and physical fitness. In these models, the dichotomous PFT was coded as 1 when an individual reached the highest PFT score and 0 otherwise. Each periodontal variable was entered in each of eight multivariable logistic regression models, including age, BMI, and regular exercise. ORs and 95% confidence intervals (CIs) were reported. No interactions were found during model fitting. Statistical analyses were performed,¶ considering the individual as the unit of analysis. The α level was set at 5%.

RESULTS

Characteristics of the study sample are described in Table 1. Most individuals were aged >30 years, brushed their teeth at least three times per day, performed interproximal cleaning at least one time per day, and had not undergone periodontal treatment. Approximately 60% of the sample was overweight, with a mean % BF of 19.1%. Mean PD and AL were 2.8 and 1.9 mm, respectively, and 36% of participants had moderate periodontitis (at least two interproximal sites with clinical attachment level (CAL) ≥4 mm and at least one interproximal site with PD ≥5 mm in non-adjacent teeth).

Figure 2 shows the distribution of PFT scores. A skewed distribution was observed, with 42 (37.8%) individuals reaching the maximum PFT score. The overall mean PFT score was 281.9 points (Table 2). Overweight individuals demonstrated significantly lower PFT scores than normal-weight individuals. Similarly, individuals presenting at least one tooth with AL ≥4 mm had significantly lower mean PFT scores than individuals without that condition.

Individuals who reached the highest PFT score had significantly better periodontal conditions compared with those with PFT scores below the maximum (Table 3). For instance, individuals who did not reach the highest PFT score presented significantly higher mean PD, mean AL, BOP, and number of teeth with AL ≥4 mm.

Table 4 presents the results of the univariable and multivariable logistic regression models of the association between physical fitness, oral hygiene practices, and periodontal status. Multivariable models for mean PD, mean AL, BOP, PD ≥5 mm, and AL ≥4 mm demonstrated significant associations of these variables with physical fitness, after adjusting for age, BMI, and regular exercise. For each 1-mm increment in mean PD or AL, the chance of reaching the highest PFT score decreased by 69% or 75%, respectively. The magnitude of association was similar for individuals presenting at least one tooth with PD ≥5 mm and AL ≥4 mm; for both groups, the chances of achieving the highest PFT score was decreased by ≈70% compared with individuals presenting no teeth with these thresholds. Individuals with moderate periodontitis had a 53% lower chance of reaching the highest PFT score but with borderline non-significance ($P = 0.07$).

Table 1.

Characteristics of the Study Sample (n = 111)

Variable	Result
Age (years)	34.8 ± 10.3
20 to 29	45 (40.5)
≥30	66 (59.5)
Toothbrushing	
≤2 times/day	25 (22.5)
≥3 times/day	86 (77.5)
Interproximal cleaning	
<1 time/day	36 (32.4)
≥1 time/day	75 (67.6)
Periodontal treatment	
Yes	16 (14.4)
No	95 (85.6)
BMI (kg/m^2)	25.9 ± 2.5
Normal	45 (40.5)
Overweight	66 (59.5)
Bioimpedance	19.1 ± 6.2
PD (mm)	2.8 ± 0.4
AL (mm)	2.4 ± 0.8
BOP (%)	17.7 ± 10.1
PD ≥5 mm in ≥1 tooth	24 (21.6)
AL ≥4 mm in ≥1 tooth	54 (48.7)
Moderate periodontitis	40 (36.0)

The results are presented as mean ± SD or n (%).

DISCUSSION

This study assesses the relationship between periodontal status and physical fitness in male military police officers. Periodontal disease, as assessed

¶ Stata SE for Macintosh v.10, StataCorp, College Station, TX.

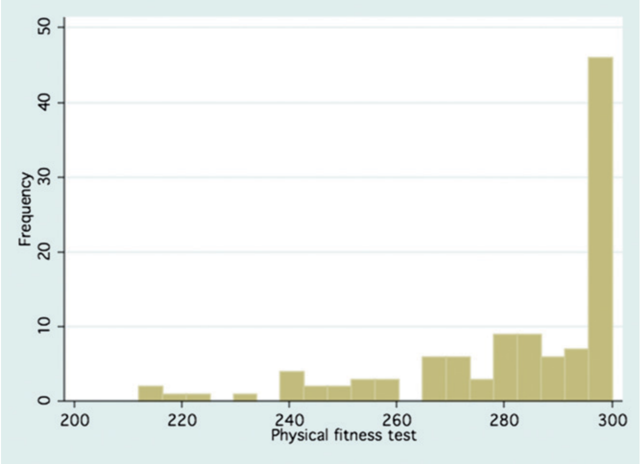

Figure 2.
Distribution of the PFT scores for study participants.

using various clinical parameters, was determined to be a risk indicator of poor physical fitness. To the best of the authors' knowledge, this inverse association between periodontal disease and physical fitness has never been demonstrated in the literature. Consequently, this study raises the possibility that the systemic challenge resulting from periodontal disease may contribute to poor physical fitness in males, keeping in mind that this is a very incipient research field in periodontology.

In the present study, poorer physical fitness was predicted by increased PD and AL. It has been demonstrated that elevated PD and AL are associated with increased serum levels of proinflammatory cytokines.[4,5] This low-grade systemic inflammatory challenge resulting from periodontal disease may explain, in part, the findings of the present study. This is plausible once there is evidence for the accumulation of in situ neutrophils, macrophages, and proinflammatory cytokines at the time of muscle injury.[11,27] Consequently, the elevation of systemic proinflammatory cytokines observed in periodontal disease may modify the muscle metabolism locally and lead to poorer physical fitness. Additionally, periodontal disease could be linked to physical fitness by acting on sensations of fatigue, which arise from a central mechanism or from local factors at the muscle–tissue level (e.g., changes in serum levels of IL-6, IL-1β, and TNF-α).[28] During exercise, the workload may create such an intense sensation that one reduces or even stops the exercise. Physiologically, these sensations serve to protect the body from damage and to maintain homeostasis and physical integrity.[29,30] This defense system could be magnified by cytokines originating from the systemic response of periodontal disease, which may serve to decrease fatigue thresholds.

Table 2.

Mean PFT Scores According to Demographic, Behavioral, and Clinical Characteristics

Characteristic	PFT Score (mean ± SD)	*P**
Age (years)		
20 to 29	280.4 ± 23.0	
≥30	283.0 ± 21.7	0.47
Toothbrushing		
≤2 times/day	282.0 ± 21.3	
≥3 times/day	281.9 ± 22.6	0.82
Interproximal cleaning		
<1 time/day	278.4 ± 22.9	
≥1 time/day	283.7 ± 21.8	0.13
BMI		
Normal	289.3 ± 16.8	
Overweight	276.9 ± 24.1	0.003
Bioimpedance		
Low % BF	282.4 ± 22.1	
High % BF	281.3 ± 22.6	0.71
Regular exercise		
≤1 times/week	274.6 ± 23.9	
≥2 times/week	283.8 ± 21.5	0.06
PD ≥5 mm		
0 teeth	283.4 ± 21.4	
≥1 tooth	276.8 ± 24.7	0.15
AL ≥4 mm		
0 teeth	285.9 ± 20.2	
≥1 tooth	277.8 ± 23.6	0.03
BOP		
≤15% of sites	280.3 ± 25.2	
>15% of sites	283.4 ± 19.3	0.94
Total	281.9 ± 22.2	

* Mann-Whitney *U* test.

In this study, increased BMI shows a strong association with physical fitness. Overweight individuals demonstrated significantly lower PFT scores compared with normal-weight individuals. This finding has also been observed in the literature.[15] Moreover, body fat accumulation has been indicated as a risk factor for periodontal disease because of the release of proinflammatory cytokines by adipocytes.[31] Consequently, it is reasonable to infer that the metabolic influence of obesity on both periodontal disease and physical fitness may be playing an important role in the associations found in the present study. This effect modification was accounted for in the multivariable analyses that were adjusted for BMI.

Table 3.

Periodontal Parameters According to the PFT Category

Periodontal Parameter	PFT Maximum Score		P*
	Yes	No	
Mean PD (mm)	2.06 ± 0.33	2.23 ± 0.48	0.03
Mean AL (mm)	2.17 ± 0.36	2.56 ± 0.89	0.01
Number of teeth with PD ≥5 mm	0.26 ± 0.73	0.72 ± 2.05	0.15
Number of teeth with AL ≥4 mm	1.33 ± 2.23	3.05 ± 5.10	0.04
BOP (% of sites)	15.35 ± 8.02	19.16 ± 10.93	0.04

* Mann-Whitney *U* test.

Table 4.

Logistic Regression Models of the Association Between Maximum PFT Score, Oral Hygiene Practices, and Periodontal Status

Model	Univariable			Multivariable*		
	OR	95% CI	P	OR	95% CI	P
Toothbrushing						
≤2 times/day	1			1		
≥3 times/day	1.39	0.54 to 3.58	0.49	1.41	0.52 to 3.79	0.50
Interproximal cleaning						
<1 time/day	1			1		
≥1 time/day	1.93	0.82 to 4.58	0.13	1.73	0.69 to 4.35	0.24
Mean PD (mm)	0.34	0.11 to 0.99	0.04	0.31	0.10 to 0.95	0.04
Mean AL (mm)	0.31	0.12 to 0.80	0.02	0.25	0.09 to 0.69	0.01
BOP (%)	0.02	0.001 to 1.15	0.06	0.01	0.001 to 0.46	0.02
PD ≥5 mm						
0 teeth	1			1		
≥1 tooth	0.47	0.17 to 1.30	0.15	0.32	0.10 to 0.99	0.04
AL ≥4 mm						
0 teeth	1			1		
≥1 tooth	0.43	0.17 to 0.94	0.04	0.33	0.13 to 0.84	0.02
Moderate periodontitis						
No	1			1		
Yes	0.59	0.36 to 1.33	0.20	0.47	0.18 to 1.08	0.07

* Each variable is included in a multivariable model adjusted for age, BMI, and regular exercise.

There is evidence supporting the idea that physical fitness is influenced by behavioral habits.[32] In this regard, diet, BMI, physical activity, and periodontitis seem to be linked,[33] comprising a behavioral axis. It could be argued that the inverse association between periodontal status and physical fitness found in this study is related to this axis. Contrarily, it would be expected that better oral hygiene habits should be associated with better physical fitness. In the present study, higher self-reported frequencies of toothbrushing and interproximal cleaning are not associated with physical fitness. Nevertheless, it has to be acknowledged that self-reported oral hygiene may not necessarily reflect the real clinical condition of supragingival biofilm control.[34]

Direct comparisons of the present findings with results from previous studies are not possible because of the absence of studies in the literature evaluating the effect of the periodontal condition on physical fitness. Nevertheless, the observed results indirectly corroborate the findings of a cardiovascular study[35] that demonstrated that periodontitis was independently associated with low levels of cardiorespiratory fitness, as measured by peak oxygen uptake during exercise in a cycle ergometer. In the present study, the evaluation of cardiorespiratory fitness is also assessed by running for 12 minutes. Consequently, it can be suggested that periodontal disease also negatively affected the cardiorespiratory capacity in the present study.

It is noteworthy that regular physical activity has a protective effect and may reduce the risks of several chronic diseases associated with low-grade systemic inflammation (e.g., cardiovascular disease, type 2 diabetes, and cancer).[36] Observational studies have revealed that lower concentrations of inflammatory biomarkers are encountered in individuals who report more intense and frequent physical activity.[37] This protection is likely also found for periodontitis,[38] given the evidence associating a lack of regular physical activity with periodontitis.[39,40] These results, along with those presented in this study, point to a possible bidirectional association between periodontitis and physical fitness/activity.

The multivariable models of BOP, PD, and CAL with physical fitness demonstrated stronger associations and lower *P* values than the corresponding univariable models. These findings indicate an effect modification of age and BMI on the association between periodontal status and physical fitness. These results were expected, considering that age[41] and BMI[6] are risk factors for periodontal disease and physical fitness. These findings highlight the importance of using multivariable models when studying associations in periodontal medicine.

As an explorative research field, the present study raises new questions and encourages other investigations about the same subject. However, the findings should be interpreted in light of the possible limitations of the design and methodology. For instance, the characteristics inherent in cross-sectional studies preclude any conclusion about cause and effect because of the lack of temporality.[42] A partial recording periodontal examination protocol was used because of time constraints, and this may have underestimated the periodontal status of the sample. It would be of interest to assess blood markers of inflammation and muscle damage; however, blood samples were not available for the present sample. Although the present study applied well-established multivariable risk assessment analytical commands, adjusting for important confounders, other factors associated with physical fitness (e.g., nutrition, daily duration of exercise) are not evaluated. Females are not included in this study to generate a homogeneous study sample and to avoid the potential differences in physical fitness/activity between males and females.[43,44] Stratified analysis by sex would have been another possibility, but the small number of female military police officers made such an analysis impossible. Added to the fact that the study sample was of a restricted population, the exclusion of females increased the internal validity of the study, while reducing the ability to extrapolate the results.

Smoking is a known risk factor for various conditions and diseases,[45] including periodontitis,[41,46] and it negatively affects physical fitness.[47] Smokers are not included in this study to avoid any confounding effect in the association between periodontal disease and physical fitness. Another strength of this study is that physical fitness was assessed by using a test that applies a broad range of physical evaluations, including speed, power, and balance, accessing muscle strength and resistance and cardiorespiratory endurance.

The associations observed in periodontal medicine studies are influenced by the parameters that are assessed and the definitions of periodontitis that are used.[48,49] It has been argued that, in addition to the destructive component of periodontal disease (e.g., AL or bone loss), the inflammatory condition of the periodontium should also be evaluated by PD and BOP records. The rationale for this strategy relies on findings demonstrating that the systemic challenge may be more evident in the presence of periodontal inflammation. In this regard, the present study assesses the periodontal status by various periodontal parameters. In this context, the associations of physical fitness with descriptors of periodontal breakdown and inflammation were consistent.

CONCLUSIONS

Periodontal disease may be considered a risk indicator for poor physical fitness in males. If periodontal health and physical fitness are truly connected, then the prevention and treatment of periodontal diseases, with aims to ensure physical fitness, should be considered at the population level. On an individual level, maintaining periodontal health may be an important strategy for improving physical fitness related to the performance of athletes.

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