**Effects of individualized bone density feedback and educational interventions on osteoporosis knowledge and self-efficacy: a** **12-yr prospective study**

**Abstract**

*Objective* To evaluate the long-term effects of bone density feedback and osteoporosis education on osteoporosis knowledge and self-efficacy.

*Methods* This is a 12-year follow-up of a randomised controlled trial, examining the effects of feedback of bone density-defined fracture risk [high (T-score<0) vs. normal (T-score≥0) risk] and two different educational interventions [the group-based Osteoporosis Prevention and Self-management course (OPSMC) vs. an osteoporosis leaflet] on osteoporosis knowledge and self-efficacy in women aged 25-44.

*Results* 74% (N=347) of 470 participants at baseline participated at 12-years. Overall, the scores were higher for osteoporosis knowledge but lower for self-efficacy at 12 years. However, neither intervention had an effect on the change in knowledge (T-score, β=-0.4, 95%CI =-0.3 to 1.1; OPSMC, β=0.2, 95%CI =-0.5 to 0.9) or self-efficacy (T-score, β=-1.1, 95%CI =-2.5 to 0.4; OPSMC, β=-0.2, 95%CI =-1.6 to 1.3). Women in households with an unemployed main financial provider had a decrease in knowledge at 12-years compared to those in households with an employed main financial provider in whom knowledge increased (β=-1.95, 95%CI =-3.40 to -0.50) but there were no other predictors of change identified for knowledge or self-efficacy.

*Conclusion* Beneficial effects of both the OPSMC and feedback of high fracture risk on osteoporosis knowledge seen previously at 2-years were not sustained after 12-years although overall knowledge was still significantly higher than at baseline. Neither intervention improved osteoporosis self-efficacy. More frequent osteoporosis education and bone density feedback may be required to maintain knowledge and other approaches to improve self-efficacy are necessary.

**Key Words:** Osteoporosis; knowledge; self-efficacy; bone density; feedback; education.

**Introduction**

Osteoporosis is a major public health problem worldwide. The financial burden on the health system it causes is increasing dramatically. For instance, in Australia the total health expenditure for osteoporosis and osteopenia in individuals over 50 years old was $2.75 billion in 2012 and it is predicted that this will increase to $3.84 billion in 2022 (1). Low bone mineral density (BMD) is a major risk factor for osteoporotic fracture (2). Since BMD in later life is a function of peak bone mass and the rate of subsequent bone loss (3), it is therefore critical to ensure preventative behaviours are taken up in younger population that improve and maintain BMD, and consequently delay the onset of osteoporosis and reduce the risk of fracture.

Osteoporosis knowledge and the concept of self-efficacy are two key factors involved in lifestyle behaviour change related to osteoporosis prevention. Self-efficacy refers to “people’s confidence in their ability to change osteoporotic preventive behaviours, specifically calcium intake and physical activity”, which is related to behaviours in three ways: the conviction that an individual has the ability to i) initiate the activity, ii) maintain the activity and iii) persist in performing the activity in the face of obstacles(4). Both osteoporosis knowledge and self-efficacy are suggested to be important determinants of calcium intake and exercise behaviours (5). Despite this, levels of osteoporosis knowledge (6, 7) and self-efficacy (6, 8, 9) are low worldwide. Studies suggest that osteoporosis knowledge and self-efficacy can be improved by a variety of interventions (6, 8, 9), at least in the short-term (up to 2 years). We previously (7) examined the effect of individualised risk feedback based on bone density and group education(the Osteoporosis Prevention and Self-management Course (OPSMC)) on osteoporosis knowledge and osteoporosis self-efficacy in premenopausal women. In that study, women with T-score < 0 who were told they were at higher risk of fracture in later life, based on data showing that those in the lower half of the bone mineral density distribution have a threefold higher fracture risk in later life(10) had a greater increase in osteoporosis knowledge at 6 weeks and 2 years compared to those who were told they were not at higher risk (T-score≥0). Similarly, receiving the OPSMC was associated with a greater increase in osteoporosis knowledge compared to receiving an osteoporosis information leaflet. However, neither T-score group nor type of education received was associated with changes in osteoporosis self-efficacy over 2-years.

For early life interventions to be effective at preventing osteoporosis in later life, their effects need to persist in the long-term, but there are no published studies, to our knowledge, assessing the very long-term effect of either risk feedback or osteoporosis education on osteoporosis knowledge and self-efficacy. Therefore, the aim of this study was to conduct a 12-year follow-up of participants from our original trial to determine whether the effect of fracture risk feedback and the OPSMC on osteoporosis knowledge persisted, and which, if any, factors affect osteoporosis self-efficacy in the longer-term.

**Materials and Methods**

This was a 12-yr follow-up of a randomized controlled trial previously conducted in 2000 in Southern Tasmania, Australia, the methods of which have already been described in detail (7). We randomly selected women aged 25-44 years, from the 2000 electoral roll, excluding women if they had previous measurement of bone density, thyroid disease, renal failure, malignancy, or rheumatoid arthritis, a history of hysterectomy or were taking hormone replacement therapy, pregnant or planning pregnancy within 2 years of study entry, lactating. Ethics approval was obtained from Royal Hobart Hospital Ethics Committee and all participants gave written informed consent.

A computer-generated random number list was used to randomly assign participants to one of two osteoporotic education groups: an information leaflet from Osteoporosis Australia “Understanding Osteoporosis” or the Osteoporosis Prevention and Self-management course (OPSMC). The OPSMC is a chronic disease self-management course developed by the Arthritis Foundation of Victoria and utilized by Osteoporosis Australia. This small-group patient education program aimed to increase knowledge, improve confidence and awareness and self-management of osteoporosis prevention with an emphasis on promoting appropriate lifestyle changes. OPSMC sessions of 2 hours were held weekly for 4 weeks with a maximum of 16 participants per group. The osteoporosis information leaflet provided a comprehensive description of osteoporosis and discussed the role of lifestyle factors including diet, exercise and smoking, and optimal levels of calcium intake and exercise (11).

BMD at the spine and hip was measured (Hologic QDR2000, Waltham, MA) at baseline. Participants with a mean spine and hip T-score<0 received a letter informing them that their results indicated that they were at higher risk of fractures in the future and encouraging them to discuss the results and treatment options with their general practitioner, whereas those with a mean T-score≥0 were informed that they were not at a higher risk. The cut-off of a T-score of 0 was chosen based on data showing 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). Data specific to a younger population was not available but as evidence suggests that bone mass tracks throughout life as has been recorded in children (12), young (13), middle-aged and aged population (14), premenopausal women who are in the lower BMD range are likely to still have lower BMD during postmenopausal period.

Participants randomized to the leaflet information group received their feedback of fracture risk with the leaflet by mail, and those in OPSMC group received the feedback at the first session of the course.

Osteoporosis knowledge was measured at baseline, 6 weeks, 2 years, and 12 years using the Osteoporosis Knowledge Assessment Tool (OKAT) which has previously been validated with demonstrated good discriminatory power (Ferguson’s sigma = 0.96) and Cronbach’s alpha =0.70 (15). The OKAT has 20 questions with true, false, and don’t know options for each. Scoring was 1 for a correct answer or 0 otherwise. The possible range of total scores was 0 to 20.

The osteoporosis self-efficacy scale (OSES) (4) was used to measure osteoporosis self-efficacy at baseline, 1 year, 2 years, and 12 years. The OSES has two subscales with 6 items each for calcium intake and physical activity. We used a four point adjectival scale with ratings of: not at all confident (score 1), mildly confident (score 2), confident (score 3) and very confident (score 4). The possible range of total scores was 12 to 48.

Other study factors measured at baseline included height by stadiometer (The Leicester height measure, Invicta Plastics Ltd, Oadby, England) and weight by a single set of calibrated scales (Heine, Dover NH USA). Body mass index was calculated [weight (kg)/height2 (m2)]. Smoking history, breastfeeding history, number of children, family history of osteoporosis and/or fracture, and fracture history in the subject, education level, employment status of main financial provider in the household, and marital status were measured by questionnaire. Calcium intake and calcium supplement use were assessed by a validated short food frequency questionnaire (16). The calcium content of food categories was determined by Australian food composition tables (17). Participants who reported taking a supplement containing calcium alone or as a main ingredient at least 4 times per week were classified as taking calcium supplements. Physical activity was assessed by a questionnaire validated in American adolescents (18), which we modified for Tasmanian conditions and had used previously in women of this age (19). This asked participants how many days in the last 14 they performed at least 20 minutes of strenuous exercise and light exercise in five categories (1 = 0 days, 2 = 1-2 days, 3 = 3-5 days, 4 = 6-8 days, 5 = 9 or more days).

***Statistical analysis***

Differences in baseline characteristics between participants who did and did not complete follow-up were tested by unpaired two-sample *t*-test, the Kruskal-Wallis test, or chi-squared test as appropriate. Linear mixed-effect models were used to test: a. the effects of feedback of high fracture risk and of the OPSMC on change in knowledge and self-efficacy from baseline to 12 years; b. the within group change in knowledge and self-efficacy from baseline to 12 years for each T-score group (T-score<0 ≥0) and educational intervention (leaflet and OPSMC).Linear regression was used to determine the predictors of changes in knowledge and self-efficacy scores from baseline to 12 years by using complete cases. To handle missing data, complete cases were weighted by the inverse of their estimated probability of being observed (20). All analyses were performed in Stata version 12 (Stata Corporation, Texas, USA). A two-tailed p value <0.05 was considered statistically significant.

**Results**

A total of 470 women (a 64% response rate) aged 25 to 44 years were recruited at baseline with 74% (347) included at year 12. Three women withdrew before bone density and baseline assessments were performed. Baseline characteristics of the remaining 467 women who did and did not complete the follow-up are presented in Table 1. Participants who were lost to follow-up were younger, had a lower level of education, and were more likely to be current smokers or to have ever smoked and less likely to be married or in a de facto relationship (a non-married couple living together on a genuine domestic basis) than those completing follow-up. However, the proportions of participants receiving each intervention and other characteristics were comparable. The comparison of baseline characteristics of each intervention group has been previously published (7) and the 248 participants receiving the information leaflet had lower baseline levels of knowledge than the 219 who received the OPSMC in spite of randomization (8.4 for both T-score≥0 and leaflet group and T-score<0 and leaflet group, 9.4 and 9.1 for T-score≥0 and OPSMC group and T-score<0 and OPSMC group, respectively). Other characteristics were comparable between groups.

Figure 1 gives the changes in osteoporosis knowledge over the 12-yr follow-up by (a) T-score group and (b) education group. Overall, knowledge at 12 years was higher than at baseline in all groups (10.5±3.3 vs. 8.8±3.4 for T-score<0 group; 10.2±3.2 vs. 8.9±3.2 for Tscore≥0 group; 10.9±3.1 vs. 9.3±3.4 for the OPSMC group; 9.8±3.3 vs. 8.4±3.2 for leaflet group; p<0.001 for all). As previously reported (7), compared to participants with T-score ≥0, participants with T-score < 0 had a significantly greater increase in knowledge at 6 weeks (4.0±3.4 vs. 3.4±3.3, p=0.03) and 2 years (2.8±3.2 vs. 2.1±3.1, p=0.02). In the present study, the between-group difference did not persist at 12 years (change in knowledge of 1.6±3.4 vs. 1.1±3.4; β=-0.4, 95%CI=-0.3 to 1.1). There was no difference in the change between groups over time (p-value for group by time interaction=0.286). Similarly, participants who received the OPSMC had a significantly greater increase in knowledge at 6 weeks (4.4±3.4 vs. 3.1±3.2, p<0.001) and 2 years (2.7±3.4 vs. 2.2±2.8, p=0.048) but not at 12 years (1.4±3.5 vs. 1.3±3.4; β=0.2, 95% CI=-0.5 to 0.9) compared to participants receiving information leaflet. There was no difference in the change between groups over time (p-value for group by time=0.534).

 Figure 2 shows the changes in osteoporosis self-efficacy over 12 years by T-score group and by education group. Osteoporosis self-efficacy at 12 years remained lower than at baseline regardless of T-score group or educational intervention but the difference was small and only reached statistical significance in the low T-score group (32.9±6.9 vs. 34.0±6.9, p=0.014 for T-score<0 group; 34.5±7.8 vs. 34.7±7.3, p>0.05 for T-score≥0 group; 33.6±7.0 vs. 34.4±6.8, p>0.05 for the OPSMC group; 33.8±7.7 vs. 34.3±7.3, p>0.05 for leaflet group). The differences in change in self-efficacy between T-score groups were not significant at either 1 or 2 years as reported in previous study (7) (-1.4±7.1 vs. -1.4±5.9 at 1 year, -1.7±6.6 vs. -1.1±6.2 at 2 years, for T-score<0 and T-score≥0 groups, respectively; p>0.05 for all) or at 12 years in the current study (-1.3±6.8 vs. -0.4±6.4 for T-score<0 and T-score≥0 groups, respectively; β=-1.1, 95% CI=-2.5 to 0.4, p for group by time=0.150). Similarly, there were no significant differences in the decrease in self-efficacy between educational intervention groups at either 1 or 2 years (-1.7±6.4 vs. -1.1±6.7 at 1 year, -1.5±6.4 vs. -1.3±6.4 at 2 years for the OPSMC and leaflet groups, respectively; p>0.05 for all) or 12 years (-1.1±6.1 vs. -0.6±7.1 for the OPSMC and leaflet groups, respectively; β=-0.2, 95%CI=-1.6 to 1.3, p for group by time=0.805).

The results of regression of potential factors affecting changes in knowledge and self-efficacy over 12 years are given in Table 2. Compared to baseline, women in households with an unemployed main financial provider had a slight decrease (-0.3, 95%CI=-1.7 to 1.1) in knowledge at 12-years compared to those in household with an employed main financial provider where knowledge was increased (1.4, 95% CI =1.1 to 1.8) (β=-1.95, 95%CI=-3.40 to -0.50). No other factors had a significant effect on change in knowledge over 12 years. Neither intervention nor any sociodemographic factors were associated with 12-year change in osteoporosis self-efficacy.

**Discussion**

This 12-yr prospective population-based study is the first study (that we know of) to evaluate the long-term effects of any intervention for improving osteoporotic knowledge and/or self-efficacy in premenopausal women. While both the OPSMC and feedback informing women they were at higher fracture risk improved osteoporosis knowledge for 2-years post-intervention, these beneficial effects did not persist in the long-term. Nonetheless, overall knowledge increased in all intervention groups over 12 years, suggesting that these increases were due to factors other than the interventions provided. Neither intervention improved osteoporosis self-efficacy at 2 or 12 years. These results suggest that more frequent osteoporosis education and bone density feedback may be necessary to maintain the increased short-term knowledge gains from these interventions, and that alternative interventions are required to improve self-efficacy.

Previous studies have employed a variety of educational interventions to improve osteoporotic knowledge, but only a few have been conducted in younger women (21, 22), and only two have specifically investigated the OPSMC (6, 8) in addition to our previous 2-yr study (7). Overall, these studies have been short-term in nature (≤3 months) and participants were not selected using random sampling (6, 8, 21, 22), thereby limiting the generalizability of their results. The two studies in younger women (age≤25) reported that brief education interventions could produce moderate increases in knowledge (up to 44%) in the short-term (≤4 weeks) (6) Studies using the OPSMC in older populations (average age>60, up to 3 months follow-up (8) and people aged 40 or over (92% women) with 6 weeks follow-up (6) showed similar short-term effects of the OPSMC on knowledge. These are similar to the short-term increases we previously reported in our younger study population (7).

 Osteoporosis knowledge decreased after 6 weeks across all groups but was still higher than at baseline after 2 and 12 years. While this may be due to the effects of the interventions, it is also possible that this reflects the natural history of osteoporosis knowledge acquisition with increasing age, and presumably increasing awareness of the issue of osteoporosis. Even though women in households with an unemployed main financial provider only accounted for 6% of our study participants, they were more likely to have a slight decrease in osteoporosis knowledge compared to those with an employed main financial provider where knowledge was increased. It may be that women living in such households would place less emphasis on osteoporosis due to financial circumstances, and/or they may have limited access to educational resources, healthcare providers and other societal supports that could assist them in acquiring and maintaining knowledge of osteoporosis. Future research on improving osteoporosis knowledge should focus on this population.

Only two other studies have evaluated the short-term (up to 3 months) effects of the OPSMC on self-efficacy (6, 8) other than our previous 2-yr study, but these two studies are not directly comparable with ours because they had a shorter duration of follow-up (maximum of 3 months) and included older participants (mean age>63). Nonetheless, as in our previous 2-yr study (7) and in our current data, these two studies reported no significant change in self-efficacy from the OPSMC (4% for both studies) as compared to the no intervention (1%) (6) or an one session course control group (3≤%) (8). Thus it seems that the OPSMC may not be effective approach for changing osteoporosis self-efficacy in either younger or older women. Information on the effect of fracture risk feedback on osteoporosis knowledge is limited. One study reported no significantly higher increase in osteoporosis knowledge after 4 months in peri- or post-menopausal women (mean age=54) who received immediate verbal information from the consultant regarding BMD results, diagnosis and implications compared to those who received a standardized letter regarding the results only from their general practitioner (13% vs. 28%) (23). This may be due to no educational intervention being provided.

As we observed in our study at 2 years follow-up (7), changes in osteoporosis self-efficacy over12-year were independent of whether participants had received feedback of high fracture risk. We also observed that the negative associations of both 1-year and 2-year changes in osteoporosis self-efficacy with number of children and hours of employment were no longer significant. This short-lived relationship might be a result of the lengthy study period as employment status might have changed and the impact of the number of children on daily routines is likely to change as children grow up and become independent.

Our study has several important strengths. The educational intervention component of the study was a robustly designed randomized controlled trial. In addition, our study was population-based with randomized sampling to ensure a low selection bias and so a high generalizability. The large sample size allowed us to have a very long-term follow-up with sufficient statistical power for these analyses. Furthermore, the 12 years follow-up made our study unique as no other relevant studies have been conducted for such a long period.

A limitation of the study is that follow–up was incomplete, with 26% of participants lost to follow-up over 12 years. However, the proportions of participants receiving the OPSMC and low T-score feedback were comparable between those who did and did not complete the study suggesting that the risk of bias from loss to follow up is low and unlikely to have affected study findings. This is supported by data from analyses using linear mixed model and inverse probability weighting to adjust for missing data, as the results did not vary from those without using inverse probability weighting (results not shown).

The OPSMC was modelled upon a chronic disease self-management course for arthritis effective in symptomatic populations (24, 25), which are likely to be different from the healthy, asymptomatic participants in the current study. However, a recent study indicated that the OPSMC intervention led to a significant increase in osteoporosis knowledge but not osteoporosis self-efficacy for calcium or exercise in adults aged ≥ 50 having sustained an acute bone fracture due to minimal trauma (8). This suggests the OPSMC is effective for improving knowledge but not self-efficacy in both symptomatic and healthy populations.

In conclusion, in this population-based randomized controlled trial in healthy women aged 25-44, both the OPSMC and high fracture risk feedback increased osteoporosis knowledge over 2 but not 12 years. Women in households with unemployed main financial providers were more likely to have decreased knowledge in a long-term, suggesting that this population should be a focus of future research. Neither intervention improved osteoporosis self-efficacy, either at 2-years or 12-years. Therefore, more frequent osteoporosis education and bone density feedback is necessary to maintain knowledge and new interventions may be required to improve self-efficacy.

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Figure legends

Fig. 1 Change in osteoporosis knowledge score by (a) T-score group and (b) educational intervention. The error bars are 95% CI.

Fig. 2 Change in osteoporosis self-efficacy score by (a) T-score group and (b) educational intervention. ≥ The error bars are 95% CI.