Individualized Fracture Risk Feedback and Long-term Benefits After 10 Years

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Introduction: This study aimed to determine if beneficial effects of individualized feedback of fracture risk on osteoporosis preventive behaviors and bone mineral density observed in a 2-year trial were sustained long-term.

Methods: This was a 10-year follow-up of a 2-year RCT in 470 premenopausal women aged 25–44 years, who were randomized to one of two educational interventions (the Osteoporosis Prevention and Self-management course [OPSMC] or an osteoporosis information leaflet) and received tailored feedback of their relative risk of fracture in later life (high versus normal risk groups). Bone mineral density of lumbar spine and femoral neck measured by dual-energy X-ray absorptiometry. Physical activity, dietary calcium intake, calcium and vitamin D supplements, and smoking status measured by questionnaires.

Results: From 2 to 12 years, the high-risk group had a smaller decrease in femoral neck bone mineral density (β=0.023, 95% CI=0.005, 0.041 g/cm^2) but similar lumbar spine bone mineral density change as the normal risk group. They were more likely to use calcium (relative risk=1.66, 95% CI=1.22, 2.24) and vitamin D supplements (1.99, 95% CI=1.27, 3.11). The OPSMC had no effects on bone mineral density change. Both high risk (versus normal risk) and the OPSMC groups (versus leaflet) had a more favorable pattern of smoking behavior change (relative risk=1.85, 95% CI=0.70, 4.89 and relative risk=2.27, 95% CI=0.86, 6.01 for smoking cessation; relative risk=0.33, 95% CI=0.13, 0.80 and relative risk=0.28, 95% CI=0.10, 0.79 for commenced or persistent smoking).

Conclusions: Feedback of high fracture risk to younger women was associated with long-term improvements in osteoporosis preventive behaviors and attenuated femoral neck bone mineral density loss therefore this could be considered as a strategy to prevent osteoporosis.

Trial registration: Australian New Zealand Clinical Trials Registry (ANZCTR) NCT00273260.

INTRODUCTION

Chronic diseases are the leading preventable causes of premature death and disability and lifestyle factors, such as good nutrition and physical activity, are critical for their prevention.[1] Assessment of health risks with feedback is a common and useful approach[2–4] for improving health behaviors. For example, there is strong evidence that risk feedback with health education can improve many health behaviors in the workplace including tobacco use, alcohol consumption, and dietary fat intake.[5] The commonality of lifestyle risk factors across chronic diseases means that a risk feedback intervention for one disease that improves lifestyle behaviors is likely to have benefits for a range of conditions.

Individualized risk feedback has been applied to the prevention of osteoporosis and related fractures.[6] Previous controlled trials suggest that premenopausal women informed of having low bone mineral density (BMD) or higher fracture risk improve osteoporosis preventive behaviors (e.g., cigarette smoking, low levels of physical activity, inadequate calcium intake, and vitamin D deficiency).[7–9] For example, in a previous 2-year RCT premenopausal women receiving feedback of being at high fracture risk in later life had more favorable changes in preventive behaviors and greater increases in femoral neck (FN) BMD compared with those who were informed they had normal risk.[7] However, to the authors' knowledge, there are no published trials examining the long-term effects of providing individualized risk feedback for fracture or any other diseases. Long-term effectiveness is important for diseases that develop slowly and become apparent later in life, such as osteoporosis and cardiovascular disease.

Therefore, the aim of this study is to perform a further 10-year follow-up of a previous 2-year RCT to examine the long-term effects of the feedback of fracture risk and educational interventions on BMD of FN and lumbar spine (LS) and osteoporosis preventive behaviors.

METHODS

Study Sample

This was an additional 10-year follow-up of a registered (NCT00273260) 2-year RCT previously conducted in Southern Tasmania, Australia.[7] Women aged 25–44 years were randomly selected from the 2000 Tasmanian Electoral Roll and recruited between April and November 2000 from this predominantly Caucasian population.[7] Women were excluded if they had previous measurement of BMD, thyroid disease, renal failure, malignancy, rheumatoid arthritis, a history of hysterectomy or were taking hormone replacement therapies, were pregnant or planning pregnancy within 2 years, or were lactating. Ethics approval was obtained from the Tasmania Health and Medical Human Research Ethics Committee. All participants gave written informed consent.

Measures

At baseline, 470 women were randomized 1:1 to receive one of two osteoporosis educational interventions: the Osteoporosis Prevention and Self-management course (OPSMC) (OPSMC group, n=219) or an information leaflet (leaflet group, n=251) using computer generated random numbers. The OPSMC is a chronic disease self-management course developed by the Arthritis Foundation of Victoria and utilized by Osteoporosis Australia, aiming to increase knowledge and improve confidence and awareness and self-management of osteoporosis prevention. It emphasizes lifestyle changes such as increasing calcium intake and appropriate physical activity. OPSMC sessions of 2 hours were held weekly for 4 weeks (≤16 participants per group). The osteoporosis information leaflet from Osteoporosis Australia, "Understanding Osteoporosis," provided a comprehensive description of osteoporosis and of the role of lifestyle factors including diet, exercise, smoking, and optimal levels of calcium

intake and exercise.[8] This was delivered by mail and did not include the intensive behavioral change interventions provided during the OPSMC.

Spine and hip BMD was measured at baseline, 2, and 12 years by operators blinded to intervention status by dual-energy X-ray absorptiometry (Hologic QDR2000 densitometer), which was calibrated daily (Coefficient Of Variation=1%). At baseline, those with a mean spine and hip T-score<0 were informed that they were at a higher risk of fracture in later life (high-risk group, *n*=232) whereas those with a mean T-score≥0 were informed that they were not at higher risk (normal risk group, *n*=238). This was based on the observation that those in the lower half of the BMD distribution have threefold higher fracture risk both in later life and in the early postmenopausal period.[10] The leaflet group received written feedback of fracture risk with their leaflet by mail, and the OPSMC group received written feedback at the first OPSMC session. Participants at higher risk were asked to discuss their BMD results with general practitioners.

Primary outcomes for the 12-year follow-up were FN and LS BMD, calcium intake, calcium supplement use, and physical activity. These behaviors were measured yearly for first 2 years and at 12 years. Secondary outcomes were use of vitamin D supplements and smoking status.

Calcium intake was assessed by a validated short food frequency questionnaire, which correlates well with 4 day weighed records for estimated calcium intake (r =0.79, *p*=0.001).[11] The calcium content of food was determined by Australian food composition tables.[12] Participants were classified as taking calcium supplements if they reported taking a supplement containing calcium alone or as a main ingredient at a frequency of four or more times weekly.

Physical activity was assessed by a questionnaire validated in American adolescents,[13] modified for Tasmanian conditions and previously in women of this age.[14] This asked how many days in the last 14 the participants performed >20 minutes of strenuous exercise and light exercise, measured in five categories (0, 1–2, 3–5, 6–8, and ≥9 days). Smoking status was assessed by questionnaire asking whether participants were regular smokers, defined as smoking at least seven cigarettes, cigars, or pipes weekly for >3 months.

Changes in osteoporosis preventive behaviors were determined by their status at 2 and 12 years. Participants who smoked at 2 but not 12 years were classified as ceased smoking, those who did not smoke at either 2 or 12 years as never smoking, those who did not smoke at 2 years but did at 12 years as commenced smoking, and as persistent smoking otherwise. A similar classification was used for change in calcium supplement use. Change in calcium intake was categorized as increased or decreased and change in physical activity was classified as unchanged, increased or decreased.

At 12 years, participants were asked if they had regularly (five or more times/week for >9 months of the year) used vitamin D supplement during each year during the last 12 years. Participants were categorized as recent users if using vitamin D supplements for the preceding 2 consecutive years and no recent use otherwise.

Serum 25-hydroxyvitamin D (25(OH)D) level was assessed at 12 years, from venous blood samples, using liquid chromatography tandem-mass spectrometry (CV=3%–6%, using an internal standard).

Other factors measured at baseline, 2 and 12 years included height by stadiometer (The Leicester height measure) and weight by a single set of calibrated scales (Heine). BMI was calculated [weight/height^2 (kg/m^2)]. Breastfeeding history, education level, employment status, and marital status were assessed by questionnaire. Self-reported fractures with age at each fracture, use of anti-osteoporosis medications, and menopausal status was also reported at 12 years.

Statistical Analysis

Mean (SD), median (IQR), and number (%) were used to describe continuous and categoric variables as appropriate (based on normality checking using Shapiro–Wilk test). Differences in characteristics between intervention groups were tested using Student's *t*-test, Kruskal–Wallis or chi-square test as appropriate. Linear mixed-effects modeling was used to estimate effects of fracture risk feedback and educational interventions on changes in FN and LS BMD from 2 to 12 years, adjusting for potential confounders. Intervention groups, time (follow-up number) and the interaction between the interventions **X** time (treatment effect) were considered fixed factors in the model. Potential interactions between the two interventions were also tested. Participant identification number was included as a random effect to account for the dependence of repeated observations. This model is powerful in dealing with repeated measures with missing data.[15] Log-binomial and log-multinomial regressions were used to estimate the relative risk (RR) of categories of behavior change, from 2 to 12 years, associated with each intervention. This model is very well suited to compute an adjusted RR in clinical trials of common outcomes.[16] Models were further adjusted for age, anthropomorphic and sociodemographic factors, and menopausal status at the 12 year follow-up. Confounders were selected if (1) the association with both the outcome and exposure of interest was biologically plausible, and (2) their addition to the

model caused a >10% change in the estimated coefficient for the intervention. To handle missing data, including that missing because of loss to follow-up, a weighted estimating equation method was used.[17,18] Analyses were performed in Stata, version 12. A two-tailed *p*-value <0.05 was considered statistically significant.

RESULTS

A total of 470 women (64% response rate) aged 25–44 years were recruited at baseline with 88% (*n*=415) retained at year 2 and 74% (*n*=347) at year 12 (Figure 1). Women who completed 12-year follow-up had similar characteristics to those who were lost to follow-up, other than being slightly older (Appendix Table 1). Women in the high-risk group were shorter and had lower weight; there was a greater proportion of women who had ever smoked among those who received the information leaflet than among those who received the OPSMC (Table 1). Menopausal status at 12 years was similar across the groups as were other baseline characteristics. Serum 25(OH)D at 12 years was slightly higher in the high-risk group than the normal risk group but was similar between educational intervention groups. Five participants used anti-osteoporosis medication and they were all in the OPSMC and high-risk groups.

Unadjusted FN and LS BMD at each time point (stratified by intervention groups) and the estimated effects of the interventions over time are shown in Appendix Table 2 and Table 2, respectively. There were no significant interactions between educational intervention **X** fracture risk feedback. FN and LS BMD were lower at 12 years than at 2 years in both fracture risk feedback and both educational intervention groups as well as in the study sample as a whole ($p<0.001$ for all). Women in the high-risk group had a smaller reduction in FN BMD between 2 and 12 years than the normal risk group after adjusting for confounders

(β=0.023, 95% CI=0.005, 0.041). There was no evidence for a similar effect for LS BMD. There were no effects of educational intervention on change in BMD at any site.

Table 3 gives the estimated RR of each behavior change category between intervention groups. Women in the high-risk group (versus normal risk) were more likely to have ceased smoking (RR=1.85, 95% CI=0.70, 4.89) and less likely to have commenced smoking or persistently smoked with never smoked as the referent outcome (RR=0.33, 95% CI=0.13, 0.80); similarly, the OPSMC group had a more favorable pattern of smoking behavior change compared with the leaflet group.

Women in the high-risk group were more likely to commence or keep using calcium supplements (compared with never using supplements; RR=1.66, 95% CI=1.22, 2.24), and to report recent vitamin D supplements use (RR=1.99, 95% CI=1.27, 3.11). They were also less likely to report a decrease in light physical activity (RR=0.71, 95% CI=0.51, 0.99) than those with normal risk. There were no differences between educational intervention groups for use of calcium or vitamin D supplements or change in light or strenuous physical activity or dietary calcium intake.

DISCUSSION

Feedback of the assessment of health risks is a useful approach to improving lifestyle behaviors that are important to a broad spectrum of chronic diseases, but the current study is the first to address the important issue of whether long-term improvements can be achieved. In this study, after 10 years, feedback of high fracture risk was associated with a slower loss of FN but not LS BMD, improved use of calcium and vitamin D supplements and a favorable effect on smoking status. The OPSMC was associated with improved smoking behavior

compared with a leaflet but did not benefit BMD. These changes suggest that feedback of relative fracture risk based on BMD testing could be considered in young women as a strategy to improve long-term bone health and prevent osteoporosis in later life.

Various forms of risk estimates with feedback are effective at improving informed health decision making, health behaviors and outcomes.[2,5,19,20] For example, feedback of risk status to participants followed by health education is effective for improving health behaviors in the worksite setting, such as reducing tobacco use, alcohol consumption, and dietary fat intake.[5] However, for bone[7–9,21] and other diseases, studies of such interventions have been relatively short-term. This is the first study to demonstrate very long-term benefits to both preventive behaviors and an objective health outcome (namely BMD). After an additional 10-year follow-up, the short-term benefits observed at 2 years for calcium supplements use and FN BMD persisted.[7] The persistent effect of the intervention on slowing of FN BMD loss (about 2.4%) is most important. It has been estimated that for each 5% loss in FN BMD in elderly women there is a 40% and 90% increase in all fractures and hip fracture risk, respectively.[22] Thus, slowing FN BMD loss by 2.4% is likely to be important for the prevention of osteoporosis and fracture in later life.

In addition, the longer follow-up period enabled detection of effects on smoking behavior with the probability of women quitting smoking in the high-risk group being around double that of those in the normal risk group. Women in this group were also 67% less likely to commence or have been persistently smoking by 12 years. These are substantial effects—they are greater than cessation rates achieved by print-based self-help interventions[23] and telephone counseling.[24] The OPSMC had similar effects on smoking. Such improvements have potential benefits for prevention of a wide range of diseases other than osteoporosis.

Smoking is the leading preventable cause of mortality including for atherosclerotic cardiovascular disease, lung cancer, and chronic obstructive pulmonary disease—the three major causes of smoking-related mortality.[25] Feedback of high fracture risk was also associated with use of vitamin D supplementation in the long-term, doubling the probability of participants using a vitamin D supplement consecutively for the preceding 2 years. Given the high prevalence of vitamin D deficiency worldwide[26] and its broad health benefits beyond bone,[27] this behavior change has substantial public health implications.

The authors observed no effect of feedback of high fracture risk on LS BMD, which is unsurprising as there was also no effect after 2 years.[7] This could be explained by site-specific responses of bone to lifestyle behavior changes, which have been seen with physical activity and calcium intake in premenopausal women. For example, an exercise protocol targeting the upper and lower body improved LS BMD compared with a protocol focusing on the lower body alone.[28] In a meta-analysis of exercise trials in premenopausal women protocols incorporating impact loading and resistance components improved both FN and LS BMD, but those only with impact components improved FN BMD alone.[29] The authors postulate that compressive forces on the spine from impact may be less than those at the hip and that muscle activity at the hip during jumping provides additional tensile forces not seen at the spine.[29,30] RCTs of calcium supplements in younger women have also shown variations in effects at different sites, though the reasons for this are unclear.[31] Nevertheless, site-specific effects of these factors should be considered when developing future interventional programs.

Given the lack of effect of the OPSMC on either behavior or BMD at 2 years,[7] it was unsurprising that no effects were observed after another 10 years, although interestingly, it

was associated with long-term smoking behavior. As previously discussed,[7] the OPSMC was designed similarly to a chronic disease self-management course for arthritis, which has only a small effect on health status and behaviors even in symptomatic populations.[32,33] This study was in healthy women, who may be less motivated to change than those who are symptomatic. The lack of effect of the OPSMC for BMD and most behaviors is consistent with the finding that its effect on osteoporosis knowledge also dissipated from 2 years[34] to 12 years.[35]

Limitations

This study has several potential limitations. The 64% response rate may have resulted in selection bias, but as previously discussed,[7] although this sample had a lower proportion of current smokers (17%) compared with the Tasmanian prevalence of daily smoking (29%) in women aged 25 to 44 years in 1998, socioeconomic factors like educational levels and the unemployment rate in this study approximate overall population figures. Therefore, the current findings are likely to be generalizable to healthy Caucasian women of this age. Missing data because of drop-outs is another potential limitation, but loss to follow-up was similar in all intervention groups, and baseline characteristics were comparable between those who did and did not complete the study, other than those lost to follow-up being slightly older. Moreover, this was accounted for by using both linear mixed-effects model and inverse probability weighting. The results were also similar using complete case data, so the likelihood of loss to follow-up influencing these findings is low. Participants could not be blinded to interventions, but, BMD, the most clinically important outcome, was measured objectively by dual-energy X-ray absorptiometry, by an operator blinded to intervention status and so is unlikely to be biased by subjective factors. Self-reported behavioral measures could be subject to recall bias, but the fact that serum 25(OH)D concentrations at 12 years

were substantially higher in women who reported recent vitamin D supplement supports the validity of self-reported data, as do previous studies validating self-reported smoking.[36,37] It was considered unethical to perform dual-energy X-ray absorptiometry but withhold participants' results so the authors are unable to compare any effects of fracture risk feedback to a no feedback control group.

CONCLUSIONS

Feedback of high fracture risk was associated with long-term improvements in calcium and vitamin D supplement use and smoking behavior, and slowed loss of FN BMD in premenopausal women. Such feedback could be considered as a strategy to improve long-term bone health and prevent osteoporosis in later life. Furthermore, the improvements in behaviors suggest that an approach targeting bone may have benefits for other chronic diseases. The fact that a relatively simple behavioral intervention was able to produce such long-standing effects is also likely to be influential for the design of interventions for other chronic diseases.

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TW, GJ, and BO were involved in study design. TW and GJ were responsible for data collection and management. FW performed data analysis, in consultation with KW, TW, LL, MR and GJ. FW and TW drafted the manuscript together. All authors revised manuscript content and approved the final manuscript and had access to the data. TW is the guarantor of the study and accepts full responsibility for the finished article, had access to any data, and controlled the decision to publish.

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LIST OF FIGURES

[†]Unable to continue due to health related issues, including illness, pregnancy, disability and mortality.

OPSMC, Osteoporosis Prevention and Self-management course.

Table 1. Characteristics of Participants by Fracture Risk Group, and by Education Intervention Group

Characteristics	Fracture risk group			Educational intervention		
	High	**Normal**	***p*-value**	**OPSMC**	**Leaflet**	***p*-value**
Baseline	n=231	n=236		n=220	n=247	
Age (years), median (IQR)	38.8 (34.8, 42.6)	39.1 (34.6, 42.1)	0.70	38.6 (33.3, 42.1)	39.6 (35.2, 42.3)	0.19
Height (cm)	**162.0 (6.5)**	**164.2 (6.0)**	<0.001	162.7 (6.3)	163.5 (6.5)	0.21
Weight (kg), median (IQR)	**63.0 (57.2, 69.0)**	**71.6 (63.6, 83.7)**	<0.001	66.8 (60.1, 76.3)	66.4 (60.2, 76.0)	0.90
Education level, n (%)			0.97			0.22
≤Grade 10	76 (33)	79 (34)		76 (35)	79 (32)	
Grade 10 to 12	50 (22)	49 (21)		39 (18)	60 (24)	
>Grade 12	105 (45)	106 (45)		104 (47)	107 (44)	
Employment status, n (%)			0.87			0.66
0 hours/week	32 (14)	32 (14)		27 (12)	37 (15)	
≤20 hours/week	56 (24)	53 (22)		51 (23)	58 (24)	
> 20 hours/week	142 (62)	151 (64)		142 (65)	151 (61)	
Currently smoking, n (%)	37 (16)	42 (18)	0.61	32 (15)	47 (19)	0.20
Ever smoked, n (%)	113 (49)	113 (48)	0.86	**94 (43)**	**132 (54)**	0.02
Married or de facto, n (%)	167 (72)	173 (73)	0.81	169 (77)	171 (69)	0.07
Calcium intake (mg/d), median (IQR)	720 (486, 984)	731 (534, 969)	0.58	709 (508, 986)	739 (511, 960)	0.78
Strenuous activity level (days/2 weeks), median (IQR)	3 (2, 4)	3 (2, 4)	0.51	3 (2, 4)	3 (2, 4)	0.37
12 years	n=171	n=176		n=160	n=187	
Menopause status, n (%)			0.65			0.11
Post menopause	45 (26)	41 (23)		47 (29)	39 (21)	
Pre-menopause	65 (38)	69 (39)		61 (38)	61 (38)	
Status unclear	10 (6)	16 (9)		14 (9)	14 (9)	
Currently menopausal	51 (30)	50 (29)		38 (24)	38 (24)	
Serum 25(OH)D levels (nmol/L), median (IQR)	64.7 (51.6, 78.9)	60.0 (44.4, 76.0)	0.08	63.1 (47.6, 78.1)	62.7 (47.2, 76.0)	0.66

Fractures, n (%)[a]	23 (11)	20 (12)	0.56	23 (14)	20 (11)	0.30

Notes: All values are Mean (SD) unless otherwise indicated. Boldface indicates statistical significance ($p<0.05$).
[a]Women reporting a fracture between baseline and 12 years.

OPSMC, Osteoporosis Prevention and Self-management course; IQR, interquartile range.

Table 2. Absolute Change in BMD in Each Intervention Group and Effect of Fracture Risk Feedback and Educational Interventions on Absolute Change in BMD Between 2 and 12 Years

	Mean of change[a] (95% CI)	**Unadjusted β (95% CI)**	**Adjusted[b] β (95% CI)**
Bone mineral density (g/cm^2)		**Group by time**	**Group by time**
Femoral neck			
Normal risk (n=162)[d]	**–0.145 (–0.159, –0.132)**	ref	ref
High risk (n=163)[c]	**–0.123 (–0.134, –0.112)**	**0.022 (0.005, 0.040)**	**0.023 (0.005, 0.042)**
Leaflet (n=176)[d]	**–0.130 (–0.143, –0.118)**	ref	ref
OPSMC (n=149)[c]	**–0.139 (–0.152, –0.127)**	–0.009 (–0.026, 0.009)	–0.011 (–0.029, 0.008)
Lumbar spine			
Normal risk (n=162)[d]	**–0.041 (–0.052, –0.029)**	ref	ref
High risk (n=163)[c]	**–0.055 (–0.066, –0.044)**	–0.011 (–0.027, 0.005)	–0.011 (–0.027, 0.006)
Leaflet (n=176)[d]	**–0.047 (–0.058, –0.036)**	ref	ref
OPSMC (n=149)[c]	**–0.048 (–0.060, –0.036)**	0.001 (–0.016, 0.017)	0.002 (–0.015, 0.018)

Notes: Boldface indicates statistical significance (p<0.05). Linear mixed-effects model was used to test treatment effect (group by time).

[a]Unadjusted absolute change in BMD from 2 to 12 years within each subgroup.

[b]Adjusted for other items in column, duration of follow-up, age at 2 years, change in weight and height between 2 years and 12 years and menopause status at 12-year.

[c]Intervention group.

[d]Control group.

OPSMC, Osteoporosis Prevention and Self-management course; BMD, bone mineral density

Table 3. Effect of Fracture Risk Groups and Educational Intervention on the Change in Behaviors Between 2 and 12 Years

Change in behaviors	**Fracture risk group**		**RR (95% CI)**		**Educational intervention**		**RR (95% CI)**	
	High	**Normal[d]**	**Unadjusted**	**Adjusted[a]**	**OPSMC**	**Leaflet[d]**	**Unadjusted**	**Adjusted[a]**
Smoking	n=151	n=144			n=132	n=163		
Never smoked[c]	133 (88)	121 (84.0)	1.00	1.00	116 (88)	138 (85)	1.00	1.00
Cessation	12 (8)	6 (4.2)	1.91 (0.74, 4.95)	1.85 (0.70, 4.89)	12 (9)	6 (4)	2.47 (0.95, 6.40)	2.27 (0.86, 6.01)
Commenced or persistent smoking	6 (4)	17 (11.8)	**0.34 (0.14, 0.83)**	**0.33(0.13, 0.80)**	4 (3)	19 (12)	**0.26 (0.09, 0.75)**	**0.28 (0.10, 0.79)**
Calcium intake	n=162	n=161			n=149	n=174		
Decreased[c]	66 (41)	72 (45)	1.00	1.00	67 (45)	71 (41)	1.00	1.00
Increased	96 (59)	89 (55)	0.91 (0.71, 1.17)	0.89 (0.69, 1.15)	82 (55)	103 (59)	1.10 (0.86, 1.42)	1.15 (0.89, 1.48)
Calcium supplements	n=161	n=161			n=149	n=173		
Never supplement[c]	79 (49)	112 (70)	1.00	1.00	87 (59)	104 (60)	1.00	1.00
Commenced or persistent supplement	74 (46)	44 (27)	**1.68 (1.24, 2.28)**	**1.66 (1.22, 2.24)**	57 (38)	61 (35)	1.08 (0.81, 1.45)	1.12 (0.83, 1.50)
Cessation	8 (5)	5 (3)	1.60 (0.53, 4.79)	1.52 (0.50, 4.59)	5 (3)	8 (5)	0.73 (0.24, 2.17)	0.62 (0.21, 1.87)
Vitamin D supplements[b]	n=171	n=175			n=159	n=187		
No recent use[c]	122 (71)	150 (86)	1.00	1.00	119 (75)	153 (82)	1.00	1.00
Recent use	49 (29)	25 (14)	**2.01 (1.30, 3.09)**	**1.99 (1.27, 3.11)**	40 (25)	34 (18)	1.38 (0.92, 2.08)	1.37 (0.90, 2.09)
Strenuous physical activity	n=162	n=161			n=149	n=174		
Unchanged[c]	56 (35)	49 (30)	1.00	1.00	42 (28)	63 (36)	1.00	1.00
Increased	43 (26)	50 (31)	0.85 (0.61, 1.21)	0.90 (0.62, 1.31)	40 (27)	53 (31)	0.88 (0.62, 1.25)	0.87 (0.62, 1.24)
Decreased	63 (39)	62 (39)	1.01 (0.77, 1.33)	1.02 (0.77, 1.37)	67 (45)	58 (33)	**1.35 (1.02, 1.78)**	1.30 (0.99, 1.71)

Light physical activity	n=161	n=161			n=148	n=174		
Unchanged[c]	75 (47)	64 (40)	1.00	1.00	59 (40)	80 (46)	1.00	1.00
Increased	47 (29)	43 (27)	1.09 (0.77, 1.55)	1.13 (0.80, 1.59)	44 (30)	46 (26)	1.12 (0.79, 1.60)	1.07 (0.76, 1.52)
Decreased	39 (24)	54 (33)	0.72 (0.51, 1.02)	**0.71 (0.51, 0.99)**	45 (30)	48 (28)	1.10 (0.78, 1.55)	1.16 (0.84, 1.61)

Notes: Values are n (%) unless otherwise indicated. Boldface indicates statistical significance ($p<0.05$). Log binomial and multinomial regression models were used as appropriate.

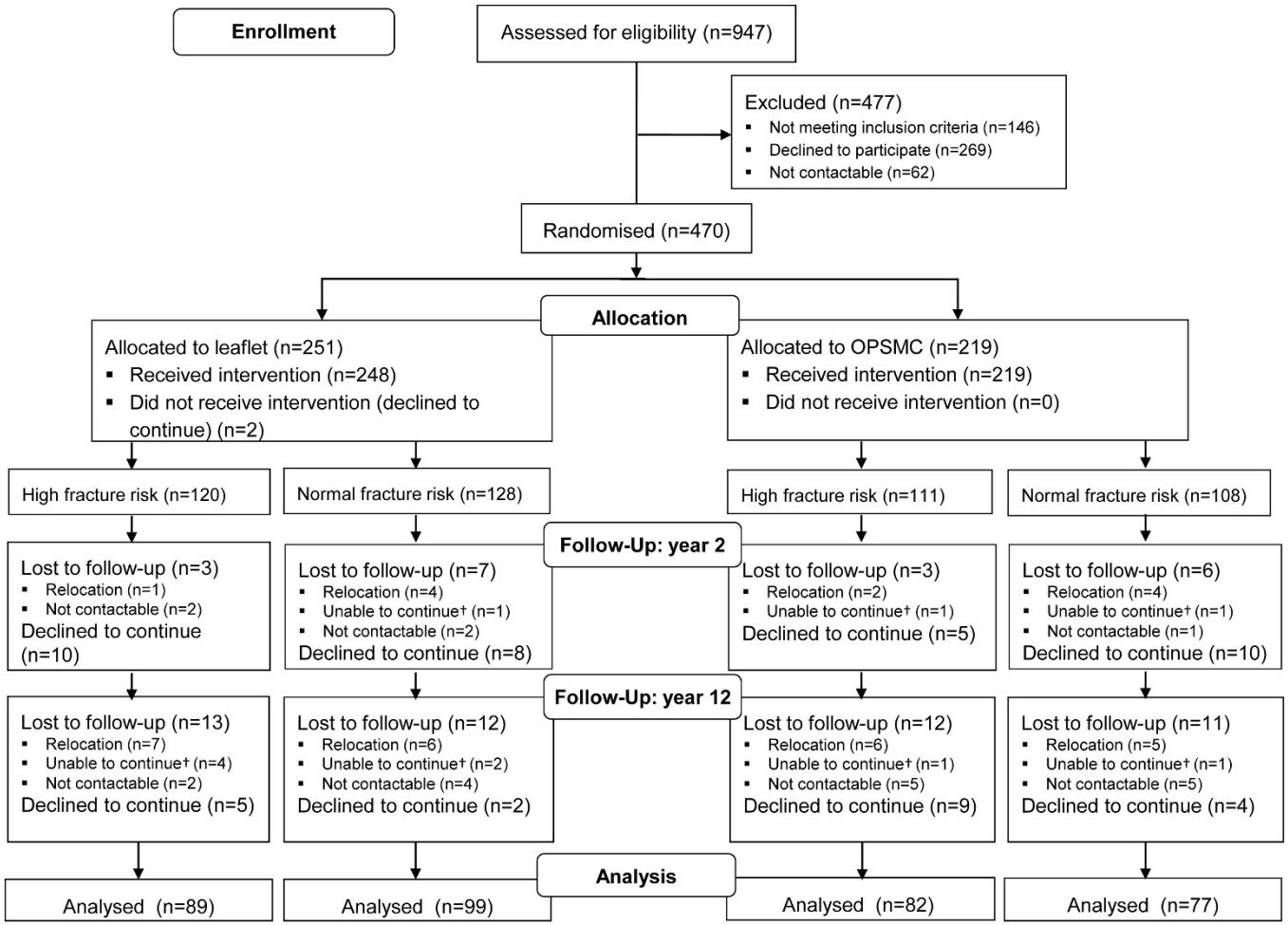
[a]Adjusted for age at 2 years, baseline number of children, employment status, education level, and marital status.

[b]Recent use if using vitamin D supplements for the preceding 2 consecutive years and no recent use otherwise. See content for the groupings of all behaviors in detail.

[c]Referent group for outcome.

[d]Reference group for comparison of intervention groups.

RR, relative risk; OPSMC, Osteoporosis Prevention and Self-management course.


Enrollment
Assessed for eligibility (n=947)
Excluded (n=477)
Not meeting inclusion criteria (n=146)
Declined to participate (n=269)
Not contactable (n=62)
Randomised (n=470)
Allocation
Allocated to leaflet (n=251)
Received intervention (n=248)
Did not receive intervention (declined to continue) (n=2)
Allocated to OPSMC (n=219)
Received intervention (n=219)
Did not receive intervention (n=0)
High fracture risk (n=120)
Normal fracture risk (n=128)
High fracture risk (n=111)
Normal fracture risk (n=108)
Follow-Up: year 2
Lost to follow-up (n=3)
Relocation (n=1)
Not contactable (n=2)
Declined to continue (n=10)
Lost to follow-up (n=7)
Relocation (n=4)
Unable to continue† (n=1)
Not contactable (n=2)
Declined to continue (n=8)
Lost to follow-up (n=3)
Relocation (n=2)
Unable to continue† (n=1)
Declined to continue (n=5)
Lost to follow-up (n=6)
Relocation (n=4)
Unable to continue† (n=1)
Not contactable (n=1)
Declined to continue (n=10)
Follow-Up: year 12
Lost to follow-up (n=13)
Relocation (n=7)
Unable to continue† (n=4)
Not contactable (n=2)
Declined to continue (n=5)
Lost to follow-up (n=12)
Relocation (n=6)
Unable to continue† (n=2)
Not contactable (n=4)
Declined to continue (n=2)
Lost to follow-up (n=12)
Relocation (n=6)
Unable to continue† (n=1)
Not contactable (n=5)
Declined to continue (n=9)
Lost to follow-up (n=11)
Relocation (n=5)
Unable to continue† (n=1)
Not contactable (n=5)
Declined to continue (n=4)
Analysis
Analysed (n=89)
Analysed (n=99)
Analysed (n=82)
Analysed (n=77)

Appendix Table 1. Comparison of Baseline Characteristics of Participants Who Did and Did Not Complete the Study

Characteristic	**Completed study n=347**	**Withdrawals n=120**	***p*-value**
Age (years)	38.3 (5.2)	36.3 (5.6)	<0.001
Feedback of high fracture risk, n (%)	177 (51)	60 (50)	0.892
Received OPSMC, n (%)	160 (46)	60 (50)	0.462
Height (cm)	163.5 (6.3)	162.1 (6.6)	0.084
Weight (kg)	69.6 (13.4)	69.3 (14.3)	0.819
Strenuous activity level (Median)	3	3	0.345
Calcium intake (mg/d)	782.3 (401.5)	808.6 (391.2)	0.533
Calcium supplement use n (%)	7 (2.0)	3 (2.5)	0.414
BMD of FN (g/cm^2)	0.93 (0.13)	0.93 (0.15)	0.797
BMD of LS (g/cm^2)	1.08 (0.12)	1.08 (0.12)	0.914

Notes: All values are mean (SD) unless otherwise indicated.

OPSMC, Osteoporosis Prevention and Self-management course; BMD, bone mineral density; FN, femoral neck; LS, lumbar spine.

Appendix Table 2. Unadjusted FN and LS BMD at Each Time Point (Stratified by Fracture Risk Feedback Group and Educational Intervention Group)

Time point	High fracture risk	Normal fracture risk
Baseline	(n=231)	(n=236)
FN BMD	0.836 (0.823, 0.850)	1.018 (1.005, 1.030)
LS BMD	0.992 (0.982, 1.002)	1.169 (1.157, 1.181)
2 year	(n=213)	(n=206)
FN BMD	0.859 (0.848, 0.870)	1.033 (1.019, 1.046)
LS BMD	0.994 (0.983, 1.004)	1.172 (1.158, 1.185)
12 year	(n=171)	(n=176)
FN BMD	0.736 (0.723, 0.749)	0.889 (0.873, 0.905)
LS BMD	0.936 (0.920, 0.953)	1.130 (1.111, 1.149)
	OPSMC	**Leaflet**
Baseline	(n=220)	(n=247)
FN BMD	0.934 (0.915, 0.954)	0.923 (0.907, 0.938)
LS BMD	1.084 (1.066, 1.101)	1.080 (1.065, 1.094)
2 year	(n=197)	(n=222)
FN BMD	0.945 (0.927, 0.964)	0.944 (0.928, 0.959)
LS BMD	1.079 (1.061, 1.098)	1.083 (1.067, 1.099)
12 year	(n=160)	(n=187)
FN BMD	0.813 (0.795, 0.832)	0.814 (0.795, 0.832)
LS BMD	1.030 (1.007, 1.054)	1.038 (1.017, 1.060)

Notes: Values are mean (95% CI).

FN, femoral neck; LS, lumbar spine; BMD, bone mineral density; OPSMC, Osteoporosis Prevention and Self-management course