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Full length article

Association between pelvic floor disorders and bone mineral density: Findings from the HUNT study

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ABSTRACT

Objectives: To examine the association between pelvic floor disorders (pelvic organ prolapse, urinary incontinence and anal incontinence) and bone mineral density (BMD).
Study design: A cross-sectional study of 6809 women who participated in the third survey of the population-based Norwegian HUNT study was undertaken. BMD was measured by dual-energy X-ray absorptiometry. Information on BMD and self-reported pelvic floor disorders from the HUNT study was linked with hospital-derived data on diagnosis and surgical treatment of pelvic floor disorders. BMD was categorized according to the World Health Organization criteria (normal, osteopenia and osteoporosis). Multi-variate logistic regression models were used to estimate odds ratios (OR) with 95% confidence intervals (CI) for the association between pelvic floor disorders and BMD.
Results: Women with a hospital diagnosis of stress urinary incontinence (SUI) were less likely to have osteopenia (OR 0.66, 95% CI 0.50–0.87) or osteoporosis (OR 0.66, 95% CI 0.34–1.30) compared with women without a diagnosis of SUI. In women with self-reported information on pelvic floor disorders, women with a history of SUI had lower odds for osteopenia (OR 0.88, 95% CI 0.75–1.02) or osteoporosis (OR 0.69, 95% CI 0.46–1.01), while no association was found between anal incontinence, self-reported surgery for pelvic organ prolapse, and osteopenia or osteoporosis.
Conclusion: Pelvic organ prolapse was not associated with BMD. The reasons underlying the observed association between SUI and BMD require further investigation.

Introduction

Together with the other Scandinavian countries, Norway is world leading in the prevalence of osteoporosis and low-energy fractures [1–3]. Osteoporotic fractures are associated with increased morbidity and mortality, and impose a substantial burden on individuals, healthcare systems and society [1,4]. Fractures resulting from osteoporosis are increasingly common in postmenopausal women [4], and depending on which skeletal part is measured, approximately one in 10 Norwegian women aged > 50 years are osteoporotic according to the World Health Organization's (WHO) definition [5]. There are well-known therapeutic measures to prevent osteoporotic fractures, and identifying individuals at risk has the potential for significant impact for both individuals and healthcare systems. Studies have shown huge treatment gaps in both women and men internationally, with corresponding opportunities for potential prevention of thousands of fragility fractures each year [6]. The fracture-related burden is expected to increase further over the next decades, mainly due to population ageing, and previous studies have called for more preventive action to identify and treat individuals at risk [1,4,6].

Risk factors for osteoporosis include increasing age, female sex, current cigarette smoking, low body weight, prior history of fragility fracture, alcohol intake, chronic glucocorticoid use, and certain medical conditions [4]. Knowledge about additional risk factors for reduced bone mineral density (BMD) may further improve the identification of individuals at increased risk of fractures. Pelvic floor disorders (PFDs),

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including pelvic organ prolapse (POP), urinary incontinence and anal incontinence, are common conditions in women, and it has been hypothesized that PFDs and low BMD may represent manifestations of a generalized disturbance in collagen metabolism [7]. Based on this hypothesis, previous studies have investigated the association between PFDs and reduced bone quantity or quality [7–12]. However, these studies provided conflicting results, and often included participants undergoing osteoporotic evaluation in a clinical setting. Therefore, the objective of the present study was to examine the association between PFDs and BMD in the population-based Trøndelag Health Study (HUNT study) in Norway.

Methods

Design

This population-based cross-sectional study was based on data from the third survey of the HUNT study (HUNT3), linked to hospital-derived data on diagnosis and surgical treatment of PFDs using the unique identification numbers of all Norwegian citizens.

Study population

The HUNT study, initiated in 1984, is an ongoing population-based cohort study that has collected comprehensive data on participants' health and lifestyle through clinical measurements, interviews and questionnaires through four surveys [13]. HUNT3 (2006–2008) included bone densitometry [dual-energy X-ray absorptiometry (DXA)] in a subgroup of participants; those selected were inhabitants of the five largest municipalities in the Northern Trøndelag region and comprised a random sample of participants, in addition to those who reported asthma-related respiratory symptoms, diagnosis and use of medication.

In total, 7588 female HUNT3 participants attended for a BMD scan in HUNT3. Women with available data on BMD measurements of the total hip were eligible for the current study (n = 7441). Six hundred and thirty-two women with incomplete information on body mass index (BMI) (n = 19), smoking history (n = 179), physical activity (n = 1) or education (n = 462) were excluded, leaving 6809 women in the final study population (Fig. S1, see online supplementary material).

Exposures

Data on PFDs, including POP, urinary incontinence and anal incontinence, were collected from the electronic patient administrative systems of the two regional hospitals: Levanger Hospital and Namsos Hospital. Information on International Classification of Diseases, 9th Revision or 10th revision codes indicating PFDs were retrieved between 1 September 1987 and HUNT3 participation. Accordingly, information on NOMESCO Classification of Surgical Procedures codes indicating surgical treatment for PFDs was obtained. Details on diagnoses and surgical procedures codes are given in Table S1 (see online Supplementary material).

In further analyses, self-reported information on PFDs on surgical treatment for POP and symptoms of urinary incontinence or anal incontinence from HUNT questionnaires was used.

Outcome

BMD of the total hip was measured in g/cm^2 using DXA (Lunar Prodigy GE Healthcare, Little Chalfont, UK). BMD measurements from the left hip were preferred, but for a small number of women with left hip replacement, BMD measurements from the right hip were used (n = 167). Methods of calibration and quality control are described elsewhere [14]. BMD was standardized as T-scores, calculated as observed minus mean BMD divided by standard deviation from a healthy female reference population aged 20–39 years from the HUNT study. BMD T-score was categorized according to WHO criteria into normal (T-score $\geq$ -1.0), osteopenia (T-score between −1.0 and −2.5) and osteoporosis (T-score $\leq$ −2.5) [15].

Covariates

Data on covariates were assessed at the time of participation in HUNT3, and included age, BMI, educational status, smoking history, parity, level of physical activity and early menopause (defined as age at menopause < 45 years). Parity was categorized into nulliparous, one birth, two births, and three births or more. Smoking history was categorized into ever or never daily smoking. Educational status was derived from work titles based on recommendations from Statistics Norway [16]. Height and weight measurements were conducted with the participants wearing light clothes and no shoes. BMI was calculated as weight divided by height squared, and categorized into underweight/normal (<25 kg/m^2), overweight (25–<30 kg/m^2) and obese (≥30 kg/m^2). Physical activity was categorized into not physically active (<30 min daily activity and physical activity less than once per week), moderate physical activity (≥30 min daily activity or physical activity once per week) and high physical activity (physical activity more than once per week). In sensitivity analyses, additional adjustment was made for level of social activity (self-reported participation in association or club meeting, music, singing or theatre, parish work, outdoor activities, dance, and sports or exercise).

Statistical analysis

Multi-variate logistic regression models with normal BMD as the reference group were used to assess the association between the primary variables of interest (diagnoses, surgical treatment and self-reported symptoms of PFDs) and osteopenia or osteoporosis. Unadjusted associations were studied initially, and then adjustments were made for age, educational status, BMI, smoking, parity, level of physical activity and early menopause. In sensitivity analyses restricted to women who were likely to be postmenopausal, only women who were aged > 50 years at participation in HUNT3 were included. The authors also conducted sensitivity analysis restricted to participants who were selected at random for BMD measurement, to see if the selection criteria for BMD measurement influenced the results. Furthermore, sensitivity analyses were performed with additional adjustment for history of systemic oestrogen use or level of social activity. All analyses were performed using Stata (Stata/MP 16.1 for Mac, StataCorp, College Station, TX, USA).

Ethics

This study was approved by the Regional Committee for Medical and Health Research Ethics Northern Norway (REC North, Ref. No. 118524). Participants in the HUNT study have given informed, written consent for research on their data and linkage to specific registers.

Results

Among 6809 study participants, 68.1% had a normal BMD score, 27.9% were classified as osteopenic and 4.0% were classified as osteoporotic. Compared with women with normal BMD, women with osteopenia or osteoporosis were older, more likely to be smokers, and reported lower educational status. Furthermore, women with osteopenia or osteoporosis were more likely to report early age at menopause and had a lower BMI compared with women with normal BMD (Table 1). In total, 343 (5.0%) participants were registered with one or more diagnoses of POP, and 414 (6.1%) were registered with one or more diagnoses of urinary incontinence in the patient administrative system prior to HUNT3 participation. According to hospital information systems, 158 (2.3%) women underwent surgery for POP and 132 women

Table 1
Descriptive characteristics of the study population ($n = 6809$).

		Overall	Bone mineral density		
			Normal (n=4638)	Osteopenia (n=1900)	Osteoporosis (n=271)
Age at HUNT3 participation, years, mean (SD)		54.7 (16.2)	49.8 (14.9)	63.7 (14.0)	74.3 (10.4)
Education level, *n* (%)					
	Lower secondary	703 (10.3)	402 (8.7)	246 (12.9)	55 (20.3)
	Upper secondary	3786 (55.6)	2475 (53.4)	1145 (60.3)	166 (61.3)
	Tertiary	2320 (34.1)	1761 (38.0)	509 (26.8)	50 (18.5)
BMI (kg/m^2), *n* (%)					
	<25	2631 (38.6)	1561 (33.7)	893 (47.0)	177 (65.3)
	25–<30	2581 (37.9)	1762 (38.0)	744 (39.2)	75 (27.7)
	≥30	1597 (23.5)	1315 (28.4)	263 (13.8)	19 (7.0)
Daily smoking status, *n* (%)					
	Never	2829 (41.5)	1973 (42.5)	743 (39.1)	113 (41.7)
	Ever	3980 (58.5)	2665 (57.5)	1157 (60.9)	158 (58.3)
Parity, *n* (%)					
	Nulliparous	818 (12.0)	619 (13.3)	165 (8.7)	34 (12.5)
	One birth	711 (10.4)	526 (11.3)	159 (8.4)	26 (9.6)
	Two births	2449 (36.0)	1684 (36.3)	677 (35.6)	88 (32.5)
	Three births or more	2831 (41.6)	1809 (39.0)	899 (47.3)	123 (45.4)
Physical activity, *n* (%)					
	Not physically active	412 (6.1)	242 (5.2)	140 (7.4)	30 (11.1)
	Moderate physical activity	2188 (32.1)	1497 (32.3)	610 (32.1)	81 (29.9)
	High physical activity	4209 (61.8)	2899 (62.5)	1150 (60.5)	160 (59.0)
Social activity, *n* (%)					
	Not socially active	504 (7.4)	234 (5.0)	207 (10.9)	63 (23.2)
	Moderate social activity	1700 (25.0)	1073 (23.1)	552 (29.1)	75 (27.7)
	High social activity	3505 (51.5)	2574 (55.5)	854 (44.9)	77 (28.4)
Early menopause (<45 years), *n* (%)		802 (11.8)	501 (10.8)	268 (14.1)	33 (12.2)
Ever use of systemic hormone therapy, *n* (%)		1430 (21.0)	876 (18.9)	501 (26.4)	53 (19.6)
Selection criteria for BMD measurement, *n* (%)					
	Random sample	4683 (68.8)	3046 (65.7)	1408 (74.1)	229 (84.5)
	Respiratory symptoms	2126 (31.2)	1592 (34.3)	492 (25.9)	42 (15.5)

SD, standard deviation; BMI, body mass index.
Percentages may not sum to 100% due to rounding.

(1.9%) underwent surgery for stress urinary incontinence (SUI) (Table 2).

The relationship between BMD and hospital-based information on PFDs is shown in Table 3. In the unadjusted models, women with a diagnosis of POP were more likely to have osteopenia or osteoporosis, but these associations disappeared after adjustment for age. In the fully adjusted analysis, women diagnosed with SUI were less likely to have osteopenia [odds ratio (OR) 0.66, 95% confidence interval (CI) 0.50–0.87] or osteoporosis (OR 0.66, 95% CI 0.34–1.30) compared with women without a diagnosis of SUI. The fully adjusted ORs for osteopenia and osteoporosis among women with surgical treatment for SUI were 0.59 (95% CI 0.37–0.92) and 0.56 (95% CI 0.19–1.71), respectively.

Table 4 provides estimates for associations between BMD and self-reported PFDs. Self-reported surgery for POP was not associated with lower BMD in the fully adjusted models. Women who reported any current symptoms of urinary incontinence were less likely to have osteopenia (OR 0.85, 95% CI 0.74–0.98) and associations with osteoporosis, although non-significant, were in the same direction (OR 0.81, 95% CI 0.59–1.13). Self-reported symptoms of SUI were associated with decreased odds of osteopenia and osteoporosis, although estimates were attenuated in the fully adjusted models [OR 0.88 for osteopenia (95% CI 0.75–1.02) and OR 0.69 for osteoporosis (95% CI 0.46–1.01)]. Women who reported previous treatment for urinary incontinence were less likely to have osteopenia (OR 0.79, 95% CI 0.64–0.98) or osteoporosis (OR 0.65, 95% CI 0.39–1.07). Associations between surgical treatment for SUI and lower BMD were slightly stronger [OR 0.70 for osteopenia (95% CI 0.50–0.97) and OR 0.50 for osteoporosis (95% CI 0.20–1.23)]. No association was found between self-reported symptoms of anal incontinence and BMD.

Sensitivity analyses restricted to women aged > 50 years (Tables S2 and S3), see online Supplementary material) or restricted to women selected at random for BMD measurement (results not shown) did not change the results substantially. Similarly, additional adjustment for history of systemic oestrogen use or level of social activity did not influence the estimates (results not shown).

Discussion

In this population-based, cross-sectional study of 6809 women, POP and anal incontinence were not associated with low BMD. Unexpectedly, diagnosis, surgical treatment and self-reported symptoms of SUI were associated with decreased odds of osteopenia or osteoporosis.

Several previous studies have evaluated the association between PFDs and bone strength measured as BMD and/or trabecular bone score. In line with the present results, several previous studies found no association between POP and low bone strength [8,10,12,17], although two studies reported increased risk of fractures among women with POP which appeared to be confined to women with moderate to severe rectocele or cystocele [9,11]. The present results, although limited by low numbers, did not indicate that the association between POP and BMD may vary according to type of prolapse.

In the present study, analyses of anal incontinence were limited by the small number of women with this exposure and thus low power, but provided no evidence for an association between anal incontinence and BMD. A lack of association between faecal incontinence and bone strength was also found in a cross-sectional study based on 681 postmenopausal women undergoing osteoporosis evaluation [10]. In contrast, Richter et al. reported that women with osteopenia had increased risk of incontinence of solid stool [12]. This may indicate that low BMD is mainly associated with higher severity of anal incontinence.

The present results suggest that SUI is associated with lower risk of osteopenia or osteoporosis. This is consistent with findings from Richter et al. who reported lower odds of urinary incontinence ≥ 2–3 times/week among women with osteopenia compared with women with

Table 2
Number of study participants with reported diagnosis or surgical treatment of pelvic floor disorders prior to HUNT3 ($n = 6809$).

	Overall ($n = 6809$)	Bone mineral density		
		Normal ($n = 4638$)	Osteopenia ($n = 1900$)	Osteoporosis ($n = 271$)
Diagnosis, *n* (%)				
Pelvic organ prolapse				
Cystocele	168 (2.5)	78 (1.7)	77 (4.1)	13 (4.8)
Recto-/enterocele	103 (1.5)	58 (1.3)	43 (2.3)	2 (0.7)
Uterine prolapse	142 (2.1)	74 (1.6)	58 (3.1)	10 (3.7)
Unspecified prolapse	150 (2.2)	75 (1.6)	65 (3.4)	10 (3.7)
Any pelvic organ prolapse	343 (5.0)	176 (3.8)	142 (7.5)	25 (9.2)
Incontinence				
Stress urinary incontinence	344 (5.1)	249 (5.4)	83 (4.4)	12 (4.4)
Urinary incontinence, other	183 (2.7)	119 (2.6)	53 (2.8)	11 (4.1)
Mixed urinary incontinence	113 (1.7)	75 (1.6)	33 (1.7)	5 (1.8)
Any urinary incontinence	414 (6.1)	293 (6.3)	103 (5.4)	18 (6.6)
Faecal incontinence	12 (0.2)	6 (0.1)	6 (0.3)	0
Surgical treatment, *n* (%)				
Surgical treatment for pelvic organ prolapse	158 (2.3)	80 (1.7)	70 (3.7)	8 (3.0)
Surgical treatment for urinary incontinence	132 (1.9)	98 (2.1)	30 (1.6)	4 (1.5)

Table 3
Association of hospital data on pelvic floor disorders with bone mineral density ($n = 6809$).

	Osteopenia		Osteoporosis	
	OR	95% CI	OR	95% CI
Pelvic organ prolapse				
Cystocele				
Model 1	**2.47**	**1.79–3.40**	**2.95**	**1.62–5.37**
Model 2	1.22	0.87–1.70	1.05	0.56–1.99
Model 3	1.40	0.98–1.99	1.47	0.75–2.89
Recto-/enterocele				
Model 1	**1.83**	**1.23–2.72**	0.59	0.14–2.42
Model 2	1.00	0.66–1.53	0.25	0.06–1.07
Model 3	1.19	0.77–1.85	0.37	0.08–1.62
Uterine prolapse				
Model 1	**1.94**	**1.37–2.75**	**2.36**	**1.21–4.63**
Model 2	0.92	0.64–1.33	0.73	0.36–1.49
Model 3	1.03	0.69–1.52	0.98	0.46–2.07
Unspecified prolapse				
Model 1	**2.16**	**1.54–3.02**	**2.33**	**1.19–4.56**
Model 2	0.91	0.63–1.30	0.55	0.27–1.11
Model 3	0.98	0.67–1.45	0.63	0.30–1.35
Any pelvic organ prolapse				
Model 1	**2.05**	**1.63–2.57**	**2.58**	**1.66–3.99**
Model 2	0.99	0.78–1.27	0.82	0.52–1.32
Model 3	1.14	0.88–1.47	1.12	0.68–1.85
Incontinence				
Stress urinary incontinence				
Model 1	0.81	0.62–1.04	0.82	0.45–1.48
Model 2	**0.57**	**0.44–0.75**	0.54	0.29–1.00
Model 3	**0.66**	**0.50–0.87**	0.66	0.34–1.30
Urinary incontinence, other				
Model 1	1.09	0.78–1.51	1.61	0.86–3.02
Model 2	**0.64**	**0.45–0.91**	0.72	0.37–1.42
Model 3	0.80	0.55–1.15	1.01	0.48–2.12
Fecal incontinence				
Model 1	2.44	0.79–7.59		
Model 2	1.31	0.39–4.41		
Model 3	1.31	0.35–4.84		
Surgical treatment				
Surgical treatment for pelvic organ prolapse				
Model 1	**2.18**	**1.57–3.02**	1.73	0.83–3.62
Model 2	1.10	0.78–1.56	0.63	0.29–1.35
Model 3	1.31	0.91–1.89	0.90	0.40–2.02
Surgical treatment for stress urinary incontinence				
Model 1	0.74	0.49–1.12	0.69	0.25–1.90
Model 2	**0.51**	**0.33–0.79**	0.47	0.16–1.32
Model 3	**0.59**	**0.37–0.92**	0.56	0.19–1.71

Model 1, unadjusted; Model 2, adjusted for age; Model 3, adjusted for age, education, body mass index, smoking status, parity, level of physical activity and early menopause; CI, confidence interval; OR, odds ratio.
Significant ORs are printed in bold.

normal BMD [12]. In contrast, Meyer et al. reported that women with low bone quality (trabecular bone score) had increased odds of urinary incontinence, although they found no association between bone quantity (BMD) and urinary incontinence [10]. A recent report from Taiwan, based on data from a national health insurance database, showed higher risk of SUI among women diagnosed with osteoporosis compared with non-osteoporotic women [18]. Notably, the Taiwanese study examined incident cases of SUI in women according to prior diagnosis of osteoporosis, whereas the present study was interested in bone health of women according to current or former PFDs.

In contrast to most previous studies including women undergoing osteoporotic evaluation in a clinical setting, women in the present study were part of a population-based cohort. Both premenopausal and postmenopausal women were included, some of whom were below the common age range for decreased BMD or PFDs. Women who report and seek treatment for SUI may be more physically active, which is linked to higher bone mass [19,20]. Although adjustment for level of physical activity or social activity did not substantially alter the results, the possibility of residual confounding cannot be ruled out because the authors were unable to control for high-impact activities such as jumping or weight-bearing activities that are more beneficial for bone density [19].

It has been hypothesized that PFDs may be linked to lower bone strength through common pathophysiological pathways of connective tissue deficiency or low oestrogen [7]. The lack of association between PFDs and lower BMD in this study suggests that PFDs may not reflect skeletal compromise.

The strengths of this study include the population-based design, a large sample size of women with a combination of self-reported and hospital-based data on PFDs, and standardized BMD measurements. The authors were also able to adjust the analyses for a variety of confounding factors, including clinically measured BMI, physical activity, lifestyle and reproductive factors.

Due to the cross-sectional design, only associations – rather than a temporal relationship – can be described between SUI and lower BMD. Information was lacking on self-reported symptoms of POP, so it was only possible to compare women with and without a self-reported history of surgical treatment for POP. Self-reported information on PFDs may be subject to over- and underestimation due to recall bias or socially desirable responding. However, the authors were able to examine the associations between BMD and self-reported data as well as hospital data on PFDs, and obtained results that were similar in magnitude. A further limitation of this study is the lack of data on the degree of SUI, history of fractures, or treatment for osteoporosis. Hospital diagnoses of PFD were not validated; however, information on surgical treatment is likely to be correct. When comparing self-reported surgical treatment for POP or SUI with hospital procedure codes indicating surgical treatment,

Table 4
Association of self-reported pelvic floor disorders with bone mineral density.

	Osteopenia		Osteoporosis	
	OR	95% CI	OR	95% CI
Surgical treatment for pelvic organ prolapse (*n*=5161)				
Yes vs none				
Model 1	**2.05**	**1.61–2.61**	**1.81**	**1.06–3.10**
Model 2	1	0.77–1.31	0.58	0.33–1.02
Model 3	1.18	0.90–1.55	0.85	0.47–1.56
Current urinary incontinence (*n*=5605)				
Yes vs no				
Model 1	0.94	0.83–1.06	0.92	0.69–1.23
Model 2	**0.71**	**0.63–0.81**	**0.57**	**0.42–0.77**
Model 3	**0.85**	**0.74–0.98**	0.81	0.59–1.13
Current stress urinary incontinence (*n*=4949)				
Yes vs no				
Model 1	0.92	0.81–1.05	0.71	0.51–1.01
Model 2	**0.72**	**0.63–0.84**	**0.47**	**0.32–0.67**
Model 3	0.88	0.75–1.02	0.69	0.46–1.01
Current urge urinary incontinence (*n*=4049)				
Yes vs no				
Model 1	0.9	0.77–1.06	0.68	0.45–1.04
Model 2	**0.72**	**0.60–0.85**	**0.56**	**0.36–0.87**
Model 3	0.85	0.71–1.02	0.85	0.53–1.35
Urinary incontinence frequency (*n*=1703)				
≥1 per week vs <1 per week				
Model 1	**1.72**	**1.38–2.14**	**1.99**	**1.17–3.40**
Model 2	0.98	0.77–1.26	0.67	0.37–1.21
Model 3	1.13	0.87–1.47	0.89	0.47–1.70
Urinary incontinence volume (*n*=1762)				
Moderate to large vs small amount				
Model 1	**1.33**	**1.07–1.64**	**2.44**	**1.39–4.26**
Model 2	0.95	0.75–1.21	1.21	0.66–2.22
Model 3	0.98	0.76–1.25	1.38	0.73–2.64
Urinary incontinence feeling (*n*=2092)				
Major problem vs no/ minor problem				
Model 1	0.84	0.60–1.19	**1.85**	**1.00–3.45**
Model 2	0.71	0.49–1.02	1.55	0.79–3.07
Model 3	0.77	0.52–1.13	1.56	0.74–3.29
Urinary incontinence, treatment (*n*=3997)				
Yes vs no				
Model 1	1.01	0.84–1.21	0.94	0.60–1.46
Model 2	**0.67**	**0.55–0.82**	**0.48**	**0.30–0.76**
Model 3	**0.79**	**0.64–0.98**	0.65	0.39–1.07
Urinary incontinence, surgical treatment (*n*=3548)				
Yes vs no				
Model 1	0.96	0.71–1.29	0.65	0.28–1.49
Model 2	**0.58**	**0.42–0.79**	**0.32**	**0.13–0.75**
Model 3	**0.7**	**0.50–0.97**	0.5	0.20–1.23
Anal incontinence (*n*=5170)				
Yes vs none				
Model 1	1.01	0.87–1.17	1.31	0.95–1.81
Model 2	0.91	0.77–1.07	1.12	0.79–1.58
Model 3	0.91	0.77–1.08	1.18	0.82–1.70

Model 1, unadjusted; Model 2, adjusted for age; Model 3, adjusted for age, education, body mass index, smoking status, parity, level of physical activity and early menopause; CI, confidence interval; OR, odds ratio.
Significant ORs are printed in bold.

approximately 50% of cases of self-reported surgery could not be verified by hospital data (Table S4), see online supplementary material). Participants may have mistaken other surgical treatment for surgery for POP or SUI. This underlines the advantage of examining both self-reported and hospital-based data. Another limitation of the present study was the lack of information on trabecular bone score which may have enriched the evaluation of skeletal integrity. Furthermore, there may have been selection bias due to the invitation of women with lung symptoms for BMD measurement. However, sensitivity analyses restricted to women invited based on a random sample did not indicate that selection for BMD measurement influenced the estimates.

Although the HUNT study population can be considered as fairly representative of the Norwegian population [13], the HUNT cohort is a rather ethnically homogeneous population, which may limit the generalizability of the study. Norway is characterized by universal access to public health care, so the present results may not be generalizable to other populations with different access to health care.

Overall, this study did not find associations between POP and BMD. The findings suggest that women with symptoms of urinary incontinence or a history of surgical treatment for urinary incontinence are less likely to have low BMD. The reasons underlying the observed association between SUI and BMD require further investigation. This study did not find evidence to suggest that women with PFDs would benefit from earlier evaluation for osteoporosis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejogrb.2022.02.002.

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