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RESEARCH ARTICLE

The association of tobacco smoking and bone health in the elderly population of Iran: results from Bushehr elderly health (BEH) program

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Abstract

Purpose Smoking has been linked with osteoporosis, but further evidence is required, especially concerning the effects of different types of tobacco smoking. We sought to examine the association between smoking and bone health in a large cohort of elderly Iranians.

Methods The data from 2377 participants aged >60 years of Bushehr Elderly Health (BEH) program were used. Regardless of the type of smoking, participants were initially classified as non-smokers, ex-smokers and current smokers. Current smokers were also categorized based on the smoking type (pure cigarette, pure hookah and both). Dual-energy X-ray absorptiometry was used to evaluate bone density as well as Trabecular Bone Score (TBS). T-score ≤ -2.5 in either of the femoral neck, total hip or spinal sites was applied to determine the osteoporosis. The association of smoking and osteoporosis was assessed using multivariable modified Poisson regression model and reported as adjusted prevalence ratios (APR). The linear regression model was used to assess the association between smoking and TBS, adjusting for potential factors.

Results A total of 2377 (1225 women) were enrolled [mean age: 69.3 (±6.4) years], among which 1054 (44.3%) participants were nonsmokers. In all, 496 (20.9%) participants were current smokers. Multivariable regression analysis revealed no significant association between smoking (either current or past) and osteoporosis in women. In men, current smoking was negatively associated with osteoporosis (APR: 1.51, 95%CI: 1.16–1.96). Among current users, cigarette smoking was associated with

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osteoporosis (APR: 1.57, 95%CI: 1.20–2.03); however, we could not detect a significant association between current smoking of hookah and osteoporosis. In men, a significant association was also detected between current cigarette smoking and TBS (coefficient: -0.03, 95%CI: −0.01, −0.04).

Conclusion Current cigarette smoking is associated with both the quantity and quality of bone mass in elderly men. Although we could not detect a significant association between hookah and osteoporosis in men, considering the prevalence of hookah smoking in the middle eastern countries, further studies are needed to determine the effect of hookah smoking on bone health.

Keywords Smoking · Tobacco products · Hookah · Osteoporosis · Iran

Introduction

Osteoporosis and osteopenia are two of the most important public health issues on the account that decreased bone mineral density (BMD) elevates fracture risk. Currently, 10 million people in the U.S. are affected by osteoporosis and a further 18 million have low BMD, which being at increased risk of osteoporosis [1]. According to the Iranian National Program on Prevention, Diagnosis and Treatment of Osteoporosis' report, half of the men and 70% of women aged over 50 years are affected by osteoporosis/osteopenia [2]. WHO estimates that tobacco is responsible for the annual death of eight million people globally [3]. A meta-analysis revealed that roughly 20% of Iranian men and 3% of Iranian women smoke daily [4].

Evidence suggests that smoking impedes bone formation by affecting osteoblasts while also increasing bone resorption by osteoclasts. Also, several studies have demonstrated that smoking negatively affects bone metabolism by reducing calcium absorption, which could lead to osteoporosis [5, 6]. Compared to non-smokers and ex-smokers, the level of bone resorption markers such as C-terminal telopeptide, free and general deoxypyridinoline in smoking men is substantially higher. Likewise, compared with non-smoking women, the level of N-terminal telopeptide is found to be significantly higher in older smoking women. Smoking has an anti-estrogen status, leading to women's precipitation of earlier menopause and osteoporosis [7].

Given the significant prevalence of osteoporosis among smokers, the silent nature of the disease before the occurrence of a fracture [8], the frequent use of cigarette and hookah in Iranian population especially women [9], and the prolonged and reversible adverse effects of smoking on osteoporosis and osteoporotic fractures [6], we sought to examine the association between tobacco consumption and osteoporosis considering the time (past or current) and the means (cigarette or hookah) of smoking in Bushehr elderly population.

Methods

The present study is a cross-sectional investigation of the second phase of the Bushehr Elderly Health (BEH) program, which was conducted in Bushehr, Iran that is described in detail elsewhere [10]. In brief, the inclusion criteria were consenting individuals, ≥60 years of age, and residence in Bushehr city at least one year before participation in the study, no plan for leaving the city for two years after taking part in the study, sufficient physical and mental ability to take part in the evaluation program and complete consent. The lack of residence in Bushehr and reluctance to enter the study were the exclusion criteria [10].

A comprehensive standardized questionnaire was used to collect information for medical history, medication use, socio-demographic factors, physical activities, and smoking. Medical examinations were also conducted by instructed personnel and then registered in a file assigned to each participant, along with the data from their laboratory tests [10]. Dual-energy X-ray absorptiometry (DXA Discovery WI, Hologic, Bedford, Virginia, USA) was used to evaluate the bone density of the study subjects in three sites; femoral neck, spinal and total hip. The protocol of the BEH program was approved by the Research Ethics Committee of Bushehr and Tehran University of Medical Sciences, Ethical Code: IR.TUMS.EMRI.REC.1394.0036) and written informed consent was signed by all participants.

Definition of variables

Participants were inquired about tobacco smoking, whether cigarette or hookah and were classified into three categories: current smokers, ex-smokers and non-smokers. Current smoking was defined as current smoking of either cigarette or hookah, regularly or occasionally. Ex-smoking was assumed as any kind of tobacco smoking in the past (cigarette or hookah) but not at the time of the study. Considering the type of smoking, current smokers were also categorized to pure cigarette smoking, pure hookah smoking and both). We defined diabetes as either having a fasting plasma glucose ≥126 mg/dL, HbA1C ≥ 6.5 or taking anti-diabetic medication. Overweight and obesity were defined as body mass index (BMI: weight in kg divided by the square of height in meter) ≥ 25 and ≥ 30, respectively. Hypertension referred to the presence of systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg or taking anti-hypertensive medications.

We defined hypercholesterolemia by levels of cholesterol ≥200 mg/dl, hypertriglyceridemia as a serum triglyceride ≥150 mg/dl, low HDL-C as <40 mg/dl for men and < 50 mg/dl for women and high LDL-C as >110 mg/dl. According to the ATP-III criteria, high waist circumference (WC) noted to WC >102 cm in men and > 88 cm in women. The intensity of the physical activity level in 24 h of work, sports, and leisure time was expressed in metabolic equivalents [10]. Four lifestyle categories were defined based on the level of physical activity (sedentary: 1–1.39, low active: 1.4–1.59, active: 1.6–1.89, very active: 1.9–2.5) [11]. We pooled the sedentary and low active population into two low physical activity and active and very active groups as high physical activity. Daily food intake of calcium was divided into three groups—low (<500 mg/day), moderate (500–1000 mg/day) and high (>1000 mg/day). Calcium and Vitamin D supplement consumption were defined based on the questions inquired about the use of dietary supplements, as a self- reported taking any type of calcium or vitamin D, respectively. T-score index ≤ −2.5 standard deviation (SD) in either the femoral neck, lumbar spine or total hip was applied to determine the osteoporosis [12]. Trabecular bone score (TBS) was also assessed using the DXA scan.

Statistical analyses

Categorical variables were presented in numbers (percentage) and continuous variables were presented in mean ± SD. In cases of non-normal distribution, continuous variables were shown by median and interquartile ranges. All the variables were reported separately comparing osteoporotic versus non-osteoporotic. To compare continuous variables, the independent *t*-test was used. Categorical variables distribution was examined through a Chi-squared test. Since osteoporosis is a common outcome among the elderly population, using odds ratios may overestimate the associations [13], so the associations between osteoporosis and smoking were assessed using modified Poisson model adjusted for the potential effects of age, BMI, diabetes, hypertension, high WC, hypercholesterolemia, hypertriglyceridemia, low HDL, high LDL, taking Vitamin D supplement, taking a calcium supplement, daily calcium food intake, and low physical activity. Measures of association were reported as adjusted prevalence ratios (APR). We used the best subset method with the Akaike Information Criterion (AIC), to select the final model from all possible subsets. To check the association of tobacco smoking and TBS, the linear regression model was used considering the TBS as a continuous outcome. Data were analyzed using the Stata 14 software (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP) and $P \leq 0.05$ was considered statistically significant in all tests.

Results

The present study examined a total of 2377 subjects, including of 1225 women (51.5%). The mean age of the population was 69.3 ± 6.4 years with no difference between men and women ($P = 0.14$). A total of 827 (34.8%) participants were ex-smokers and 496 (20.9%) reported smoking either cigarette or hookah at the study time (current smokers). Among current smokers, 96.3% of women only smoked hookah at the time of study while smoking cigarettes was more prevalent (62.7%) in men. Fig. 1 shows the percentage of hookah and cigarette smoking among all participants.

The baseline characteristics of the study participants are presented in Table 1. Women with and without osteoporosis were significantly different in terms of age, BMI, high WC, diabetes, hypertension, hypertriglyceridemia, low HDL and physical activity (all p values <0.05). Comparing men with and without osteoporosis age, BMI, high WC, diabetes, hypertriglyceridemia, low HDL levels, and calcium intake showed significant differences (all p values <0.05).

Table 2 showed the results of multivariable modified Poisson regression analysis. Using the best subset method, adjusting for age, education, BMI and hypertriglyceridemia in women, there was a positive and significant association between age and the likelihood of osteoporosis in women (APR:1.02, 95%CI: 1.01–1.02), while body mass index, years of education, and hypertriglyceridemia were significantly and negatively correlated to osteoporosis. As an instance, every one-year increase in women's education decreased the prevalence of osteoporosis by nearly 3% (APR: 0.97, 95%CI: 0.96–0.99), provided that other variables were constant. Osteoporosis was less likely among women with hypertriglyceridemia (APR: 0.83, 95% CI: 0.75–0.92). More importantly, in women, we found no significant association between tobacco smoking and osteoporosis neither in ex-smokers (APR: 1.07, 95%: 0.96–1.18) nor in current smokers (APR: 0.99, 95% CI: 0.88–1.12). The best set for adjustment in men

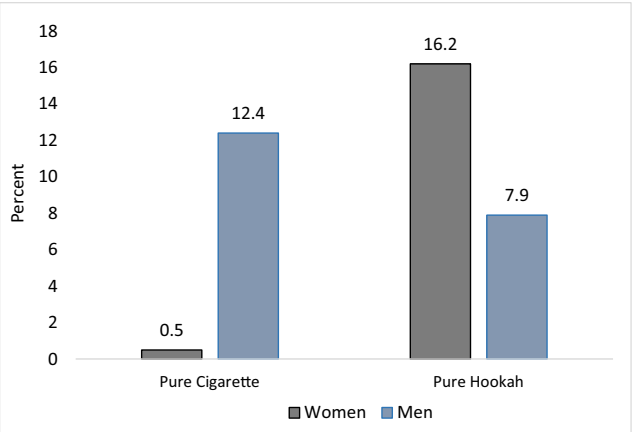

Fig. 1 The type of tobacco smoked among current smokers, by sex

Table 1 Comparing the baseline characteristics of the study participants in terms of having osteoporosis

Variables		Osteoporosis (−)	Osteoporosis (+)	p value
Women				
Age, mean (SD)		67.0 (4.7)	70.7 (6.9)	<0.001
BMI, mean (SD)		30.6 (4.9)	27.4 (5.3)	<0.001
Diabetes, n (%)		214 (42.1)	236 (33.0)	0.001
Hypertension, n (%)		403 (79.3)	522 (72.8)	0.009
High waist circumference, n (%)		472 (92.9)	553 (77.1)	<0.001
Hypercholesterolemia, n (%)		205 (40.4)	280 (39.1)	0.646
Hypertriglyceridemia, n (%)		215 (42.3)	205 (28.6)	<0.001
Low HDL, n (%)		316 (62.2)	383 (53.4)	0.002
High LDL, n (%)		264 (52.0)	374 (52.2)	0.927
Vitamin D supplement, n (%)		64 (12.6)	92 (12.8)	0.904
Calcium supplement, n (%)		65 (12.8)	92 (12.8)	0.985
Daily dietary calcium intake, n (%)	<500 mg/day	309 (61.3)	472 (66.2)	0.065
	500–1000 mg/day	173 (34.3)	224 (31.4)	
	>1000 mg/day	22 (4.4)	17 (2.4)	
Low Physical activity, n(%)		368 (72.4)	579 (80.8)	0.001
Smoking, n (%)	Never	393 (44.3)	84 (31.8)	0.006
	Past smoking	318 (35.8)	88 (33.3)	
	Current smoking	177 (19.9)	92 (34.9)	
Men				
Age		69.0 (6.1)	71.3 (7.3)	<0.001
BMI		26.8 (3.8)	24.3 (4.1)	<0.001
Diabetes, n (%)		301 (33.9)	44 (16.8)	<0.001
Hypertension, n (%)		638 (71.9)	175 (66.3)	0.077
High waist circumference, n (%)		299 (33.7)	45 (17.1)	<0.001
Hypercholesterolemia, n (%)		223 (25.1)	66 (25.0)	0.970
Hypertriglyceridemia, n (%)		272 (30.6)	55 (20.8)	0.002
Low HDL, n (%)		371 (41.8)	90 (34.1)	0.025
High LDL, n (%)		389 (43.8)	113 (42.8)	0.773
Vitamin D supplement, n (%)		34 (3.8)	7 (2.7)	0.365
Calcium supplement, n (%)		30 (3.4)	9 (3.4)	0.981
Daily dietary calcium intake, n (%)	<500 mg/day	89 (10.1)	17 (6.6)	0.007
	500–1000 mg/day	438 (49.7)	110 (42.6)	
	>1000 mg/day	355 (40.3)	131 (50.8)	
Low Physical activity, n (%)		674 (75.9)	211 (79.9)	0.174
Smoking, n (%)	Never	265 (52.2)	312 (43.5)	0.006
	Past smoking	151 (29.7)	270 (37.7)	
	Current smoking	92 (18.1)	135 (18.8)	

SD: standard deviation

BMI: Body Mass Index

HDL: High-density lipoprotein

LDL: Low-density lipoprotein

includes age, education, BMI, high-WC, diabetes, hypertriglyceridemia, and calcium intake. Like women, osteoporosis was positively associated with age while a significant negative association were detected for years of education (APR: 0.97, 95%CI: 0.95–0.99), BMI (APR: 0.91, 95% CI: 0.91, 95%CI: o.88–0.93), and diabetes (APR: 0.59, 95%CI: 0.43–0.80). Interestingly, in men, osteoporosis was positively associated with current tobacco smoking; the results indicated that compared with nonsmokers, the likelihood of having osteoporosis is increased by 51% in current smokers, suggesting a significant association (APR: 1.51, 95%CI: 1.16–1.96). We couldn't find any association between osteoporosis and the ex-smoking

Table 2 Results of modified poison regression analysis on the association between various factors and having osteoporosis

Variables		PR	95%, CI	p value
Women				
Smoking status	Never	Ref	–	–
	Past smoker	1.07	0.96–1.18	0.184
	Current smoker	0.99	0.88–1.12	0.978
Age		1.02	1.01–1.02	<0.001
BMI		0.96	0.95–0.97	<0.001
Education		0.97	0.96–0.99	0.004
Hypertriglyceridemia		0.82	0.74–0.92	0.001
Men				
Smoking status	Never	Ref	–	–
	Past smoker	1.18	0.91–1.53	0.210
	Current smoker	1.51	1.16–1.96	0.002
Age		1.01	1.00–1.03	0.021
Education		0.97	0.95–0.99	0.040
BMI		0.91	0.88–0.93	<0.001
High waist circumference		0.95	0.66–1.35	0.764
Diabetes		0.59	0.43–0.80	0.001
Hypertriglyceridemia		0.85	0.64–1.11	0.248
Daily dietary calcium intake	>1000 mg/day	Ref	–	–
	500–1000 mg/day	1.18	0.76–1.85	0.447
	<500 mg/day	1.47	0.94–2.28	0.086

BMI: Body Mass Index

of cigarettes in men (APR: 1.18, 95%CI: 0.91–1.54). The result of additional analysis to determine the role of tobacco type showed that current smoking of cigarettes, but not hookah, was positively and significantly associated with osteoporosis in men (APR: 1.57, 95%CI: 1.21–2.03) (Table 3).

Table 4 provides the results of the linear regression model to determine the association of TBS and tobacco smoking adjusted for potential risk factors. The best subset for the regression analysis in women included age, education, high WC, BMI, diabetes, hypertriglyceridemia, and calcium food intake.

The results showed that in women, compared to non-smokers, there was a negative association between past smoking and TBS (β: -0.012, 95% CI: −0.023, −0.001). In

Table 3 Results of modified poisson regression on the relationship between the type of smoking and osteoporosis in men

Variables		PR	95%, CI	P value
Current smoking type	Cigarette	1.57	1.20–2.03	0.001
	Hookah	1.14	0.79–1.63	0.472
Age		1.02	1.00–1.03	0.013
Education		0.98	0.95–0.99	0.033
BMI		0.91	0.88–0.94	<0.001
High waist circumference		0.90	0.62–1.32	0.616
Diabetes		0.57	0.42–0.78	0.001
Hypertriglyceridemia		0.84	0.63–1.12	0.243
Daily dietary calcium intake	>1000 mg/day	Ref		
	500–1000 mg/day	1.22	0.77–1.93	0.396
	<500 mg/day	1.55	0.98–2.45	0.056

BMI: Body Mass Index

Table 4 Results of the linear regression model on the relationship between the tobacco smoking and Trabecular Bone Score, by sex

Variables		Coefficient	95%, CI	p value
Women				
Smoking status	Never	Ref		
	Past smoker	-0.012	(−0.023, −0.001)	0.037
	Current smoker	−0.007	(−0.020, 0.006)	0.313
Age		−0.003	(−0.004, −0.002)	<0.001
Education		0.004	(0.003, 0.005)	<0.001
BMI		−0.003	(−0.004, −0.002)	<0.001
Diabetes		−0.007	(−0.017, 0.003)	0.148
Hypertriglyceridemia		0.008	(−0.002, 0.018)	0.106
High waist circumference		−0.012	(−0.027, 0.003)	0.116
Daily dietary calcium intake	>1000 mg/day	Ref		
	500–1000 mg/day	−0.015	(−0.042, 0.012)	0.285
	<500 mg/day	−0.028	(−0.054, −0.001)	0.044
Men				
Smoking status	Never	Ref		
	Past smoker	−0.015	(−0.027, −0.004)	0.009
	Current smoker	−0.034	(−0.048, −0.021)	<0.001
Age		−0.001	(−0.002, −0.000)	0.012
Education		0.002	(0.001, 0.003)	<0.001
BMI		−0.005	(−0.006, −0.004)	<0.001
Diabetes		0.010	(−0.001, 0.021)	0.083
Low HDL		0.010	(0.001, 0.021)	0.046
High waist circumference		−0.036	(−0.051, −0.021)	<0.001
Daily dietary calcium intake	>1000 mg/day	Ref		
	500–1000 mg/day	−0.007	(−0.026, 0.010)	0.403
	<500 mg/day	−0.014	(−0.033, 0.004)	0.123

BMI: Body Mass Index

HDL: High-density lipoprotein

men, a negative association was detected in both ex-smokers (β: -0.015, 95%CI: −0.027, −0.004) and current smokers (β: -0.034, 95%CI: −0.048, −0.021). Dividing the current smokers to pure cigarette smoking and hookah, revealed a significant association between cigarette smoking and TBS (β: -0.034, 95%CI: −0.050, −0.018); However, we could not detect such association in hookah users (β: -0.016, 95% CI: −0.036, 0.003).

Discussion

The present study mainly indicated that current cigarette smoking is associated with the presence of osteoporosis in men. We also assessed the link between tobacco smoking and TBS and showed the negative association, adjusting with other potential factors. Our findings did not reveal an association between osteoporosis and smoking among women and ex-smoker men.

The relationship between tobacco use and decreased bone density has been implicated previously. Our study results showed the significant association between current smoking and osteoporosis in men that is supported to some extent by Hannan et al., who indicated that smoking men were more prone to osteoporosis than smoking women [14]; however, we believe that our results about females should be interpreted with caution.

Nicotine, the most important component of a cigarette, prohibits bone formation, and polycyclic aromatic hydrocarbons, Benzo[a]pyrene, and 7, 12-Dimethylbenz[a]anthracene reduce bone mass and bone strength. Also, tobacco smoke has anti-estrogenic effects as it increases estrogen catabolism and is associated with diminished levels of vitamin D3 and low calcium absorption [12, 15]. Studies have revealed a protective role for both estrogen and testosterone in bone metabolism. While estrogen suppresses bone resorption, testosterone increases bone proliferation by either directly acting through the androgenic receptors on osteoblasts, or indirectly by

undergoing an aromatization process which leads to the production of estrogen [5]. There are several proposed ways by which smoking may modify the production and metabolism of estrogen [6], but they have mostly considered the role of cigarette smoking and the effects of hookah need more evidence. In our study, in contrast with men, smoking cigarettes was not prevalent in women and only 0.5% of all women smoked a cigarette that may affect the study results. Nevertheless, Yusuf et al. found no association between tobacco smoking and osteoporosis in women [1] which supports the findings of our study. Besides, Brook et al. demonstrated that heavy and chronic cigarette smoking was a risk factor for osteoporosis in women [7]. The advantage of this study over ours is that they examined both the amount and timespan of cigarette smoking. However, the main disadvantage of the aforementioned study is that the authors did not take into account previous cigarette smoking and types of tobacco smoking. Kanis et al. indicated that compared with nonsmokers, the possibility of the femur fracture in smokers was significantly higher [16].

Our study results showed a significant association between current smoking and osteoporosis in men. There are contradictory documents in this regard; some studies found levels of testosterone were similar in both smokers and nonsmokers [17], while other studies found levels of testosterone were higher in smokers [18]. Yoo et al. demonstrated that the incidence of osteoporosis was higher in smoking men [19]. The main difference between this finding and that of our study is that the present study took into account current smoking and previous smoking variables, while Yoo et al. did not examine them.

Our study revealed that past tobacco smoking had a significant association with TBS in both men and women. Moreover, we showed that current cigarette smoking significantly associated with TBS in men. The evidence to show the association between TBS and smoking is limited. González et al., in a study on active or former smokers, with and without COPD, showed that a significant proportion of the study population had an affected TBS [20]. Further studies are needed to show the causal effect of smoking on TBS.

This study, with a large sample size of the older population from a population-based study, provided information on the association of smoking and bone health. We could assess the effect of hookah smoking which is prevalent in our region, especially in the study population. Our study had also some shortcomings. Cigarette smoking was uncommon in women that may indicate the loss of power in our analysis and makes the result not generalizable especially to other populations with frequent cigarette smoking. Also, we were unable to evaluate the extent or the duration of tobacco use by the study participants. Also, the ingredients used in hookah may vary significantly. This may affect the results produced in our study group of hookah users. We suggest future prospective studies be performed to investigate the impact of the duration of tobacco smoking while also considering the passive smoker population.

Conclusion

We conclude that current smoking is associated with osteoporosis in men. Dividing the current smokers to cigarettes and hookah smokers showed significant associations only in cigarette users. The bone quality (assessed by TBS) is also negatively associated with both current and ex-smoking in men; however, among women, with a high prevalence of hookah smoking, we could not find a similar association. Comprehensive studies with more power are needed to determine the pathophysiologic mechanisms of both hookah and cigarette in both sexes.

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Compliance with ethical standards

Conflict of interest There is no conflict of interest.

References

1. Ayo-Yusuf O, Olutola B. Epidemiological association between osteoporosis and combined smoking and use of snuff among south African women. Niger J Clin Pract. 2014;17(2):174–7.
2. Hemmati F, Sarokhani D, Sayehmiri K, Motadayen M. Prevalence of osteoporosis in postmenopausal women in Iran: a systematic review and meta-analysis. Iran J Obstet Gynecol Infertility. 2018;21(3):90–102.
3. Organization TIWH. fact-sheets-tobacco. World Health Organization. 2019. https://www.who.int/news-room/fact-sheets/detail/tobacco. [cited 2019Nov9].
4. Moosazadeh M, Ziaaddini H, Mirzazadeh A, Ashrafi-Asgarabad A, Haghdoost AA. Meta-analysis of smoking prevalence in Iran. Addiction Health. 2013;5(3–4):140–53.
5. Al-Bashaireh AM, Haddad LG, Weaver M, Chengguo X, Kelly DL, Yoon S. The effect of tobacco smoking on bone mass: an overview of pathophysiologic mechanisms. J Osteoporos. 2018;2018:1–17.
6. Yoon V, Maalouf N, Sakhaee K. The effects of smoking on bone metabolism. Osteoporos Int. 2012;23(8):2081–92.
7. Brook JS, Balka EB, Zhang C. The smoking patterns of women in their forties: their relationship to later osteoporosis. Psychol Rep. 2012;110(2):351–62.
8. Lentle BC, Prior JC. Osteoporosis: what a clinician expects to learn from a patient's bone density examination. Radiology. 2003;228(3):620–8.
9. Sighaldeh SS, Baheiraei A, Dehghan S, Charkazi A. Persistent use of hookah smoking among Iranian women: a qualitative study. Tob Prev Cessat. 2018;4.
10. Shafiee G, Ostovar A, Heshmat R, Darabi H, Sharifi F, Raeisi A, et al. Bushehr elderly health (BEH) programme: study protocol and design of musculoskeletal system and cognitive function (stage II). BMJ Open. 2017;7(8):e013606.
11. Mahan LK, Raymond JL. Krause's food & the nutrition care process-e-book: Elsevier Health Sciences; 2016.
12. Camacho PM, Petak SM, Binkley N, Clarke BL, Harris ST, Hurley DL, et al. American Association of Clinical Endocrinologists and American College of endocrinology clinical practice guidelines for

the diagnosis and treatment of postmenopausal osteoporosis—2016. Endocr Pract. 2016;22(s4):1–42.
13. Zou G. A modified poisson regression approach to prospective studies with binary data. Am J Epidemiol. 2004;159(7):702–6.
14. Hannan MT, Felson DT, Dawson-Hughes B, Tucker KL, Cupples LA, Wilson PW, et al. Risk factors for longitudinal bone loss in elderly men and women: the Framingham osteoporosis study. J Bone Miner Res. 2000;15(4):710–20.
15. Kim KH, Lee CM, Park S, Cho B, Chang Y, Park S, et al. Secondhand smoke exposure and osteoporosis in never-smoking postmenopausal women: the fourth Korea National Health and nutrition examination survey. Osteoporos Int. 2013;24(2):523–32.
16. Kanis JA, Johnell O, Odén A, Johansson H, De Laet C, Eisman J, et al. Smoking and fracture risk: a meta-analysis. Osteoporos Int. 2005;16(2):155–62.
17. Halmenschlager G, Rossetto S, Lara GM, Rhoden EL. Evaluation of the effects of cigarette smoking on testosterone levels in adult men. J Sex Med. 2009;6(6):1763–72.
18. Wang W, Yang X, Liang J, Liao M, Zhang H, Qin X, et al. Cigarette smoking has a positive and independent effect on testosterone levels. Hormones. 2013;12(4):567–77.
19. Yoo JE, Park HS. Prevalence and associated risk factors for osteoporosis in Korean men. Arch Osteoporos. 2018;13(1):88.
20. González J, Rodriguez-Fraile M, Rivera P, Restituto P, Colina I, de los Desamparados Calleja M, et al. Trabecular bone score in active or former smokers with and without COPD. PloS one. 2019;14(2):e0209777.