Social disadvantage, bone mineral density and vertebral wedge deformities in the Tasmanian Older Adult Cohort

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Mini abstract (50 words)

The relationship between social disadvantage and bone mineral density (BMD) is complex and remains unclear; furthermore, little is known of the relationship with vertebral deformities. We observed social disadvantage to be associated with BMD for females, independent of BMI. A lower prevalence of vertebral deformities was observed for disadvantaged males.

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Abstract

Background: The relationship between social disadvantage and bone mineral density (BMD) appears complex and remains unclear, and little is known about the association between social disadvantage and vertebral wedge deformities. We examined the relationship between social disadvantage, BMD and wedge deformities in older adults from the Tasmanian Older Adult Cohort.

Methods: BMD and wedge deformities were measured by DXA and associations with extreme social disadvantage was examined in 1,074 randomly-recruited population-based adults (51% female). Socioeconomic status was assessed by Socio-Economic Indexes For Areas values derived from residential addresses using Australian Bureau of Statistics 2001 census data. Lifestyle variables were collected by self-report. Regression models were adjusted for age, body mass index (BMI), dietary calcium, serum vitamin D (25(OH)D), smoking, alcohol, physical inactivity, calcium/vitamin D supplements, glucocorticoids, and hormone therapy (females only).

Results: Compared to other males, socially disadvantaged males were older (65.9yr versus 61.9yr, $p=0.008$), and consumed lower dietary calcium and alcohol (both $p\leq 0.03$). Socially disadvantaged females had greater BMI (29.9 ± 5.9 versus 27.6 ± 5.3 , $p=0.002$) and consumed less alcohol ($p=0.003$) compared to other females. Socially disadvantaged males had fewer wedge deformities compared to other males (33.3% versus 45.4%, $p=0.05$). After adjustment, social disadvantage was negatively associated with hip BMD for females ($p=0.02$), but not for males ($p=0.70$), and showed a trend for fewer wedge deformities for males ($p=0.06$), but no association for females ($p=0.85$).

Conclusions: Social disadvantage appears to be associated with BMD for females, independent of BMI and other osteoporosis risk factors. A lower prevalence of vertebral deformities was observed for males of extreme social disadvantage. Further research is required to elucidate potential mechanisms for these associations.

Introduction

A complex relationship exists between social disadvantage and bone health. Non on-linear patterns of association have been reported for bone mineral density (BMD) across the socioeconomic continuum for females (1) and males (2). However, greater fracture incidence has been observed in socially disadvantaged groups compared to less disadvantaged groups (3), which presented a linear pattern of association. Whilst underlying mechanisms for these relationships are unclear, social disadvantage may act upon bone through various pathways and at different stages of osteoporosis, which may be related to different risk factor profiles in different social groups. For instance, social disadvantage is associated with known risk factors for osteoporosis such as physical inactivity, and smoking (4, 5), and the relationship between social disadvantage and obesity has been well-documented (6, 7). Recent Australian data suggest that, compared to other females, those experiencing the greatest social disadvantage have 60% increased odds of being physically inactive, more than twice the likelihood of being a smoker, the greatest age-adjusted daily energy intake from foods, and 13% greater fat mass (4). Results were similar for men from the same region, and interestingly, greater measures of obesity were observed in the most disadvantaged group compared to other men, despite having more physically demanding occupations (5). Those data suggest it imperative to elucidate predictors of bone health specific to the most disadvantaged populations who may be predisposed to a greater risk.

Vertebral deformity prevalence, including wedge, crush and biconcave deformities, increase with advancing age for both sexes (8, 9). Wedge deformities are the most frequently observed of the three types, clustering at the mid-thoracic and thoracolumbar regions of the spine (8). To date, there are no data examining the association between social disadvantage and wedge deformities, although obesity has been associated with a higher prevalence of deformities in women but not men (10).

Taken as a whole, those data suggest the relationship between bone health and extreme social disadvantage is not simple. In this study we aimed to investigate the relationship between extreme social disadvantage and BMD and wedge deformities in older men and women.

Methods

Subjects

The Tasmanian Older Adult Cohort (TasOAC) is an ongoing prospective study of older males and females aged 51-81 years, located within Southern Tasmania; an area with a population base of approximately 229,000. Baseline measures for TasOAC were ascertained April 2002 to September 2004. Subjects (98% Caucasian) were randomly selected using computer-generated random numbers from the Commonwealth electoral rolls for southern Tasmania, with equal numbers of males to females (57% participation).

All participants in the TasOAC cohort provided informed written consent. Approval for the study was obtained from the Southern Tasmanian Health and Medical Human Research Ethics Committee.

Anthropometrics

Height was measured to the nearest 0.1cm, with shoes, socks, and headgear removed, using a stadiometer. Weight was measured to the nearest 0.1kg with shoes, socks, and bulky clothing removed, using a single pair of electronic scales (Seca Delta Model 707, Hamburg, Germany), which was calibrated prior to each clinic. Body mass index (BMI) was calculated as kg/m^2 .

Bone mineral density

Areal BMD (g/cm^2) was measured for the lumbar region ($\text{L}_2\text{-L}_4$) of the spine in the posterior-anterior (PA) projection, the proximal femur (at the femoral neck, Ward's triangle, and trochanter), and total body. Testing was performed by a Hologic dual energy x-ray absorptiometry (DXA) scanner (Hologic Corp., Waltham, Massachusetts, USA). Short-term precision in vivo (calculated as the CV of repeated scans) was 2%, as previously reported (11).

We determined *a priori* to examine BMD in our participants with, and without, anterior wedging, given that wedge deformities are the most common type of vertebral deformity. A vertebral deformity was defined as a ratio of anterior to posterior heights of <0.8 , as previously reported (10). That ratio represented $\geq 20\%$ reduction in the height of the anterior portion of a vertebral body relative to the posterior height of that body, as it **is** the criteria applied for subsidised access to anti-osteoporotic medication in Australia (12). Each DXA scan of the spine was independently assessed by **an experienced**, trained reader **to identify the presence or absence of deformities in the thoracic spine (T4-T12) and/or lumbar spine (L1-L4), a ratio was calculated**, and classified as vertebral deformity yes/no (males $n=229$, females $n=198$), **as previously published (10)**.

Socioeconomic status

To determine socioeconomic status (SES) the residential address of each subject was matched to the corresponding ABS Census Collection District; an area of approximately 250 households. ABS software was used to determine the Socio-Economic Indexes for Areas (SEIFA) value from the 2001 census for each subject. SEIFA is a collection of four separate indexes, derived from the Australian Census data and constructed from different variables. SEIFA summarizes the characteristics of subjects within an area, thereby providing a single measure to rank the level of disadvantage or advantage at the area level, not of the individual subject. The indexes are: the Index of Relative Socioeconomic Disadvantage (IRSD), the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD), the Index of Education and Occupation (IEO), and the Index of Economic Resources (IER). The IRSD is the only index not equivalised for both advantage and disadvantage, accounting for the level of disadvantage only; the remaining three indexes of IRSAD, IEO and IER are equivalised for both advantage and disadvantage (13). It was decided *a priori* to use the three latter equivalised indexes for these analyses.

The 28 subjects (2.5%) for whom, SEIFA values were unavailable were excluded, leaving a total of 1,074 subjects for this analysis (52.5% female). In 2001, approximately 4% of Australian Census Collection Districts could not be given a SEIFA value for reasons which included; fewer than ten people residing in an area,

fewer than five employed people in an area, five or less occupied private dwellings in an area, or areas in which non-response to Census questions including occupation, labour force status, type of educational institution attending, or non-school qualifications exceeded 70% (13). Quartile cut-points for SEIFA values were based on the Tasmanian population (13). For this analysis, we compared the most extreme socially disadvantaged group (those with SEIFA scores falling at or below the lowest 25%) to the rest of the study population (with SEIFA index values above the 25% cut-point).

Lifestyle and behavioural exposures

Data for lifestyle and behavioural exposures were obtained by self-report. Dietary calcium (mg/d) was determined by a validated, calcium-specific food frequency questionnaire (14). Smoking was defined as currently smoking at the time of BMD measurement. Physical inactivity was categorized as sedentary versus other, in the **home-/work-** and **recreation-/sport-**domains (the latter based upon participation in walking or bike riding). Alcohol intake was categorized as consuming more than two standard drinks of alcohol per day versus not, based on current NHMRC guidelines (15). Use of calcium or vitamin D supplements, oral/inhaled glucocorticoids, or hormone therapy (HT) (females only) was defined as current at the time of BMD measurement.

Vitamin D

Serum vitamin D (25(OH)D) was measured after an overnight fast, and serum samples were assayed using a Liquid Phase radioimmunoassay (IDS, Boldon, Tyne and Wear, UK). The intra- and inter-assay coefficients of variation have previously been reported as 1.8% and 3.3%, respectively (16).

Statistical analysis

Characteristics of subjects in the extreme socially disadvantaged group were compared with the rest of the population using *t*-test. Pearson correlations were used to depict the association between BMI and BMD for males and females. Interaction

terms were checked for effect modification. Univariable and multivariable linear regression analyses were used to assess the relationship between lumbar spine, total hip and total body and social disadvantage (before and after adjustment for age), BMI, dietary calcium, physical inactivity in work- and recreation-domains, smoking, alcohol intake, calcium or vitamin D supplements, use of glucocorticoids, and 25(OH)D. The female models included a further adjustment for use of HT. Multivariable linear regression models were run with and without exclusion of participants with wedge deformities of the spine. Logistic regression was used to assess the relationship between prevalent wedge deformities and age, BMI and social disadvantage, with further adjustment for BMD. Significance was set at $p < 0.05$ and all statistical analyses were performed using MINITAB (Version 15; Minitab, State College, PA) statistical software.

Results

Table 1 presents the characteristics of males ($n=524$) and females ($n=550$) in the extreme socially disadvantaged group compared to the rest of the TasOAC population, as measured by IRSAD. No differences were observed in BMD at any skeletal site for either sex (all $p > 0.2$). Males of extreme social disadvantage were less likely to have wedge deformities compared to other males (33% vs. 45%, $p=0.05$). The number of prevalent wedge deformities for females were similar for both groups ($p=0.98$).

Males in the extreme socially disadvantaged group were older (65.9yr vs 61.9yr, $p=0.008$), had lower levels of dietary calcium (mg/d) (850 vs 913, $p=0.005$) and were less likely to consume >2 alcoholic drinks per day (27.8% vs 40.5%, $p=0.03$), compared to the rest of the male TasOAC population. Female participants of extreme social disadvantage had greater BMI (kg/m^2) (29.9 ± 5.9 vs 27.6 ± 5.3 , $p=0.002$) and were less likely to consume >2 alcoholic drinks per day (8.4% vs 19.1%, $p=0.003$) compared to other female participants. No other differences were observed for either sex. Similar patterns of association were observed for the SEIFA indexes of IER and IEO in both males and females (data not shown).

Table 2 presents the univariable and multivariable analyses for associations between social disadvantage and BMD, excluding participants with wedge deformities. Extreme social disadvantage was not associated with BMD in univariable analysis for males ([coefficient $\pm$ SD] -0.02 ± 0.02 , $p=0.36$) or females (-0.01 ± 0.02 , $p=0.63$).

After adjustment, both BMI and 25(OH)D remained significant predictors for total hip BMD for males (both $p \leq 0.002$), whilst age and alcohol consumption did not ($p=0.21$ and 0.36 , respectively). A trend for association was seen between current use of glucocorticoids and total hip BMD for males [coefficient $\pm$ SD] (-0.05 ± 0.03 , $p=0.08$). For females, age and BMI both remained significant predictors in the adjusted model ($p < 0.0001$), however, we also observed greater BMD at the total hip to be significantly associated with current HT use (0.05 ± 0.02 , $p < 0.0001$), and with females in the most extreme socially disadvantaged group (0.04 ± 0.02 , $p < 0.02$). These models explained 19% of the variability in BMD for males, and 34% for females (R^2 values). When participants with wedge deformities were included within analyses, results were sustained between total hip BMD and extreme social disadvantage for males (0.02 ± 0.02 , $p < 0.25$, r^2 20%), and for females (0.03 ± 0.01 , $p < 0.03$, r^2 35%) (see supplementary file). Similar associations were observed for BMD at the spine and total body for both sexes, and when using IER and IEO to determine extreme social disadvantage (data not shown).

Table 3 presents results from multivariable analyses examining the association between social disadvantage and wedge deformities. Extreme social disadvantage was not associated with the prevalence of wedge deformities in univariable analysis for females ([odds ratio, 95% confidence intervals, p value] OR 1.01, 95%CI 0.62-1.64, $p=0.98$), however a trend was observed for males (OR 0.60, 95%CI 0.36-1.02, $p=0.06$). We examined whether potential confounders were able to account for differences in the prevalence of wedge fractures according to social disadvantage. In males, multivariable analysis continued to show a trend for a reduced likelihood of wedge deformities in males of extreme social disadvantage (OR 0.60, 95%CI 0.36-1.02, $p=0.06$). This was independent of age and BMI. For females, and following adjustment, there was still no association between wedge deformities and extreme social disadvantage (OR 0.95, 95%CI 0.58-1.57, $p=0.85$). No further relationships

were observed between wedge deformities or BMD and any other variables listed in Table 1 for either sex (data not shown).

Discussion

This study is the first to demonstrate the existence of an association between social disadvantage and BMD independent of BMI. This was present in females, but not in males. We also report a lower prevalence of wedge deformities in males of extreme social disadvantage compared to the other TasOAC males; however, no such association was observed in females.

Extreme social disadvantage remained a significant predictor of BMD, independent of BMI, for females in our study. It is suggested that greater BMI may exert a protective effect against bone loss, with increased levels of bone mineral density (BMD) closely associated with greater BMI in older females ≥ 50 years (17, 18), but not in males (19). The positive association between increased BMD and BMI has also been observed in younger females (20). Importantly, a large proportion of the total variance in BMD (between 9-20%) is explained by BMI (10, 21, 22).

Whilst weight exerts a strong effect on BMD due to mechanisms attributed to load-bearing on bones (23), that effect has been reported to be similar for both sexes (24), and therefore is unlikely to explain the sex-difference in the effect of extreme social disadvantage reported here. It is plausible that there may be other underlying mechanisms explaining the relationship between BMD and BMI in different social groups. For instance there may be potential differences in diet quality, some of which may be related to gender specific factors such as patterns of diet restriction, or other dietary patterns possibly related to SES or the accumulation of social disadvantage over a lifetime. Furthermore, differences in leptin have been shown as associated with bone mass in non-obese women (25), suggesting that this area of enquiry requires elucidation to determine whether leptin may explain some of the differences observed in our study.

By contrast, we report a lower prevalence of wedge deformities in males of extreme social disadvantage compared to the other TasOAC males, but no association between

SES and wedge deformities in females. After adjusting for age and BMI, **these associations remained**. This suggests that the lower prevalence seen in males of extreme social disadvantage may be a result of different distributions of the risk factors between these two groups. For instance, males of lower SES may have an increased exposure to 25(OH)D as a result of their greater likelihood of having manual occupations based outside (5), in contrast to males of upper SES whose occupation may primarily be based inside (5), though a difference in serum 25(OH)D levels was not seen in our study. Trauma associated with heavy manual labour (26), or participation in contact sports (26), may also play a role in males, and this may also explain why no such relationship was observed for females. Given that our male participants were aged >50 years, it is plausible that vertebral deformities may be related to trauma occurring during early to mid life; an explanation proffered elsewhere (26, 27) and which might attenuate associations between current lifestyle factors and vertebral deformities.

Our study has some limitations. The exclusion of 28 participants who could not be given a SEIFA code may have the potential to bias our results if they were of extreme social disadvantage; however, the inability to apply SEIFA codes for reasons such as non-response, or fewer than ten people residing in an area, may also affect areas of high affluence, and the number of people excluded for this reason was smaller than expected (2.5% versus 4% usually seen), so it is unlikely to substantially affect our findings. These findings from Southern Tasmania, Australia, may not be generalisable to populations of other ethnicity or locations. Furthermore, we acknowledge that Australia is a high-income country, and our term of extreme social disadvantage is relative only to the rest of Australia. As this is a cross-sectional study we are unable to determine causality. We applied a binary categorisation of SES in order to examine the extreme of social disadvantage upon bone health in this cohort, because the lowest SES groups are those in which greater incidence of fractures (determined by radiological evidence) have been observed (3). However, that binary categorisation limits the sensitivity of examining SES on a continuum from the most disadvantaged to the most advantaged. **The size of our sample is fixed however we have power to detect r^2 of <1% in the whole sample and 2.5% in gender specific analyses. Due to sample size, we cannot exclude the possibility that we may have observed relationships between more of our exposure variables and BMD or wedge deformities**

had our sample been larger. We did not adjust for the use of other medications known to affect bone, such as bisphosphonates. In addition, we did not assess antecedent risk factors such as prior fracture, which may play a role in these associations. Finally, the binary categorization of some variables, such as smoking and HT use, limited our ability to examine a dose-response effect with bone.

Our study also has strengths. This is the first study to examine the relative association of extreme social disadvantage upon the contested relationship between BMI and BMD in an elderly cohort of Australian men and women. These data add to the newly emerging area of research examining the social determinants of bone quality. Importantly, our findings were consistent across all SEIFA indexes. Area-based measures of SES such as the SEIFA indexes are an accepted proxy for public health purposes (28, 29), and the application of three different SEIFA indexes, formulated from various combinations of parameters of social disadvantage and advantage, allows for comparison of a range of combinations of SES parameters.

In conclusion, our findings suggest that extreme social disadvantage is associated with lower BMD for females, but not males. However, extreme social disadvantage was associated with a lower prevalence of wedge deformities in males, whilst no association between deformities and social disadvantage was observed in females. Our study raises many questions concerning the role played by social disadvantage upon wedge deformities in males. Whilst the impact of social determinants upon other morbidities has been well documented, the adverse outcomes for bone health are much less understood. Extreme social disadvantage may play a role in bone health for both sexes. Our findings also suggest that further work is required to examine whether increased BMD in groups experiencing extreme social disadvantage translates to a reduced or increased fracture risk.

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Competing interests

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Table 1: Characteristics of males and females in the extreme social disadvantage group (below 25% cut-point of the Index of Relative Socioeconomic Advantage and Disadvantage) compared to the rest of the TasOAC population, presented as median (range), mean ($\pm$ SD), or frequency (%).

Variables	Males		<i>p</i> (<i>t</i> - test)	Females		<i>p</i> (<i>t</i> - test)
	Extreme social disadvanta ge (n=72)	Rest of TasOAC (n=452)		Extreme social disadvanta ge (n=83)	Rest of TasOAC (n=467)	
Age (yr)	65.9 (51.2- 79.6)	61.9 (51.1- 79.9)	0.00 8	60.1 (51.5- 78.2)	61.4 (51.0- 80.9)	0.74
Body mass index (kg/m ²)	28.1 $\pm$ 3.5	27.7 $\pm$ 3.9	0.35	29.9 $\pm$ 5.9	27.6 $\pm$ 5.3	0.00 2
Dietary calcium (mg/d)	850 (262- 1775)	913 (191- 2471)	0.00 5	852 (210- 1920)	852 (144- 2590)	0.87
Current smoker	10 (13.9%)	59 (13.1%)	0.85	12 (14.5%)	46 (9.9%)	0.27
Physically inactive- work domain	27 (37.5%)	189 (41.8%)	0.49	32 (38.6%)	186 (39.8%)	0.83
Physically inactive- recreation domain	33 (45.8%)	211 (46.7%)	0.89	30 (36.1%)	185 (39.6%)	0.55
Alcoholic drinks >2 per day	20 (27.8%)	183 (40.5%)	0.03	7 (8.4%)	89 (19.1%)	0.00 3
Calcium/vitami n D supplements	2 (2.8%)	15 (3.3%)	0.80	9 (10.8%)	55 (11.8%)	0.80

Glucocorticoid s	5 (6.9%)	39 (8.6%)	0.61	6 (7.2%)	41 (8.8%)	0.62
Osteoporosis treatments	1 (1.4%)	5 (1.1%)	0.05	7 (8.4%)	21 (4.5%)	0.20
Serum vitamin D (25(OH)D)	54.3±17.7	55.7±19.1 *	0.53	48.7±18.0*	49.8±18.2 *	0.60
Vitamin D (<50nmol/L)	29 (40.3%)	173 (38.4%)	0.76	43 (52.4%)	240 (51.8%)	0.92
Wedge deformities at the spine	24 (33.3%)	205 (45.4%)	0.05	30 (36.1%)	168 (36.0%)	0.98
Hormone therapy	N/A	N/A	N/A	24 (28.9%)	113 (24.2%)	0.38
<i>Bone mineral density (gm/cm³)</i>						
Spine	1.059±0.20 1	1.063±0.1 69	0.88	0.960±0.17 4	0.966±0.1 60	0.78
Spine (excl deformities)	1.068±0.20 3	1.067±0.1 69	0.97	0.944±0.18 6	0.967±0.1 60	0.41
Hip	1.011±0.15 1	1.034±0.1 41	0.24	0.910±0.15 2	0.905±0.1 44	0.79
Total body	1.133±0.11 1	1.154±0.1 22	0.15	1.022±0.11 9	1.025±0.1 14	0.83
<i>Osteoporotic (T-score <2.5 SD below the mean)</i>						
Spine	23 (31.9%)	92 (20.4%)	0.03	30 (36.1%)	159 (34.0%)	0.72
Spine (excl deformities)	15 (20.8%)	46 (10.2%)	0.06	24 (28.9%)	99 (21.2%)	0.09

*Missing data: Males (n=1), Females (most extreme socially disadvantaged group n=1, rest of the TasOAC population n=4)

Table 2: Univariable and multivariable models examining mean bone mineral density (gm/c²) at the total hip for males and females, excluding participants with wedge deformities

Variables	Univariable regression model		Multivariable regression model	
	Coefficient ± SD	<i>p</i>	Coefficient ± SD	<i>p</i>
Males, n=295				
Age (yr)	-0.002 ± 0.001	0.03	-0.001 ± 0.001	0.21
Extreme social disadvantage	0.021 ± 0.023	0.36	0.008 ± 0.021	0.70
Body mass index (kg/m ²)	0.015 ± 0.002	<0.0001	0.015 ± 0.002	<0.0001
Dietary calcium (mg/d)	0.001 ± 0.001	0.35	0.001 ± 0.001	0.22
Serum vitamin D (25(OH)D)	0.001 ± 0.001	0.02	0.001 ± 0.001	0.002
Physically inactive- work domain	0.007 ± 0.017	0.70	0.004 ± 0.016	0.79
Physically inactive- recreation domain	-0.003 ± 0.017	0.84	0.005 ± 0.016	0.76
Current smoker	-0.046 ± 0.027	0.09	-0.040 ± 0.025	0.11
Alcoholic drinks >2 per day	0.040 ± 0.018	0.02	0.015 ± 0.017	0.36
Calcium/vitamin D supplements	-0.039 ± 0.045	0.38	-0.057 ± 0.041	0.16
Glucocorticoids	-0.048 ± 0.029	0.10	-0.047 ± 0.027	0.08
Females, n=352				
Age (years)	-0.006 ± 0.001	<0.0001	-0.006 ± 0.001	<0.0001
Extreme social disadvantage	0.010 ± 0.022	0.63	0.044 ± 0.018	0.02
Body mass index (kg/m ²)	0.014 ± 0.001	<0.0001	0.014 ± 0.001	<0.0001
Dietary calcium (mg/d)	0.001 ± 0.001	0.36	0.001 ± 0.001	0.44
Serum vitamin D (25(OH)D)	-0.001 ± 0.001	0.85	0.001 ± 0.001	0.51

	0.001			
Physically inactive- work domain	0.010 ± 0.016	0.53	-0.002 ± 0.013	0.91
Physically inactive- recreation domain	0.001 ± 0.016	0.99	0.006 ± 0.013	0.65
Current smoker	-0.040 ± 0.024	0.09	-0.024 ± 0.020	0.22
Alcoholic drinks >2 per day	-0.020 ± 0.020	0.32	-0.010 ± 0.016	0.54
Calcium/vitamin D supplements	-0.032 ± 0.023	0.16	-0.019 ± 0.019	0.32
Glucocorticoids	-0.023 ± 0.026	0.38	-0.028 ± 0.022	0.21
Hormone therapy	0.071 ± 0.017	0.38	0.046 ± 0.015	0.002

Multivariable models (excluding participants with wedge deformities) adjusted for age, body mass index, physical inactivity, smoking, alcohol consumption, calcium or vitamin D supplements, and glucocorticoid adjustment for hormone therapy.

Table 3: Odds ratio and 95%CI (*p* value) of prevalent wedge deformities for males and females, adjusted for age, body mass index and social disadvantage

Variables	Multivariable regression model	
	Odds ratio	95%CI (<i>p</i> value)
Males, n=524		
Age (yr)	1.00	0.97, 1.02 (0.83)
Body mass index (kg/m ²)	1.01	0.97, 1.06 (0.63)
Most socially disadvantaged	0.60	0.36, 1.02 (0.06)
Females, n=550		
Age (years)	1.04	1.02, 1.07 (<0.0001)
Body mass index (kg/m ²)	1.03	1.00, 1.07 (0.05)
Most socially disadvantaged	0.95	0.58, 1.57 (0.85)

Table 4: Univariable and multivariable models examining mean bone mineral density (gm/c²) at the total hip for males and females, including participants with wedge deformities

Variables	Univariable regression model		Multivariable regression model	
	Coefficient $\pm$ SD	<i>p</i>	Coefficient $\pm$ SD	<i>p</i>
Males				
Age (yr)	-0.003 $\pm$ 0.001	0.002	-0.002 $\pm$ 0.001	0.02
Extreme social disadvantage	0.023 $\pm$ 0.018	0.21	0.019 $\pm$ 0.017	0.25
Body mass index (kg/m ²)	0.015 $\pm$ 0.001	<0.001	0.015 $\pm$ 0.002	<0.001
Dietary calcium (mg/d)	0.001 $\pm$ 0.001	0.08	0.001 $\pm$ 0.001	0.04
Serum vitamin D (25(OH)D)	0.001 $\pm$ 0.001	0.02	0.001 $\pm$ 0.001	0.002
Physically inactive- work domain	0.008 $\pm$ 0.013	0.53	0.005 $\pm$ 0.012	0.66
Physically inactive- recreation domain	0.001 $\pm$ 0.013	0.96	0.009 $\pm$ 0.011	0.44
Current smoker	-0.060 $\pm$ 0.018	0.001	-0.050 $\pm$ 0.017	0.003
Alcoholic drinks >2 per day	0.016 $\pm$ 0.013	0.22	-0.001 $\pm$ 0.012	0.94
Calcium/vitamin D supplements	-0.017 $\pm$ 0.035	0.63	-0.037 $\pm$ 0.032	0.24
Glucocorticoids	-0.033 $\pm$ 0.022	0.14	-0.028 $\pm$ 0.020	0.17
Females				
Age (years)	-0.006 $\pm$ 0.001	<0.001	-0.005 $\pm$ 0.001	<0.001
Extreme social disadvantage	-0.005 $\pm$ 0.017	0.78	0.031 $\pm$ 0.014	0.03
Body mass index (kg/m ²)	0.013 $\pm$ 0.001	<0.001	0.014 $\pm$ 0.001	<0.001
Dietary calcium (mg/d)	0.001 $\pm$ 0.001	0.69	-0.001 $\pm$ 0.001	0.90
Serum vitamin D (25(OH)D)	-0.001 $\pm$ 0.001	0.61	0.001 $\pm$ 0.001	0.28
Physically inactive- work domain	0.017 $\pm$ 0.013	0.18	0.002 $\pm$ 0.010	0.87
Physically inactive- recreation domain	0.003 $\pm$ 0.013	0.84	0.014 $\pm$ 0.010	0.17
Current smoker	-0.035 $\pm$ 0.020	0.08	-0.028 $\pm$ 0.017	0.09

Alcoholic drinks >2 per day	-0.010 ± 0.016	0.52	-0.004 ± 0.013	0.78
Calcium/vitamin D supplements	-0.044 ± 0.019	0.02	-0.023 ± 0.016	0.14
Glucocorticoids	-0.040 ± 0.022	0.07	-0.040 ± 0.018	0.03
Hormone therapy	0.054 ± 0.014	<0.001	0.038 ± 0.012	0.001

Multivariable models (including participants with wedge deformities) adjusted for age, body mass index, comorbidities, physical inactivity, smoking, alcohol consumption, calcium or vitamin D supplements, and glucocorticoid use. **P** values are shown in bold. **P** values in bold indicate statistical significance at the 0.05 level. **P** values in bold indicate statistical significance at the 0.05 level.