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Relationships between bone geometry, volumetric bone mineral density and bone microarchitecture of the distal radius and tibia with alcohol consumption☆,☆☆

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ABSTRACT

Purpose: Chronic heavy alcohol consumption is associated with bone density loss and increased fracture risk, while low levels of alcohol consumption have been reported as beneficial in some studies. However, studies relating alcohol consumption to bone geometry, volumetric bone mineral density (vBMD) and bone microarchitecture, as assessed by high-resolution peripheral quantitative computed tomography (HR-pQCT), are lacking.

Methods: Here we report an analysis from the Hertfordshire Cohort Study, in which we studied associations between HR-pQCT measures at the distal radius and tibia and alcohol consumption in 376 participants (198 men and 178 women) aged 72.1–81.4 years.

Results: A total of 30 (15.2%), 90 (45.5%) and 78 (39.4%) men drank minimal/none (<1 unit/week), low (≥1 unit/week and <11 units/week) and moderate/high (≥11 units/week) amounts of alcohol respectively. These figures were 74 (41.8%), 80 (45.2%) and 23 (13.0%) respectively in women for minimal/none (<1 unit/week), low (≥1 unit/week and <8 units/week) and moderate/high (≥8 units/week). At the distal radius, after adjustment for confounding factors (age, BMI, smoking status, dietary calcium intake, physical activity and socioeconomic status and years since menopause and HRT use for women), men that drank low alcohol had lower cortical thickness ($p = 0.038$), cortical vBMD ($p = 0.033$), and trabecular vBMD ($p = 0.028$) and higher trabecular separation ($p = 0.043$) than those that drank none/minimal alcohol. Similar differences were shown between minimal/none and moderate/high alcohol although these only reached statistical significance for the cortical parameters. Interestingly, after similar adjustment, women showed similar differences in the trabecular compartment between none/minimal alcohol and low alcohol at the distal tibia. However, women that drank moderate/high alcohol had significantly higher trabecular vBMD ($p = 0.007$), trabecular thickness ($p = 0.026$), and trabecular number ($p = 0.042$) and higher trabecular separation ($p = 0.026$) at the distal radius than those that drank low alcohol.

Conclusions: Our results suggest that alcohol consumption (low and moderate/high) may have a detrimental impact on bone health in men in both the cortical and trabecular compartments at the distal radius with similar results in women in the trabecular compartment between none/minimal alcohol and low alcohol at the distal tibia suggesting that avoidance of alcohol may be beneficial for bone health.

Abbreviations: aBMD, areal bone mineral density; BMI, body mass index; Ct. area, cortical area; Ct.vBMD, cortical density; Ct.Po, cortical porosity; Ct.Th, cortical thickness; DXA, dual energy X-ray absorptiometry; HCS, Hertfordshire Cohort Study; HRpQCT, high-resolution peripheral quantitative computed tomography; pQCT, peripheral quantitative computed tomography; Tt.area, total cross-sectional area; Tb.vBMD, trabecular BMD; Tb.N, trabecular number; Tb.Th, trabecular thickness; Tb.Sp, trabecular separation; vBMD, volumetric bone mineral density.

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Introduction

There is increasing interest in how modifiable lifestyle factors may influence bone health. Among these, alcohol consumption is of particular interest, given rising alcohol consumption in most populations [1,2]. In a number of reports, decreased areal bone mineral density (aBMD) and increased fracture risk has been reported in individuals with chronic heavy alcohol consumption [3–5]; alcohol consumption was independently associated with the risk of both hip and wrist fractures, with a dose–response relationship, in a prospective cohort of 84,484 middle-age women [6]. Compared with abstainers, women consuming greater than or equal to 25 g alcohol/d (1.8 drinks or more per day) had a relative risk (RR) of 2.33 (95% CI = 1.18–4.57) for hip fractures and an RR of 1.38 (95% CI = 1.09–1.74) for wrist fractures [6]. Another study found an increased odds of vertebral fracture among men who consumed more than 0.3 drinks per day compared with abstainers (adjusted odds ratio 4.61 [1.19–17.90]) [7]. However, there have also been reports of a positive association between modest alcohol consumption and bone health; a systematic review of the literature with meta-analysis found that the association between alcohol consumption and hip fracture seemed to be J-shaped rather than linear [4–6,8–11]. Compared with abstainers, persons consuming more than 0.5 to 1.0 drinks per day had a lower hip fracture risk (RR 0.80 [95% CI = 0.71–0.91]), and persons consuming more than 2 drinks per day had a higher risk (RR 1.39 [95% CI = 1.08–1.79]). Alcohol consumption is included in fracture risk stratification tools, including FRAX®, but with a cut off of >2 drinks per day [12].

It is increasingly recognized that bone geometry, and bone microarchitecture contribute to bone strength and thus fracture risk [13], but there are few studies which have examined the relationships between alcohol consumption and measurements of volumetric BMD and bone geometry using peripheral quantitative computed tomography (pQCT) and no consistent relationships have been shown [14,15]. The aim of this study was therefore to explore the relationships between alcohol consumption and bone geometry, vBMD and bone microarchitecture assessed by HR-pQCT and aBMD assessed by DXA in a well phenotyped cohort of elderly men and women from the Hertfordshire Cohort Study (HCS).

Materials and methods

Study participants

The HCS is a population-based UK cohort designed to examine the relationships between growth in infancy and the subsequent risk of adult diseases, such as osteoporosis. Study design and recruitment have been described in detail previously [16]. HCS participants were generally comparable with those in the nationally representative Health Survey for England [16]. In brief, in conjunction with the National Health Service Central Registry and the Hertfordshire Family Health Service Association, we traced men and women who were born between 1931 and 1939 in Hertfordshire and still lived there during the period 1998–2003. A nurse-administered questionnaire and clinic visit were done at this time. In 2004–2005, 642 men and women from the geographical area of East Hertfordshire took part in a follow-up clinic visit which included a nurse-administered questionnaire. Of these, 376 (59%) agreed to a HR-pQCT scan in 2011–2012. The East and North Hertfordshire Ethical Committees granted ethical approval for the study and all participants gave written informed consent in accordance with the Declaration of Helsinki [17].

Demographic and clinical assessment

Height was measured to the nearest 0.1 cm using a wall-mounted SECA stadiometer on the day of scanning, and weight using electronic scales (make, model) to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2). Data related to alcohol consumption and smoker status were available from the 2004–2005 follow-up. Details regarding physical activity, dietary calcium intake, and socioeconomic status, age at menopause and HRT use were available from the nurse-administered questionnaire assessed in 1998–2003 [16].

Physical activity was calculated as a standardized score ranging from 0 to 100 derived from frequency of gardening, housework, climbing stairs and carrying loads in a typical week [18]. Higher scores indicated greater levels of activity. Dietary calcium intake was assessed using a food frequency questionnaire [19]. Socioeconomic status was determined using own current or most recent occupation of the participant in men and single women, and of the husband in ever-married women based on the Office of Population Censuses and Surveys Standard Occupational Classification Scheme for occupation and social class. Assessment of smoking habits included questions concerning smoker status (never, ex or current).

Alcohol consumption was categorized into bands because of concerns that there may be J-shaped relationships between alcohol consumption and bone parameters [3]. Questions were asked about the quantity of alcohol consumed at the point of questionnaire administration in 2004–2005. Those that drank <1 units of alcohol per week were defined as minimal alcohol. Those that drank more alcohol than this were subdivided into those that drank under half of the maximum recommended amount of alcohol (<11 units in men, <8 units in women), hereafter defined as low alcohol, and those that drank more than half of the maximum recommended amount of alcohol (≥11 units in men, ≥8 units in women), hereafter defined as moderate–high alcohol [20].

Dual-energy X-ray absorptiometry

Dual-energy X-ray absorptiometry (DXA) was performed at time of HR-pQCT in 2011–2012. Bone area (cm^2), BMC (g) and aBMD (g/cm^2) at the non-dominant hip were measured using DXA (Lunar Prodigy Advanced Scanner, GE Medical Systems, UK). Positioning for all scans was completed in accordance with the manufacturer's instructions.

High-resolution peripheral quantitative computed tomography

Each participant had measurements of the non-dominant distal radius and distal tibia using HR-pQCT (XtremeCT, Scanco Medical AG, Switzerland) except when it had previously been fractured in which case the dominant side was scanned. This allowed acquisition of a stack of parallel CT slices using a two-dimensional detector array. A total of 110 slices were obtained which represented a volume of bone 9 mm in axial length with a nominal resolution (voxel size) of 82 μm. The scanned limb was immobilized during the examination in a carbon fiber cast. Antero-posterior 2D scout views were performed to determine the region to be scanned. All scans were acquired by one of two trained technicians using standard positioning techniques. These were in keeping with the manufacturer's guidelines and as described by Boutroy et al. [21]. Each scan was assessed for motion artefact, and if present a second scan was performed. The quality of the measurements was assessed by using a 5-point scale recommended by the manufacturer (1, excellent; 2, good; 3, acceptable; 4, poor; 5, unacceptable). Only examinations with quality grades 1 through 4 were included in the study.

Image analysis was carried out using the standard manufacturer's method which has been described in detail previously [22,23]. In brief, we used a semi-automated, hand-drawn contouring system to delineate the periosteal surface. A threshold-based algorithm then separated cortical from trabecular compartments. The threshold used to discriminate cortical from trabecular bone was set to one-third of the apparent cortical bone density value. Standard morphologic analysis produced total (Tt.vBMD, g/cm^3) and trabecular BMD (Tb.vBMD, g/cm^3).