Published in final edited form as:

Occup Environ Med. 2014 May ; 71(5): 329–331. doi:10.1136/oemed-2013-101967.

EXPOSURE TO HEAVY PHYSICAL OCCUPATIONAL ACTIVITIES DURING WORKING-LIFE AND BONE MINERAL DENSITY AT THE HIP AT RETIREMENT AGE

K Walker-Bone¹ [Reader in Occupational Rheumatology], S D'Angelo¹ [Statistician], HE Syddall¹ [Senior Statistician], KT Palmer¹ [Professor of Occupational Medicine], C Cooper¹ [Professor of Rheumatology], DNM Coggon¹ [Professor of Occupational Medicine], and EM Dennison¹ [Professor of Musculoskeletal Epidemiology]

¹MRC Lifecourse Epidemiology Unit (University of Southampton), Southampton, UK

Abstract

Background—People in sedentary occupations are at increased risk of hip fracture. Hip fracture is significantly associated with low bone mineral density (BMD) measured at the hip. Physical activity is important in the development and maintenance of BMD but the effects of occupational physical activity on bone health are unclear. We investigated the influence of lifetime physical activity on bone mineral density at the hip.

Methods—This was a cross-sectional epidemiological study of the associations between total hip BMD measured by dual-energy X-ray absorptiometry at retirement age and lifetime exposure to occupational physical workload (standing/walking 4 hours/day; lifting 25 kg; energetic work sufficient to induce sweating and manual work).

Results—Complete data on occupational exposures were available for 860 adults (488 men and 372 women) who had worked 20 years. Their mean age was 65 years and many reported heavy physical workplace activities over prolonged durations. There were no statistically significant associations between total hip BMD and any of these measures of lifetime occupational physical activity in men or women.

Conclusion—Lifetime cumulative occupational activity was not associated with hip bone mineral density at retirement age. Our findings suggest that, if sedentary work conveys an increased risk of hip fracture, it is unlikely that the mechanism is through reductions in bone mineral density at the hip and may relate to other physical effects, such as falls risk. Further studies will be needed to test this hypothesis.

Keywords

Hip fractures; osteoporosis; bone mineral density; occupational physical activity

Introduction

Osteoporosis is a major public health problem because it strongly predisposes to fragility fractures, the most devastating of which occur at the hip. Risk of hip fracture approximately doubles for each standard deviation decrease in bone mineral density (BMD) [1]. Physical activity plays an important role in the development and maintenance of BMD, particularly those activities which involve weight-bearing and muscle loading [2]. Bone growth and peak bone mass are enhanced by physical exercise and regular leisure-time exercise has been shown to retard bone loss in postmenopausal women [3]. For many people, a significant proportion of their lifetime exposure to intensive physical activity will occur in the workplace. However, it is not currently clear what impact on bone health can be achieved with intensive occupational physical activity.

There is evidence from case-control studies that hip fracture patients are more likely to have worked in sedentary occupations than referents [4-6]. One possible explanation for this would be if sedentary work attenuated hip BMD as compared with the effects of heavy physical activity. However, despite the importance of BMD in fracture occurrence, it is also possible that intensive occupational physical activity might lead to other benefits important in fracture prevention such as enhanced muscle strength and coordination and/or reduced risk of falls. The existing literature in which relationships between BMD and occupational activity have been evaluated shows conflicting results [7-13]. Therefore, we investigated the association of hip BMD with lifetime occupational physical activity using data from the Hertfordshire Cohort Study [14].

Methods

Most aspects of the study design have been described elsewhere [14]. In brief, we studied 498 men and 468 women who were born in Hertfordshire, UK during 1931-39, and who still lived there when surveyed (1998-2003). At recruitment, participants completed a health questionnaire which included: smoking, alcohol, dietary calcium intake, leisure-time physical activity, family history of fractures, time since menopause, use of hormone replacement therapy (HRT) and relevant co-morbidities. People with a diagnosis of, or taking treatment for, osteoporosis were not eligible for this study. Everybody was asked for their lifetime history of jobs held for longer than one year and for each job, they were asked whether an average working day entailed standing or walking for at least four hours per day, lifting weights of ≥ 25 kg, or energetic physical activity sufficient to cause sweating. Bone densitometry (DXA) was acquired at the total hip and femoral neck using a Hologic QDR 4500 instrument.

Statistical analysis was performed with Stata© version 12 software. We focused on four occupational risk factors – years of standing/walking for ≥ 4 hours per day, years of lifting weights ≥ 25 kg, years of energetic physical work, and years of manual work (determined from job titles). Each variable was derived by summing the times spent in relevant jobs (with a correction factor of 0.5 for part-time employment), and classified to approximate thirds of its distribution in the study sample. Associations of total hip BMD with these and

other risk factors were assessed by linear regression, and characterised by estimates of mean difference in BMD with associated 95% confidence intervals (CIs).

Ethical approval was provided by the East and North Hertfordshire NHS Research Ethics Committees, and all patients gave written informed consent.

Results

In total, 966 people were recruited (498 men and 468 women) amongst whom the majority 877 (91%) had undertaken ≥ 20 years of paid work. The 89 (all women) who had done ≥ 20 years paid work were excluded from further analyses. An additional 17 subjects (10 men and 7 women) for whom there were missing data about non-occupational confounding factors (age, BMI, smoking status, alcohol consumption, dietary calcium intake, current physical activity, family history of fractures, and in women, time since menopause and use of HRT) were also excluded, leaving a total sample of 860 (488 men and 372 women) in these analyses.

Ages ranged from 59.7 to 71.7 years (mean 64.8 in men and 66.4 in women). Participants reported a wide range of prolonged exposure to occupational physical activities: median (interquartile range [IQR]) numbers of years exposed to walking/standing ≥ 4 hours/day, work involving lifting weights ≥ 25 kg, energetic activities sufficient to cause sweating, and manual work among men were: 44(26,48), 37(6,46), 20.5(3,43) and 41(12,48) years respectively. Corresponding median (IQR) years of exposure among women were 15(2.5, 25.5), 0(0,6), 0(0,0) and 7(0,22.5).

When potential non-occupational confounders (as listed above and including occupational physical activity) were included in a single regression model for each sex, higher BMI was significantly associated with greater total hip BMD (increase per 5 kg/m² 72.1 g/cm², 95%CI 56.6 to 87.7, in men; and 65.9 g/cm², 95%CI 54.6 to 77.3, in women), and in women, with current use of HRT (difference from never use 93.2 g/cm², 95%CI 59.4 to 127.1). However, when all potential confounders were taken into account, there was no indication that any of the four occupational activities was associated with greater total hip BMD (Table). Most of the associations were in the opposite direction, although not statistically significant. Nor was there evidence of an effect in unadjusted analyses (data not shown). For comparison, the same analyses were performed using BMD at the femoral neck as the outcome variable and the findings were unchanged (data not shown).

Discussion

In this study, we found no evidence that cumulative exposure to occupational physical activities (standing, lifting, manual work or work sufficiently intense to induce sweating) was associated with higher BMD at the hip.

The technique for measuring BMD used in this study was the gold standard, and gave the expected associations with BMI and use of HRT. Moreover, the ascertainment of occupational exposures, although dependent on recall, was more complete and detailed than in many previous studies. Nor can the absence of association be ascribed to a lack of

statistical power. Thus, the upper 95% confidence limits for the difference in BMD between the highest and lowest thirds of exposure to occupational standing/walking were 7.3 g/cm² in men and 18.7 g/cm² in women. This is much smaller than the differences of 72.1 g/cm² and 65.9 g/cm² for a 5 kg/m² increase in BMI.

There are a few published studies of occupational activity and BMD, and these have taken various methodological approaches. Some have summed occupational exposures with those from leisure-time activity [7]. Others have assessed self-reported physical activity at home and at work but over a recent period e.g. 4 weeks or 12 months or at specified time points (age 12, age 15-19 and recent). Some researchers have compared BMD between groups of workers from different occupations with presumed different levels of occupational physical exercise: e.g. farmers vs. housewives or office workers [8]. One investigation observed and recorded occupational physical activity (actual walking distance, number of flights of stairs and mean heart rate) but only for one shift per worker [9]. Few studies have estimated occupational activity throughout the life-course [10-12].

Two studies have reported positive associations between occupational activity and BMD. Among 44 nurses aged 47-48 years, femoral neck BMD was significantly greater than in 55 female clerks, and total time standing at work was positively correlated with hip BMD [13]. And in another cross-sectional survey, 71 female postmenopausal agricultural workers had greater hip and spine BMD than matched office workers or housewives [8]. Against this, several other studies have not found associations [7,9-12], and one indicated lower spinal BMD in men exposed to the heaviest levels of occupational activity [7]. A few data suggest that BMD is increased only by heavy occupational activity early in life. For example, among 152 adults (mean age 65 years) neither lifetime nor recent occupational activity correlated with quantitative ultrasound at the calcaneus, but a weakly positive correlation was seen for past occupational physical activity at ages 14-21 years in men and 22-34 years in women [12]. Similar findings were reported in a sample of 144 South African women, in whom 'peak bone strain score' for activities at age 14-21 years was associated with lumbar spine BMD at age 42.6 (+/- 8.9) years, whereas total lifetime exposure was not [11]. Coupland and colleagues again found no significant association of BMD in the spine, femoral neck, trochanter, radius or whole body with lifetime or current measures of occupational activities including: sitting, standing, walking or lifting/carrying. The only significant positive associations were with standing at age 30 years [10].

Although there are conflicting data in the literature as to the effects of heavy physical activity on BMD as an outcome, BMD is a biomarker of risk of osteoporotic fracture and there are three consistent published studies suggesting that risk of hip fracture is higher in sedentary workers [4-6]. Interpretation of this apparent paradox is hampered because none of the three studies included any assessment of BMD in their methodology. However, we suggest that this apparent paradox could be explained if sedentary work predisposed to fractures, not through effects on BMD, but by adverse impacts on muscle function, strength, coordination or bulk, leading to an increased risk of falling or less protection of the femoral neck when falls occurred. This hypothesis should be investigated in future studies.

Acknowledgments

The Hertfordshire Cohort Study was supported by the Medical Research Council of Great Britain and Arthritis Research UK. We thank all of the men and women who took part in the Hertfordshire Cohort Study; the HCS Research Staff; and Vanessa Cox who managed the data.

We would like to thank Mr James Bennett, Statistician, who carried out the original analyses of these data.

References

1. Marshall D, Johnell O, Wedel H. meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ*. 1996; 312(7041):1254–1259. [PubMed: 8634613]
2. Cheung AM, Giangregorio L. Mechanical stimuli and bone health: what is the evidence? *Curr Opin Rheumatol*. 2012; 24:551–6.
3. Kelley GA. Aerobic exercise and bone density at the hip in postmenopausal women: a meta-analysis. *Prev Med*. 1998; 27:798–807. [PubMed: 9922061]
4. Cooper C, Wickham C, Coggon D. Sedentary work in middle life and fracture of the proximal femur. *Br J Ind Med*. 1990; 47:69–70. [PubMed: 2310712]
5. Suen L. Occupation and risk of hip fracture. *J Pub Health Med*. 1998; 20:428–33. [PubMed: 9923950]
6. Jaglal SB, Krieger N, Darlington GA. Lifetime occupational physical activity and risk of hip fracture in women. *Ann Epidemiol*. 1995; 5:321–4. [PubMed: 8520716]
7. Brahm H, Mallmin H, Michaelsson K, Strom H, Ljunghall S. Relationships between bone mass measurements and lifetime physical activity in a Swedish population. *Calcif Tiss Int*. 1998; 62:400–12.
8. Damilaikis J, Perisinakis K, Kontakis G, Vagios E, Gourtsoyiannis N. Effect of lifetime occupational physical activity on indices of bone mineral status in healthy postmenopausal women. *Calcif Tissue Int*. 1999; 64:112–6. [PubMed: 9914317]
9. Uusi-Rasi K, Nygard CH, Oja P, Pasanen M, Sievanen H, Vuori I. Walking at work and bone mineral density of premenopausal women. *Osteoporos Int*. 1994; 4:336–40. [PubMed: 7696829]
10. Coupland CAC, Grainge MJ, Cliffe SJ, Hosking DJ, Chilvers CED. Occupational activity and bone mineral density in postmenopausal women in England. *Osteoporos Int*. 2000; 11:310–5. [PubMed: 10928220]
11. Mickelsfield L, Rosenberg L, Cooper D, Hoffman M, Kalla A, Stander I, Lambert E. Bone mineral density and lifetime physical activity in South African women. *Calf Tissue Int*. 2003; 73:463–9.
12. Kolbe-Alexander TL, Charlton KE, Lambert EV. Lifetime physical activity and determinants of estimated bone mineral density using calcaneal ultrasound in older South African adults. *J Nutr Health Aging*. 2004; 8:521–30. [PubMed: 15543427]
13. Weiss M, Yogev R, Dolev E. Occupational sitting and low hip mineral density. *Calcif Tissue Int*. 1998; 62:47–50. [PubMed: 9405733]
14. Syddall HE, Aihie Sayer A, Dennison EM, Martin HJ, Barker DJP, Cooper C. Cohort profile: The Hertfordshire Cohort Study. *Int J Epidemiol*. 2005; 34:1234–42. [PubMed: 15964908]

What This Paper Adds

1. Hip fractures are the most devastating consequence of osteoporosis in terms of mortality and morbidity, as well as healthcare costs
2. Our study assessed the impact of lifetime cumulative occupational physical activity and found no association with BMD at the hip at retirement age
3. Our findings suggest that the association between sedentary work and hip fracture reported previously is not mediated through reduced bone density in this group
4. Our results highlight the need for further studies investigating the relationship between occupational physical activity and muscle power, strength, coordination and falls risk

Table 1
Associations of four types of lifetime occupational activity with total hip bone mineral density measured at age 65 years in the Hertfordshire cohort study

Occupational activity	Men				Women			
	Years of exposure	n	Difference in total hip BMD ^d (g/cm ²)		Years of exposure	n	Difference in total hip BMD ^b (g/cm ²)	
			Mean	95% CI			Mean	95% CI
Standing/walking for 4 hours per day	<37	164	Baseline		<8.5	129	Baseline	
	37-47	184	-12.2	-38.8 to 14.4	8.5-22.5	123	3.5	-25.0 to 32.0
	>47	140	-22.7	-52.7 to 7.3	>22.5	120	-9.7	-38.2 to 18.7
Lifting weights 25 kg	<17	165	Baseline		0	247	Baseline	
	17-44	171	-17.0	-44.5 to 10.5	>0	125	-8.5	-32.8 to 15.9
	>44	152	9.8	-18.0 to 37.6				
Physical work sufficient to cause sweating	<5	166	Baseline		0	319	Baseline	
	5-39	161	-30.3	-57.6 to -3.0	>0	53	1.6	-32.3 to 35.5
	>39	161	-24.4	-51.7 to 3.0				
Manual work	<24	165	Baseline		<0.5	128	Baseline	
	24-46	166	-9.8	-37.7 to 18.1	0.5-15.5	120	-3.5	-32.1 to 25.1
	>46	157	-5.1	-33.3 to 23.1	>15.5	124	-4.4	-33.3 to 24.6

^d Each risk factor was analysed in a separate linear regression model with adjustment for age, BMI, log of daily dietary calcium intake, current physical activity score (all treated as continuous variables), smoking status (never, ex- or current), alcohol consumption (none, low, moderate or high) and family history of fractures (no or yes).

^b Each risk factor was analysed in a separate linear regression model with adjustment for age, BMI, log of daily dietary calcium intake, current physical activity score (all treated as continuous variables), smoking status (never, ex- or current), alcohol consumption (none, low, moderate or high), family history of fractures (no or yes), years since menopause (<10, 10 and <15, 15 and <20, 20 or hysterectomy) and use of hormone replacement therapy (never, 5 years ago, within past 5 years but not current, or current).