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ORIGINAL ARTICLE

An association between respiratory function and hip bone mineral density in older men: a cross-sectional study

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Abstract The association between respiratory function and bone mineral density (BMD) among women living in the community has been reported previously. We examined the association between forced expiratory volume in 1 s (FEV_1) and BMD measured at hip using dual-energy X-ray absorptiometry in a group of 947 men (aged 65 to 76 years) recruited from general practice age-sex registers in Cambridge between 1991 and 1995. A positive and significant correlation was seen between FEV_1 and BMD measured at total hip, femoral neck, and trochanter. A unit change (1 l) in FEV_1 was associated with a change of BMD by 0.019, 0.017, and 0.026 g/cm^2 in the total hip, femoral neck, and tochanteric region, respectively. These associations were independent of possible confounding factors such as age, height, weight, smoking habit, major disease prevalence, and medications, which might affect bone metabolism. In categorical analyses, the highest BMD was seen in the highest FEV_1 quartile, while the lowest BMD was seen in the lowest FEV_1 quartile. This pattern was seen in all three skeletal sites and was independent of covariates listed above. Compared with the bottom FEV_1 quartile, mean hip BMDs in the top quartile were 2–3.5% higher. The exact mechanism of this association is not clear to us. One plausible explanation is that respiratory function and bone health both reflect common but as yet unknown determinants.

Keywords Bone density · Community · Forced expiratory volume · Men · Osteoporosis · Respiratory function

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Introduction

The association between respiratory function and bone mineral density among patients with chronic respiratory diseases has been reported previously [1]. Further, higher risk of osteoporosis among subjects with airflow limitation has been demonstrated in a recent study [2]. We have previously reported a positive and continuous association between forced expiratory volume in 1 s (FEV_1) and bone mineral density (BMD) of the proximal femur in women living in the general community in the UK [3]. This association was independent of age, height, weight, smoking habit, medication use, and presence of chronic diseases, which can affect bone metabolism. We wished to examine the association between respiratory function FEV_1 and hip BMD in a group of older men living in the community.

Methods

This study involved men who participated in the Cambridge General Practice Health Study, which invited men aged 65 or above, resident in the community, and identified using general practice age and sex match registers between 1991 and 1995. Those who consented for the health survey completed the health and lifestyle questionnaire, which gathered information on their current and past medical history. Height and weight were measured in light clothing without shoes during the physical examination by trained personnel at Addenbrooke's Hospital, Cambridge. History of cancer, heart disease, stroke, and respiratory disease, were assessed using self-completed questionnaires. The use of systemic corticosteroids was recorded as "never" or "ever," while participants were categorized into three groups on their smoking habits: "current smokers," "past smokers," and "never smoked." BMD of the nondominant proximal femur was measured using the Hologic QDR 1000 densitometer (Hologic, Waltham, MA, USA). The

Table 1 Descriptive data of 947 men aged 65–76 years, according to FEV_1 quartiles in the Cambridge General Practice Study

Parameter	Quartile 1 ($n=234$)	Quartile 2 ($n=234$)	Quartile 3 ($n=240$)	Quartile 4 ($n=236$)	p Value
Characteristics	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age, years	69.9 (2.8)	69.5 (2.8)	69.1 (2.7)	68.4 (2.5)	<0.001
Height, cm	169.9 (6.5)	177.7 (6.2)	172.3 (6.4)	175.5 (6.1)	<0.001
Weight, kg	76.2 (11.9)	77.3 (10.5)	78.5 (11.5)	79.4 (9.7)	0.009
BMI, kg/m^2	26.3 (3.8)	26.5 (3.2)	26.4 (3.2)	25.7 (2.6)	0.008
FEV_1, liter	1.79 (0.31)	2.45 (0.12)	2.83 (0.11)	3.37 (0.28)	<0.001
Total hip BMD, g/cm^2	0.935 (0.151)	0.959 (0.141)	0.963 (0.146)	0.982 (0.133)	0.004
Femoral neck BMD, g/cm^2	0.759 (0.133)	0.778 (0.117)	0.782 (0.126)	0.803 (0.121)	0.003
Trochanter BMD, g/cm^2	0.712 (0.124)	0.746 (0.123)	0.751 (0.131)	0.766 (0.119)	<0.001
Percentage of men with	Number (%)	Number (%)	Number (%)	Number (%)	
COAD/asthma	88 (37.6)	42 (17.7)	31 (12.9)	22 (9.3)	<0.001
Cancer	14 (6.0)	11 (4.6)	12 (5.0)	14 (5.9)	0.890
Cardiovascular disease	43 (18.4)	37 (16.0)	24 (10.0)	28 (11.9)	0.035
Current smoking habit	41 (17.5)	27 (11.4)	13 (5.4)	9 (3.8)	<0.001
Steroid use	20 (8.5)	5 (2.1)	12 (5.0)	4 (1.7)	0.001

coefficient of variance for hip BMD measurements in our unit was 1.6% for the femoral neck, 1.5% for the trochanter, and 3.0% for Ward's triangle [4].

Forced expiratory volume in the 1st second (FEV_1) was measured twice using a portable spirometer (Micromedical, UK) [5]. The higher reading of the two measurements was used in the analysis.

Statistical analyses

Men were divided into quartiles according to FEV_1, and descriptive data of each quartile were given as mean (SD) or percentages (number). Correlations between hip BMD, age, weight, height, and FEV_1 as continuous variables were examined using Pearson correlation coefficients. Mean BMDs at total hip, femoral neck, and trochanter were compared using multivariate analysis of variance, initially adjusted for age, height, and weight, and then additionally for possible confounders such as respiratory disease, cardiovascular disease, and smoking habit. A linear regression model was fitted to examine the relationship of FEV_1 (independent variable) on BMD (dependent variable) with and without covariates in the model. Data were analyzed using SPSS software, version 10 for Windows.

Results

Descriptive data

The descriptive data of 947 men aged 65 to 76 years (mean 69.2 years, SD = 2.8) are shown in Table 1. Compared with men in the highest quartile of FEV_1, men in the lowest quartile were older, shorter, and lighter, and had lower average BMDs in all hip regions. The percentage of current smokers, corticosteroid users, and men with history of cardiovascular disease and respiratory disease were significantly higher in the lowest FEV_1 quartile when compared with the highest.

Association between FEV_1 and BMD

Significant and positive correlations were observed between FEV_1 and BMD measured in all three hip sites. Age, weight, and height also showed significant correlations with both BMD and FEV_1 (Table 2).

Table 2 Correlations between age, weight, height, hip BMD, and FEV_1. All variables were entered as continuous measures

	Weight	Height	Total hip BMD	Femoral neck BMD	Trochanteric BMD	FEV_1
Age	−0.124	−0.087	−0.106	−0.105	−0.073	−0.198
	<0.001	0.007	0.001	0.001	0.026	<0.001
Weight	-	0.482	0.441	0.376	0.339	0.128
	-	<0.001	<0.001	<0.001	<0.001	<0.001
Height	-	-	0.208	0.192	0.233	0.301
	-	-	<0.001	<0.001	<0.001	<0.001
Total hip BMD	-	-	-	0.854	0.910	0.137
	-	-	-	<0.001	<0.001	<0.001
Femoral neck BMD	-	-	-	-	0.781	0.132
	-	-	-	-	<0.001	<0.001
Trochanteric BMD	-	-	-	-	-	0.167
	-	-	-	-	-	<0.001

Table 3 Adjusted mean (SD) BMD values in FEV_1 quartiles in men aged 65–76 years, in the Cambridge General Practice Study. *Fem neck BMD* femoral neck BMD, *Troch BMD* trochanteric BMD

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	*p* Value
Total Hip BMD[a]	0.945 (0.012)	0.963 (0.012)	0.959 (0.012)	0.973 (0.012)	0.18
Total Hip BMD[b]	0.950 (0.012)	0.963 (0.012)	0.957 (0.012)	0.970 (0.012)	0.45
Fem neck BMD[a]	0.768 (0.012)	0.781 (0.012)	0.779 (0.012)	0.795 (0.012)	0.15
Fem neck BMD[b]	0.773 (0.012)	0.782 (0.012)	0.777 (0.012)	0.792 (0.012)	0.41
Troch BMD[a]	0.721 (0.012)	0.748 (0.012)	0.749 (0.012)	0.756 (0.012)	0.01
Troch BMD[b]	0.725 (0.012)	0.74 (0.012)	0.748 (0.012)	0.752 (0.012)	0.09

[a]Adjusted for age, weight, and height
[b]Adjusted for age, weight, height, respiratory diseases, cardiovascular diseases, smoking, and steroid use

Mean (and SD) BMDs of total hip, femoral neck, and trochanter in FEV_1 quartiles are shown in Table 3. After adjusting for possible confounding factors, the highest BMDs were observed in the highest FEV_1 quartile, while the lowest BMDs were seen in the lowest FEV_1 quartile, and this pattern was seen in all three hip regions. Mean BMDs generally showed an upward trend with increasing FEV_1.

Results of the regression analysis are shown in Table 4. A significant and positive relationship, independent of the effects of age, height, weight, smoking habits, prevalent disease, or steroid medication was observed between FEV_1 and hip BMD. A unit change in FEV_1 (1 l) was associated with a statistically significant 0.031, 0.027, and 0.034 g/cm^2 change in BMD in total hip, femoral neck, and trochanter, respectively. Including the potential confounding factors in the model attenuated these associations but they still remained significant. Excluding current smokers or steroid users in the regression model did not materially alter the regression slopes (data not shown).

Discussion

We previously reported a continuous and positive association between FEV_1 and hip BMD among community-living women who participated in the same study. These women were recruited from the same community and were assessed by the same team in the same manner. The association seen in these women was independent of age, body mass index, smoking habit, and history of diseases or medications which might influence bone metabolism [3]. The association was evident in young, middle, and older age groups almost to the same extent. Although the exact mechanism of this association was not clear, a common underlying determinant, such as physical activity was a plausible explanation.

Table 4 Regression coefficients of BMD with FEV_1 in men aged 65–76 years, in the Cambridge General Practice Study

	Coefficient (per 1 l/s)	SE	*p* Value
Total hip BMD, unadjusted	0.031	0.008	< 0.001
Total hip BMD, adjusted[a]	0.019	0.007	0.006
Femoral neck BMD, unadjusted	0.027	0.007	< 0.001
Femoral neck BMD, adjusted[a]	0.017	0.006	0.005
Trochanter BMD, unadjusted	0.034	0.008	< 0.001
Trochanter BMD, adjusted[a]	0.026	0.006	< 0.001

[a]Adjusted for age, weight, height, respiratory diseases, cardiovascular diseases, smoking, and steroid use

In the current study, a positive correlation was seen between respiratory function measured by FEV_1 and hip BMD measured at total hip, femoral neck, and trochanter in men aged 65–76 years. The association was independent of age, weight, height, smoking habits, steroid use, and prevalent diseases, which might affect bone metabolism. After adjusting for above potential confounding factors, mean hip BMD of men in the highest FEV_1 quartile was approximately 2.0–3.5% higher when compared with mean BMD in those in the lowest quartile. This is somewhat less than what was seen in women previously [3]. BMD in all three hip regions showed a general upward trend from the lowest to the highest FEV_1. In contrast to women, the mean differences in BMD in FEV_1 quartiles were not statistically significant except in the trochanteric area. However, more sensitive regression analyses showed statistically significant relationships.

In the regression analysis, the magnitude of the association seen between respiratory function and BMD in men was weaker than that seen in the subgroup analysis of women over 65 years [3]. In older women ($n = 1{,}195$), a unit (1 l) change in FEV_1 was associated with a change in BMD of 0.039, 0.029, and 0.040 g/cm^2 in total hip, femoral neck, and trochanter, respectively. In the current study involving men of a similar age group, corresponding figures were 0.019, 0.017, and 0.026 g/cm^2. Nevertheless, while these differences were small, and observed mean BMDs for men did not reach osteoporosis or osteopenia thresholds in the lowest quartiles, they may still be of interest in terms of understanding the mechanisms involved in bone loss.

The differences we observed in the association between respiratory function and BMD between men and women could partly be due to differences in sample sizes and, hence, lack of power, although a real gender difference cannot be excluded. Gender differences were observed in both BMD and hip geometry [6, 7]. Gender differences in BMD were observed early in life, between

prepubertal men and women [8] and also in forearm bones among Japanese [9]. If physical activity is the link between BMD and respiratory function, the association might be expected to be greater among men, who are more physically active than women. Other possible factors such as smoking, alcohol consumption, prevalence of diseases, and use of drugs which can affect bone metabolism may also differ in men and women. Although recruited from the same community, considerable differences in the prevalence of current smokers and in the number of patients with a history of cancers and other relevant diseases were seen between men in the current study and women in our previous study [3], reflecting the well-recognized sex differences in health.

Our study has several limitations. Selection bias is unlikely to explain the relationship unless nonresponders differed from responders with respect to the relationship between respiratory function and BMD. That is, that nonresponders were more likely to have good respiratory function and low BMD or vice versa, which does not seem plausible. There are measurement errors in assessment of BMD and respiratory function, but random measurement error would attenuate any relationship. We did not quantify smoking and corticosteroid use, and they were used as categorical variables in the analysis. The effects of smoking and corticosteroids both on BMD and lung functions are dose related, so we may not have adjusted adequately for smoking and steroid use. Nevertheless, regression analyses after excluding steroid users and current smokers found similar relationships between respiratory function and BMD. We did not include spine BMD in the analysis, since spine BMD is influenced by the presence of degenerative changes and vertebral fractures. Vertebral fractures reduce lung function, and the extent of this problem was not known to us in this study.

The association between respiratory function and BMD seen in these studies need further exploration. Whether respiratory function has a direct influence on BMD or both measures reflect a common predisposing factor is unknown. Elucidating the nature of the relationship may help in the understanding of the determinants and prevention of bone loss in later life.

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