Allied Medical Research Journal

Volume 1 | Issue 2 | Original Article

June 2023

Determining the Relative Risk of Smoking and Physical Inactivity in Developing Osteopenia and Osteoporosis

Received
Feb 8, 2023

Revised
March 24, 2023

Accepted
April 5, 2023

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Recommended Citation

[Abid F, Khalid H, Qasim F, Qazi A, Asif MG, Mustafa M. Determining the Relative Risk of Smoking and Physical Inactivity in Developing Osteopenia and Osteoporosis. . Allied Med Res J. 2023;1(2):50-60. Available from: http://ojs.amrj.net/index.php/1/article/view/23]

DOI: https://doi.org/10.59564/amrj/01.02/007

Abstract

Background

Tobacco consumption is a widely recognized risk factor influencing various diseases' progression worldwide. According to the World Health Organization, tobacco consumption is responsible for 6.5 million deaths annually. Thus, the present study examined the relationship between smoking, physical inactivity, and the risk of developing osteoporosis and osteopenia.

Methodology

This cross-sectional study included a population-based sample of 250 participants aged 45-65. Written consent was obtained from the participants, and the study focused on assessing their smoking status. The cigarette dependency scale was utilized to measure the level of dependency on smoking.

Results

Compared to non-smokers, active smokers had a significantly higher risk ($p<0.005$) of developing osteoporosis at the femoral neck (OR=1.9, 95% CI: 1.2-3.0) and lumbar spine (OR=1.7, 95% CI: 1.1-2.7). Furthermore, the low physical activity group had significantly higher odds ratios ($p<0.05$) for developing osteoporosis and osteopenia compared to the high physical activity group at the femoral neck (OR=1.85, 95% CI: 1.2-2.7) and lumbar spine (OR=1.65, 95% CI: 1.1-2.5).

Conclusion

The study has concluded that bone mineral density at the femoral bone and lumbar spine level has significantly been reduced among active and former smokers compared to the non-smoker group.

Keywords

Bone Mineral Density, Osteoporosis, Osteopenia, Physical Activity, Smoking.

Introduction

Globally tobacco consumption is one of the most common risk factors that affect the progression of almost every disease[1], and according to the data provided by the World Health Organization, tobacco consumption alone is responsible for 6.5 million deaths per year[2]. In addition to all the modes of tobacco consumption, cigarette smoking is the most commonly accepted approach[3], and it has also been estimated that by the year 2050, the death toll will rise to 8 million deaths due to smoking[2-4]. Studies have provided evidence that cigarette smoking alone is considered an independent risk factor for developing osteopenia and osteoporosis[5-6], and according to the data, smokers are at 50% higher risk of suffering from hip fracture compared to non-smokers during their life time[7]. Evidence revealed that smokers have relatively low bone mineral density than non-smokers, which can, even in chronic cases, leads to impaired muscle function and imbalance in bone turnover[8-9]. Literature has also provided evidence regarding osteoporosis and osteopenia, and it has been estimated that there are over 200 million cases of osteoporosis, creating an annual burden of €55 billion for European Union nation's only[3-10]. According to a survey conducted in 204 countries, it has been found that 1.1 to 1.3 billion people smoke globally. The smoking addiction rate is very high and smoking cessation and preventive programs are not greatly effective[11]. Studies have revealed that cigarette smoking directly and indirectly impaired bone mineral density. Smoking compounds significantly impact osteoclast, bone angiogenesis, and calcium phosphate (Ca-K) balance and increase oxidative stress, affecting Bone Mineral Density (BMD)[12].

Moreover, one of the critical factors that regulate bone's physiological osteoclast activities is osteoprotegerin (OPG) which combines with receptor activator of nuclear factor kβ ligand (RANKL) to inhibit osteoclast becomes low among smokers[13]. Further, it has also been evident that levels of OPG reduce, and the ratio of RANKL/OPG increases among cigarette smokers, increasing the risk for osteoporosis and osteopenia and associated bone fractures prominently at the hip and lower spine[14]. Besides that, literature has also suggested that smoking reduces vitamin D and calcium absorption levels due to the inhibition of 25hydroxylation by nicotine and intestinal calcium reabsorption[15]. In addition, the increased risk of osteoporosis and associated

risk of fractures dramatically reduces with increased physical activity (PA). However, physical activity and cigarette smoking in developing osteoporosis and osteopenia are independent factors and increased physical activity significantly increases bone density and remodeling. Multiple studies have provided evidence that physical activity dramatically increases bone health and vitamin D levels in the body and that physically active individuals have a low risk of developing osteoporosis and osteopenia[16-17]. Therefore, the present study is aimed to investigate a relationship between smoking, physical inactivity and the risk of developing osteoporosis and osteopenia so that a burden of osteoporosis and osteopenia due to smoking among the age group of 45-65 years can be identified among the population of the Punjab province of Pakistan.

Methodology

This cross-sectional study involved a population-based sample of 250 participants aged 45-65. Written consent was obtained from the participants. Their smoking status was assessed using the cigarette dependency scale. Additionally, the participant's physical activity levels from the previous week were determined using the International Physical Activity Questionnaire (IPAQ). The participants' Bone Mineral Density (BMD) was measured using a DEXA scan, allowing for the diagnosis of normal BMI, osteopenia, and osteoporosis.

Inclusion and Exclusion Criteria

The participants were enrolled via a non-probability purposive sampling technique, including both males and females aged 45-65 years. They had provided written consent belonging to various districts of the Punjab province of Pakistan. At the same time, all those participants who had refused to perform the DEXA scan test to determine BMD and had any diagnosed mental or psychological disorders like Dementia, Alzheimer, and Parkinsonism etc. that made it difficult to recall the past week's physical activity and their smoking habits were excluded.

Statistical Analysis

Statistical measures were performed on SPSS version 22. A multivariate logistic regression test was performed to identify the association between cigarette smoking, physical inactivity and

bone mineral density. Odd ratios between variables to identify the risk of developing osteoporosis and osteopenia were determined at 95% of Confidence Interval. The level of significance was kept at the level of $p<0.05$.

Ethical Considerations

Information obtained from the study participants was kept confidential and only used for this study. Besides that, the purpose of the study was narrated to the participants and their consent was taken before their enrollment.

Results

A total of n=250 participants were recruited for this study; the demographic characteristics represent that the participants' mean age was 58.24±3.2 years with a male-to-female ratio of 2:1, i.e. 166 males and 84 females. The demographic description is shown in Table-1:

Table-1 Demographic description of participants recruited in the study

Variables	'n'	Age of the Participants	Male: Female	Percentages
Male	166	60.35±2.56	2:1	66.4%
Females	84	56.23±1.28		33.6%
Total	250	58.24±1.58		100%

Mean±S.D.

Further, the participants' smoking habits and physical activity levels were identified, and it was found that around n=65 of the participants were current smokers, n=85 were former smokers, and n=100 were non-smokers. Further, based on IPAQ, participants' physical activities were categorized into three domains that were low, moderate and high PA, and it was found that 48% of the participants were in the low physical activity group, 44% were in the moderate PA group whereas 8% were in high PA group as per IPAQ. Detailed descriptions are shown in Table-2.

Table-2 Smoking habits and levels of physical activities of participants	
Variables	**n (%)**
Smoking Habits	
Current	65 (26%)
Former	85 (34%)
Non-Smoker	100 (40%)
Levels of Physical Activity	
Low	120 (48%)
Moderate	110 (44%)
High	20 (8%)

Moreover, the BMD of the study participants was also determined, which suggested that among smokers and former smokers, osteoporosis and osteopenia were more common compared to the non-smoker group. Similarly, those with low PA were more osteoporotic and osteopenia than moderate and highly physically active individuals. Besides that, in comparison to non-smokers, active smokers were at significantly higher risk of ($p<0.005$) of developing osteoporosis at the level of femoral neck (OR=1.9, 1.2-3.0; 95% of CI) and at lumbar spine (OR=1.7, 1.1-2.7; 95% of CI). Whereas in the former smoker group, the risk for developing Osteoporosis was lesser in comparison to active smokers, yet it was significantly higher ($p<0.05$) than non-smoker group (OR=1.75, 1.3-2.3; 95% of CI) at the femoral neck and (OR=1.67, 1.35-2.12; 95 of CI) at the lumbar spine. Additionally, OR of developing osteoporosis and osteopenia were also found to be significantly high ($p<0.05$) among the low physical activity group in comparison to the high PA group at the level of femoral neck (OR=1.85, 1.2 to 2.7; 95% of CI) and the level of lumbar spine (OR=1.65, 1.1 to 2.5; 95% of CI) (Table-3).

Table-3 Odds ratio of developing osteoporosis among smokers and less physically active Individual						
Variables	**BMD Femoral Neck**			**OR**	**95% of CI**	**Level of Significance**
	Normal *n*	**Osteopenia** *n*	**Osteoporosis** *n*			
Smoking Habits						
Active	2	20	43	1.9	1.2 to 3	p<0.005
Former	20	45	20	1.75	1.3 to 2.3	
No Smoker	82	15	3			
Levels of Physical Activity						
Low	5	45	48	1.85	1.3 to 2.5	p<0.005
Moderate	8	52	46	1.62	1.4 to 2.8	
High	40	3	3			
Variables	**BMD Lumbar Spine**			**OR**	**95% of CI**	**Level of Significance**
	Normal *n*	**Osteopenia** *n*	**Osteoporosis** *n*			
Smoking Habits						
Active	9	11	43	1.7	1.1 to 2.7	p<0.005
Former	24	44	23	1.67	1.35 to 2	
No Smoker	86	8	2			
Levels of Physical Activity						
Low	10	40	43	1.6	1.4 to 2.2	p<0.005
Moderate	12	51	43	1.62	1.39 to 2.1	
High	46	3	2			

Discussion

The analysis of the findings revealed that in comparison to the non-smokers' group, active smokers and formers smokers have a significantly ($p<0.005$) more risks of osteoporosis and osteopenia at the level of femoral neck OR=1.9 (active), 1.67 (former smoking group) and OR=1.7 (active), 1.67 (former) at the level of the lumbar spine. In addition, the odds ratio for osteoporosis and osteopenia was also found to be significantly higher ($p<0.005$) in the low and moderate levels of the physical activity group when estimated in comparison to the high PA group. The findings of our study were according to the findings of another study that was performed to determine the effects of smoking on phosphocalcic metabolism. Secondly, on bone mass and risk of vertebral fracture in post-menopausal osteoporotic women, it was found by the authors that in comparison to the non-smokers group current smokers group had lower BMI along with the likelihood of greater infertility rate and shorter reproductive age[21]. Similarly, in another study that was performed to identify the effects of cigarette smoking on bone mineralization and fibrillary matrix composition, it was found by the authors that smoking has significantly lowered bone thickness at the level of bone trabeculae along with a decrease in both mineralization and mineral deposition rate[22].

Similarly, in another study that was performed to determine the effects of a supervised multi-component exercise program on bone mass of bariatric surgery patients, it was found that PA-induced bone benefits in patients with severe obesity and has undergone a bariatric surgery[23]. In another study performed to investigate the differences in the mean of bone formation and resorption markers between young adult male smokers and non-smokers, the authors found that levels of bone resorption markers that were serum carboxyl-terminal telopeptide of collagen type 1 (CTX1) were significantly ($p<0.005$) lower in smokers in comparisons to non-smokers. Besides that, a significant difference in the mean level of RANKL and RANKL/OPG levels was observed, reflecting that the smoker population has an increased risk for osteoporosis and fractures compared to the non-smoker's population[24]. Although the current study has successfully provided evidence regarding the risk of developing osteopenia and osteoporosis among smokers both in active and former smokers' populations, yet authors of this study suggest that besides

estimating the BMD, future studies must be based on identifying the levels of osteoprotegerin (OPG), RANKL and the ratio of RANKL/OPG at larger scale along with the effects of exercises based management approaches to improve mentioned bone turnover markers so that robust evidence against the effects of smoking on bone mineralization process along with the effects of exercises in undoing the same can be identified and can be used for the better interest of the population.

Conclusion

The study has concluded that BMD at the level of femoral bone and lumbar spine has significantly reduced among the active and former smokers compared to the non-smoker group. In addition to that, it has also been estimated that physical inactivity also poses a significant risk of developing osteoporosis and osteopenia and that both smoking and physical inactivity are independent risk factors, and an increase in physical activity may, as per the evidence of previous literature improve bone health and increase the process of bone mineralization.

Authors Contribution

Abid F: Conception, design and data acquisition.

Khalid H: Data acquisition and analysis.

Qasim F: Drafting and critical revision.

Qazi A: Drafting assistance.

Asif M: Revising the draft.

Mustafa M: Final approval.

Declaration of Interest

None.

Funding Sources

None.

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