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Association between physical activity and periodontitis as stratified by obesity in Koreans

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1. INTRODUCTION

Periodontitis is a chronic inflammatory disease that is associated with an oral bacterial infection that results in loss of connective tissue and bone support through the body's immune response[1].

Strong evidence has documented that the benefits of physical activity decrease the risk of adverse health outcomes including all-cause mortality and non-communicable diseases (NCDs) such as cardiovascular disease, stroke, metabolic syndrome, type 2 diabetes, depression, breast and colon cancer[2]. Moreover, physical inactivity was responsible for 13.4 million disability-adjusted life years worldwide and a substantial economic burden in high-income countries[3]. Thus, regular physical activity worldwide needs to be emphasized as a comprehensive priority strategy to reduce NCDs[3]. Data from the Korea National Health and Nutrition Examination Survey (KNHANES) in 2005-2013 indicate that males tend to have a distinct tendency to participate in physical activity than female4.

Several studies have reported on the association physical activity and periodontitis[5-14]. Recent animal experimental study showed that physical training attenuated bone loss and epithelial attachment loss levels of rats with periodontal disease[14]. There is also supporting epidemiologic studies including one prospective study[6], one case-control study[9], and seven cross-sectional studies[5,7,8,10-13] in primarily Brazil, Japan, United States, Germany, and Australia. These studies demonstrated conflicting results that individuals who engaged in physical activity have a lower risk of periodontitis. However, there are limited to small sample size in occupational group[11,13], lack of various confounders[7,8,10,12], exclude female from analysis[6,11,13], self-reported medical and periodontal status[6]. In addition, studies on physical activity and periodontitis have not been examined using the same physical activity indicator. A few study has been

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conducted on the association between physical activity and periodontitis in Korea. In this study, assessment of physical activity is an indicator of international standards, which is recommended level for national monitoring.

Results on association between physical activity and mortality also show mixed results[15-17] in medical area. Results from the Whitehall II prospective study showed that it is important to consider the intensity of physical activity on the mortality outcomes[18]. However, to date, these aspects have not been extensively investigated in dental area. Considering these previous studies and limitations, further research needs to overcome these factors. In addition, there was a finding that sedentary lifestyle can contribute to obesity, and this further amplifies the impact on periodontitis[19].

Thus, we hypothesized that physical activity would be associated with periodontitis in a representative Korean population.

The objectives of this article were 1) to investigate the association between types of physical activity and periodontitis after taking into consideration possible confounders including age, income, education, toothbrushing frequencies, smoking, dental visits, hypertension, obesity, diabetes mellitus, and hypercholesterolemia. 2) to compare gender differences by type of physical activity, and 3) to assess whether obesity could modify the associations, stratified analyses by obesity were performed.

2. MATERIALS AND METHODS

2. 1. Study participants

Data for this study were drawn from the 2012－2013 KNHANES, which is a study periodically conducted by the KCDC. The sampling protocol was designed to include a complex, stratified, multistage, and probability-cluster survey of a representative sample of the non-institutionalized civilian population[19].

Details of the survey design methods and methodological explanations are summarized in several reports[4].

This study analyzed the participants who had main variables and the confounders required for the analysis. The total number of participants in the 2012－2013 KNHANES was 9,191 (3,914 males and 5,277 females). All participants provided written informed consent before participating in the survey. The 2012－2013 survey was approved by the KCDC Institutional Review Board (IRB number: 2012-01EXP-01-2C, 2013-07CON-03- 4C).

2. 2. Assessment of the periodontitis

Periodontal status was assessed by trained dentists using the Community Periodontal Index of Treatment Needs (CPITN) according to the World Health Organization (WHO) guidelines[20]. CPI was scored from 0 to 4 (0 = normal, 1 = gingivitis with bleeding on probing, 2 = presence of calculus, 3 = probing depth ≥ 3.5 mm, 4 = probing depth ≥ 5.5 mm). Periodontal status was dichotomized into no (CPI score of 0－2, non-periodontitis) versus yes (CPI score of 3－4, periodontitis)[20].

2. 3. Assessment of physical activity

Physical activity was assessed by the trained interviewer using International Physical Activity Questionnaire-Short Form (IPAQ-SF), which was developed by the International Consensus Group for the Development of an International Physical Activity Questionnaire.

IPAQ-SF is composed of vigorous physical activity, moderate physical activity, and walking activity. The participants were asked to respond to each activity for the number of days and average hours of physical

activity for at least 10 minutes at a time during the last 7 days. Vigorous physical activity includes occupational and physical activities such as running (jogging), climbing, biking at high speed, swim fast, soccer, basketball, jump rope, squash, singles tennis, and carrying heavy objects. Moderate physical activity includes occupational and physical activities such as slow swimming, doubles tennis, volleyball, badminton, table tennis, and carrying light things, except for walking. Walking activity includes transportation, commuting, and walking for movement and exercise.

The participation rate of physical activity was defined as follows: 1) vigorous physical activity (three or more days of vigorous physical activities of at least 20 min/day, three days a week), 2) moderate physical activity (five or more days of moderate physical activities of at least 30 min/day), 3) walking activity (five or more days of walking activities of at least 30 min/day).

2. 4. Assessment of potential confounders

Data on confounder variables employed in the statistical analyses considered information on socio-demographic factors (age, income, education), general health behaviors (toothbrushing frequencies, smoking, dental visits), and systemic health status (hypertension, obesity, diabetes mellitus, hypercholesterolemia).

Household income was the monthly average family income and was divided into quartiles. Education level was divided into four groups of less than primary school, middle school, high school, and college or higher. Daily tooth brushing frequency was assessed by asking the following question, "How many times did you brush your teeth yesterday?" (<2 vs ≥2). The participants were asked whether they were currently smoking and the answers were categorized into: no (never smoker or past smoker) and yes (current smoker). Participants were also asked whether they had visited a dentist for a regular examination during the past year. The definition of hypertension was systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg or being medicated for hypertension. Body mass index (BMI) is used to define obesity. The BMI was calculated by dividing weight in kilograms by the square of height in meters. Obesity was defined as a BMI of 25.0 kg/m^2 or greater. Diabetes mellitus was defined as having a fasting glucose level over 126 mg/dL or being medicated for diabetes. Hypercholesterolemia was defined as having a total cholesterol > 240 mg/dL or being medicated for hypercholesterolemia.

2. 5. Statistical analysis

All statistical analyses were performed using complex sample analysis procedures according to the Guidelines for the Use of KNHANES[19].

Periodontitis was an outcome variable and three physical activities were explanatory variables. The chi-square test was used to assess the differences in the categorical variables. All data were presented as weighted percentage and standard error. The independent t-test was used to assess the differences in the continuous variables. All data were presents as weighted mean and standard error. We presented the frequency distribution of participation rate of each physical activity according to the periodontitis using chi-square test. Multivariable logistic regression analysis was performed to examine association between the physical activity and periodontitis after adjusting for related confounder variables. Adjusted odds ratio (OR) and confidence intervals (CIs) were calculated for each model. Next, interaction terms between physical activity and obesity were analyzed in the multivariable logistic regression models. For assessing whether obesity could modify the associations, stratified analyses

by obesity subgroup were performed. All analyses were conducted separately for males and females. The data were analyzed with statistical software (SPSS statistical software version 19.0, IBM, Chicago, IL.).

3. Results

3. 1. Characteristics of the participants

Prevalence of periodontitis in males and females were 33.9% and 22.2%, respectively. Table 1 describes the baseline characteristics of the participants according to periodontal status. Unlike the results in females, the prevalence of periodontitis was high in males with high income and education level. In univariate analysis for general health behaviors and systemic health status were similar results in both males and females, except for smoking status and obesity (Table 1).

3. 2. Distribution of periodontal status according to the participation of physical activity

Overall, there was a difference in the distribution of periodontal status among the three types of physical

Table 1. Characteristics of the participants according to periodontal status (N=9,191)

Variables	Male				Female		
		Non-periodontitis	Periodontitis		Non-periodontitis	Periodontitis	
	Total n	(n=2,589)	(n=1,325)	*P*-value*	(n=4,105)	(n=1,172)	*P*-value*
Age	9,191	40.0±0.36†	52.5±0.45†	<0.001†	43.1±0.35†	55.8±0.52†	<0.001†
Income							
Lowest quartile	1,542	10.7 (0.8)	16.0 (1.2)	0.001	12.4 (0.8)	26.3 (1.8)	<0.001
Lower middle quartile	2,392	24.3 (1.2)	25.9 (1.7)		26.9 (1.0)	29.4 (1.8)	
Upper middle quartile	2,479	31.3 (1.2)	27.7 (1.6)		28.6 (0.9)	24.7 (1.6)	
Highest quartile	2,778	33.6 (1.4)	30.4 (2.0)		32.2 (1.2)	19.6 (1.5)	
Education							
Primary school	2,025	6.6 (0.6)	18.9 (1.3)	<0.001	16.2 (0.8)	42.4 (2.0)	<0.001
Middle school	949	6.5 (0.6)	14.3 (1.2)		8.1 (0.5)	15.5 (1.3)	
High school	3,266	44.5 (1.2)	40.6 (1.7)		40.8 (1.0)	27.4 (1.8)	
College	2,951	42.4 (1.3)	26.2 (1.6)		34.9 (1.1)	14.7 (1.4)	
Toothbrushing frequencies							
<2	1,018	11.7 (0.7)	19.2 (1.3)	<0.001	6.5 (0.5)	12.0 (1.2)	<0.001
≥2	8,173	88.3 (0.7)	80.8 (1.3)		93.5 (0.5)	88.0 (1.2)	
Smoking							
No	7,379	59.7 (1.2)	52.5 (1.6)	<0.001	92.7 (0.6)	93.3 (0.9)	0.570
Yes	1,812	40.3 (1.2)	47.5 (1.6)		7.3 (0.6)	6.7 (0.9)	
Dental visits							
No	6,718	74.4 (1.1)	71.8 (1.5)	0.160	72.6 (0.8)	75.2 (1.6)	0.161
Yes	2,473	25.6 (1.1)	28.2 (1.5)		27.4 (0.8)	24.8 (1.6)	
Hypertension							
No	6,483	77.2 (1.0)	61.3 (1.5)	<0.001	82.4 (0.8)	60.4 (1.9)	<0.001
Yes	2,708	22.8 (1.0)	38.7 (1.5)		17.6 (0.8)	39.6 (1.9)	

Variables	Male				Female		
	Total n	Non-periodontitis (n=2,589)	Periodontitis (n=1,325)	*P*-value*	Non-periodontitis (n=4,105)	Periodontitis (n=1,172)	*P*-value*
Obesity							
No	6,221	63.7 (1.1)	61.0 (1.4)	0.139	74.7 (0.9)	60.8 (2.0)	<0.001
Yes	2,970	36.3 (1.1)	39.0 (1.4)		25.3 (0.9)	39.2 (2.0)	
Diabetes mellitus							
No	8,246	93.7 (0.5)	83.8 (1.2)	<0.001	94.5 (0.4)	83.5 (1.5)	<0.001
Yes	945	6.3 (0.5)	16.2 (1.2)		5.5 (0.4)	16.5 (1.5)	
Hypercholesterolemia							
No	7,773	89.8 (0.6)	86.6 (1.0)	0.005	87.0 (0.7)	76.9 (1.4)	<0.001
Yes	1,418	10.2 (0.6)	13.4 (1.0)		13.0 (0.7)	23.1 (1.4)	

* Obtained from chi-square test.
† Obtained from independent t-test.
All data are presents as weighted percent and standard error
‡ Data are presents as weighted mean and standard error.
Bold denotes statistical significance at p<0.05.

activity. On the univariate analysis, participants who participated in vigorous physical activity were more likely to have non-periodontitis than periodontitis in both gender (p = 0.032 for males; p <0.001 for females) (Table 2). There was a significant difference in moderate physical activity group according to periodontitis among females, not males (p = 0.265 for males; p = 0.045 for females). Males who pareticipated in walking activity exhibited lower prevalence of periodontitis (p = 0.001 for males; p = 0.104 for females).

3. 3. Association between the physical activity and periodontitis

Among males, there was no association between

Table 2. Distribution of periodontal status according to the participation of physical activity (N=9,191)

Physical activity	Total N	Male			Female		
		Non-periodontitis (n=2,589)	Periodontitis (n=1,325)	*P*-value*	Non-periodontitis (n=4,105)	Periodontitis (n=1,172)	*P*-value*
Vigorous physical activity							
No	7852	79.5 (1.0)	82.9 (1.2)	0.032	86.1 (0.7)	91.7 (0.9)	<0.001
Yes	1339	20.5 (1.0)	17.1 (1.2)		13.9 (0.7)	8.3 (0.9)	
Moderate physical activity							
No	8618	91.1 (0.7)	92.5 (0.9)	0.265	94.7 (0.4)	96.3 (0.6)	0.045
Yes	573	8.9 (0.7)	7.5 (0.9)		5.3 (0.4)	3.7 (0.6)	
Walking activity							
No	5724	56.5 (1.3)	63.1 (1.5)	0.001	64.1 (0.9)	67.2 (1.7)	0.104
Yes	3467	43.5 (1.3)	36.9 (1.5)		35.9 (0.9)	32.8 (1.7)	

*Obtained from chi-square test.
Data are presents as weighted percent and standard error
Bold denotes statistical significance at $p<0.05$

three types of physical activity and periodontits after various confounder variables. In females, physical activities were inversely associated with periodontitis (Table 3). Especially, participants who participated in vigorous physical activity have a 28% lower risk of periodontitis than participants who did not participated in (OR = 0.72, 95% CI = 0.54 – 0.95). Paricipants who engaged in moderate physical activity were 34% less likely to have perioodontitis (OR = 0.66, 95% CI = 0.44 – 0.98). However, walking activity was not found to be significantly associated with lower periodontitis.

3. 4. Interaction terms between physical activity and obesity on periodontitis among females

In the analysis of the effect of the interaction between physical activity and obesity, the association of moderate physical activity with periodontitis decreased from OR of 0.66 to 0.34 for obesity by adding the interaction term with obesity (OR = 0.34, 95% CI = 0.17 – 0.67) (Table 4). Moreover, interaction term was statistically significant (OR = 0.39, 95% CI = 0.17 – 0.87).

Table 3. Association between physical activity and periodontal status (N=9,191)

	Male (n=3,914)			Female (n=5,277)		
Physical activity	N (%)	Adjusted OR (95% CI)	*P*−value	N (%)	Adjusted OR (95% CI)	*P*−value
Vigorous physical activity						
No	3,211 (82.0)	1	0.793	4,641 (87.9)	1	0.022
Yes	703 (18.0)	1.03 (0.82−1.30)		636 (12.1)	0.72 (0.54−0.95)	
Moderate physical activity						
No	3,609 (92.2)	1	0.736	5,009 (94.9)	1	0.043
Yes	305 (7.8)	1.06 (0.75−1.49)		268 (5.1)	0.66 (0.44−0.98)	
Walking activity						
No	2299 (58.7)	1	0.119	3425 (64.9)	1	0.831
Yes	1615 (41.3)	0.87 (0.73−1.34)		1852 (35.1)	0.98 (0.82−1.18)	

Models were adjusted for age, income, education, toothbrushing frequency, smoking, dental visits, hypertension, obesity, diabetes mellitus, and hypercholesterolemia.

Table 4. Interaction effect physical activity and obesity on periodontitis among female (n=5,277)

Physical activity	N	OR (95% CI)	P−value
Vigorous physical activity			
No	4641	1	0.131
Yes	636	0.71 (0.45−1.11)	
Interaction		0.98 (0.56−1.71)	0.929
Moderate physical activity			
No	5009	1	0.002
Yes	268	0.34 (0.17−0.67)	
Interaction		0.39 (0.17−0.87)	0.023

Models were adjusted for age, income, education, toothbrushing frequency, smoking, dental visits, hypertension, obesity, diabetes mellitus, hypercholesterolemia and interaction term between physical activity and obesity.

3. 5. Stratified analyses by obesity subgroup among females

When considering the results of the stratified analyses by obesity in females, moderate physical activity in obese had a 65% lower risk of periodontitis (OR = 0.35, 95% CI = 0.18 – 0.67) (Table 5)

Table 5. Association between physical activity and periodontitis by stratified analysis of obesity subgroup among female (n=5,277)

Subgroup	N	OR (95% CI)	P-value
Non-Obesity (n=3,742)			
Moderate physical activity (No)	3556	1	0.504
Moderate physical activity (Yes)	186	0.84 (0.52-1.37)	
Obesity (n=1,535)			
Moderate physical activity (No)	1453	1	0.002
Moderate physical activity (Yes)	82	0.35 (0.18-0.67)	

Models were adjusted for age, income, education, toothbrushing frequency, smoking, dental visits, hypertension, obesity, diabetes mellitus, and hypercholesterolemia, except for subgroup.

4. Discussion

The main findings of this study were as follows: 1) Data from the KNHANSE showed that individuals who participated in moderate and vigorous physical activity had a significantly lower risk of periodontitis in females but not males; 2) Obesity modified the association between moderate physical activity and periodontitis; 3) In obese females, moderate physical activity had an independently inverse association with periodontitis.

In the fully adjusted models, results did not show an association between physical activity and periodontitis among males, which is inconsistent with the studies conducted among males[6,11,13].

In the previous studies, the terms of physical activity were used as physical fitness[5,10,11], physical strength[12], physical activity[6–9], and its measurement also varied with maximal oxygen consumption[5,10], physical fitness test including physical strength, cardiorespiratory fitness[11,13], health-enhancing behaviors[7], metabolic equivalents calculation[6], recommended national level[8,9], and handgrip strength[5,12]. The three types of physical activity evaluation in this study were conducted using IPAQ-SF. The participation rate of each physical activity was classified according to whether it meets the national guideline recommendations. This factor may be the reason for different results among studies. Because past studies[7,10,12] also did not assess the confounders (oral hygiene behaviors[7] and socioeconomic status[9,10,12]) that affect periodontitis, this study shows results that include such important confounders.

As the distribution of type in physical activity in males and females were different in this study, this study used to stratified analysis by gender. In epidemiological studies[5–7,8,10,11,13,14], physical activity has been associated with a decrease in the risk of periodontitis, but no study has presented data on female separately in the dental field. Unfortunately, there is no previous study for directly comparisons. Though many prospective studies have reached a consensus on the health benefits of physical activity for various health outcomes[17,23], the gender difference has not yet been elucidated. Further studies should be conducted on gender differences in physical activity that affect

periodontitis.

In females, only those who did moderate and vigorous physical activity were associated with a low risk of periodontitis. These results are contrary to the previous study showing inverse association in males US health professionals[6]. Unexpectedly, strength of association was slightly higher in moderate physical activity than vigorous physical activity. Recent animal study[14] has shown that moderate intensity exercise attenuated the progression of periodontitis in rats with periodontitis. Specifically, exercised rats changed favorably to inflammatory markers such as interleukin-10(IL-10) and tumor necrosis factor α(TNF-α), which play an important role in the development of periodontitis14. Blair and Morris[24] suggested that moderate intensity physical activity reduces the risk of a wide variety of chronic diseases. Lim[25] could not explicitly explain whether vigorous physical activity has additional advantages over moderate physical activity. The current result can be partially explained in these previous evidences.

The biological plausibility that physical activity has an important role in reducing periodontitis can be explained by the literatures[26,27] that physical activity reduces inflammatory markers such as C-reactive protein (CRP). CRP level has been used as a well-known marker of periodontitis[28] as well as a strong predictors for CVD[29]. In a 751 case-control study[9], the evidence of a link between physical activity and periodontitis was further reinforced with a lower level of pro-inflammatory biomarkers CRP in the GCF among physical active participants. In a recent animal study[14], moderate-intensity physical activity decreased IL-10, which is mainly involved in bone preservation in rats.

When we analyzed the interaction between physical activity and obesity in females, obesity is an effect modifier in the association between moderate physical activity and periodontitis. The risk of periodontitis is significantly reduced in individuals who engaged in moderate physical activity in obese group. Conversely, the risk of periodontitis was 2.84 times higher when obese people did not engage in physical activity. This finding is in line with a study by Shimazaki et al.[10], which analyzed the interaction effect of physical activity and BMI categories. In a prospective study[30], obesity appears to be a risk factor for periodontal attachment loss progression for females but not males. These results could explain some of our results.

Previous epidemiology studies have been limited but have generally showed an inverse association between two, except for one study[9]. This study demonstrated additional evidence in light of the limitations of the previous studies. Our study presented main strengths. First, this study used a large number of participants from the representative Korean population that can generalize the study results. Second, oral examination was assessed by trained dentists and health examination and interview and clinical laboratory analysis were conducted by physicians and medical staff who were regularly trained. Third, our study evaluated using the IPAQ-SF that was used internationally for three physical activities. Fourth, these results of gender-stratified analysis provide the first evidence linking the physical activity and periodontitis.

Finally, the present findings should be interpreted with caution due to some limitations.

There were previous studies with periodontitis as an independent variable[11-13] or as an outcome variable [5-10,14]. In this regard, bi-directional associations could not be ruled out by explanation of biological plausibility. Because this study used a cross-sectional design that was difficult to identify causality, the cause and consequences of the two variables could not precisely inferred.

5. Conclusion

In conclusion, the association between physical activity and periodontitis was found in only females. Further longitudinal studies are required to identify the mechanism of effect modification by obesity on the link between physical activity and periodontitis.

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초록

한국인에서 비만에 따른 신체활동와 치주질환과의 연관성

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연구의 배경 및 목적: 본 연구의 목적은 한국인에서 신체활동과 치주염 사이의 연관성을 조사하는 것이다.
연구방법: 국민건강영양조사 2012년과 2013년 자료를 활용하여 우리나라 성인 9,191명에 대해 분석하였다. 치주상태 조사는 지역사회치주요양필요지수(Community Periodontal Index, CPI)를 이용하여 CPI 3과 4를 치주염으로 정의하였다. 신체활동은 단축형 국제신체활동설문(International Physical Activity Questionnaire−Short Form, IPAQ−SF)을 이용하여 걷기 활동, 중등도 활동, 격렬한 활동으로 분류하여 분석하였다. 주요 변수간의 연관성은 로지스틱 회귀분석을 적용하였고, 비만 변수에 대해 층화분석을 적용하였다. 모든 분석은 성별에 따른 신체활동 수준의 차이가 있으므로 남녀를 나누어 분석하였다.
결과: 남성에서 치주염 유병률은 33.9%, 여성에서 치주염 유병률은 22.2%였다. 격렬한 신체활동과 중등도 신체활동을 하는 여성그룹에서 치주염 유병률이 각각 28% (OR=0.72, 95% CI=0.54－0.95), 34% ((OR=0.66, 95% CI=0.44－0.98) 낮았다. 반면 남성에서는 유의한 연관성을 보이지 않았다. 비만인 여성그룹에서는 중등도 활동을 한 그룹에서 65% (OR=0.35, 95% CI=0.18－0.67)의 더 높은 신체활동 감소와 연관성이 있었다.
결론: 본 연구조사 결과 중등도 신체활동은 치주염과 음의 연관성(inverse association)이 있다는 것을 보여주었다. 비만 여성에서는 중등도 신체활동이 치주염과 독립적으로 연관성이 있고 비만 변수가 효과변경인자(effect modifier)가 된다는 것을 확인하였다.

색인어: 비만 : 치주염 : 신체활동

ABSTRACT

Association between physical activity and periodontitis as stratified by obesity in Koreans

Background: The aim of this study was to examine the association between physical activity and periodontitis in the Korean population.

Methods: This study utilized data from 9,191 participants of the Korea National Health and Nutrition Examination Survey. Periodontitis was defined as a CPI score of 3 or 4. Physical activity was assessed by the trained interviewer using the International Physical Activity Questionnaire-Short Form (IPAQ-SF). IPAQ-SF is composed of vigorous physical activity, moderate physical activity, and walking activity. Multivariable logistic regression analyses and stratified analyses by obesity were performed. All analyses were conducted separately for males and females.

Results: Females who engaged in vigorous and moderate physical activity had a 28% (OR = 0.72, 95% CI = 0.54 – 0.95) and 34% (OR = 0.66, 95% CI = 0.44 – 0.98) lower risk of periodontitis, respectively. In obese females, moderate physical activity in obese had a 65% lower risk of periodontitis (OR = 0.35, 95% CI = 0.18 – 0.67).

Conclusions: Our findings suggest that moderate-intensity physical activity was inversely associated with a lower risk of periodontitis. In obese females, moderate physical activity had an independent inverse association with periodontitis.

Key words: Obesity: Periodontitis: Physical activity