ORIGINAL RESEARCH

The Effect of Education Intervention on Osteoporotic Fracture and Bone Mineral Density in Elderly Women With Osteoporosis: A Randomized Controlled Trial

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ABSTRACT

Objective • This study aimed to assess whether a 5-year follow-up education intervention changed the risk for fragility fractures and increased bone mineral density (BMD) in elderly women with osteoporosis.

Methods • This randomized controlled trial included 104 women who were hospitalized or visited a specialist for osteoporosis care at Sichuan Translational Medicine Research Hospital in China from October 2013 to June 2014. The patients were randomly assigned to either an education intervention group (n = 52) or a control group (n = 52). The intervention was conducted by an endocrinologist who provided the intervention group with personized recommendations. All participants were followed for 5 years.

Results • Compared with the control group, the patients in the intervention group had a lower risk for fragility fracture, lower pain score, higher BMD at the greater trochanter of the femur, total hip and the first lumbar vertebra, together with higher compliance with anti-osteoporosis drug regimens and higher intake of vitamin D supplements (all $P < .05$). After adjustment for history of fracture, calcium consumption, age and body mass index (BMI), the association of change in BMD and pain score and the medication possession ratio (MPR) of anti-osteoporosis drugs were both significantly different ($P < .05$, $P < .001$, respectively). In subgroup analysis by past fractures, patients who experienced post-fractures were more likely to experience refracture ($P < .05$).

Conclusions • The personalized education intervention by endocrinologists can significantly increase the BMD of the greater trochanter of the femur and reduce pain scores in elderly women with osteoporosis, suggesting that this education intervention may serve as an important addition to standard anti-osteoporosis treatment. (*Altern Ther Health Med.* 2022;28(2):89-95).

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INTRODUCTION

With the accelerating process of worldwide population aging, osteoporosis has become a major health problem. Osteoporosis is a systemic bone disease characterized by compromised bone strength and consequently an increased risk for fracture.[1] In China, the prevalence of osteoporosis has increased sharply from less than 15% before 2008 to approximately 28% after 2012. One-third of Chinese people age 50 years and older have been diagnosed with osteoporosis, causing a huge burden on the public healthcare system.[2] Osteoporotic fracture refers to fractures that occur after minor trauma or during daily activities, and is a serious consequence of osteoporosis. In 2015 alone, there were approximately 2.69 million cases of osteoporotic fractures of the wrists, vertebral bodies and hips in China, leading to an estimated medical expense of 72 billion Chinese Yuan. Moreover, this expense has been projected to continue increasing exponentially over the next 30 years.[3]

However, a low percentage of women regularly engage in health-promoting behaviors associated with osteoporosis prevention. Complex, multidimensional, m-Health interventions hold promise to effect engagement in health behavior change related to calcium and vitamin D intake, balance, core and leg strength and physical activity.[4]

Educational intervention is a basic, economical but effective measure for the prevention and treatment of osteoporosis. Previous studies have shown that educational interventions via telephone, text and video, email, training courses, group education and exercise guidance could add to the patients' knowledge about osteoporosis,[5] improve their quality of life (QoL)[6] and increase their compliance with the diagnosis[6] and treatment of osteoporosis.[5] Yet, inconsistent results have been reported by another intervention study.[8] Moreover, previous studies of education intervention had comparatively short intervention times and few of them evaluated the influence of the educational intervention on the change in BMD or the risk for osteoporotic fracture.

This prospective randomized controlled study took 5 years to investigate whether personalized educational intervention could decrease the risk for osteoporotic fracture and improve BMD in elderly women with diagnosed osteoporosis. Moreover, the educational intervention itself was evaluated to explore its association with osteoporotic fracture and BMD.

METHODS

Participants

All patients who were admitted to or visited the department of endocrinology clinic at Sichuan Provincial People's Hospital from October 2013 to June 2014 were potentially eligible for participation in this study. The study protocol was approved by the Ethics Committee of Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital (No. 080363) in China and informed consent was obtained from all participating patients.

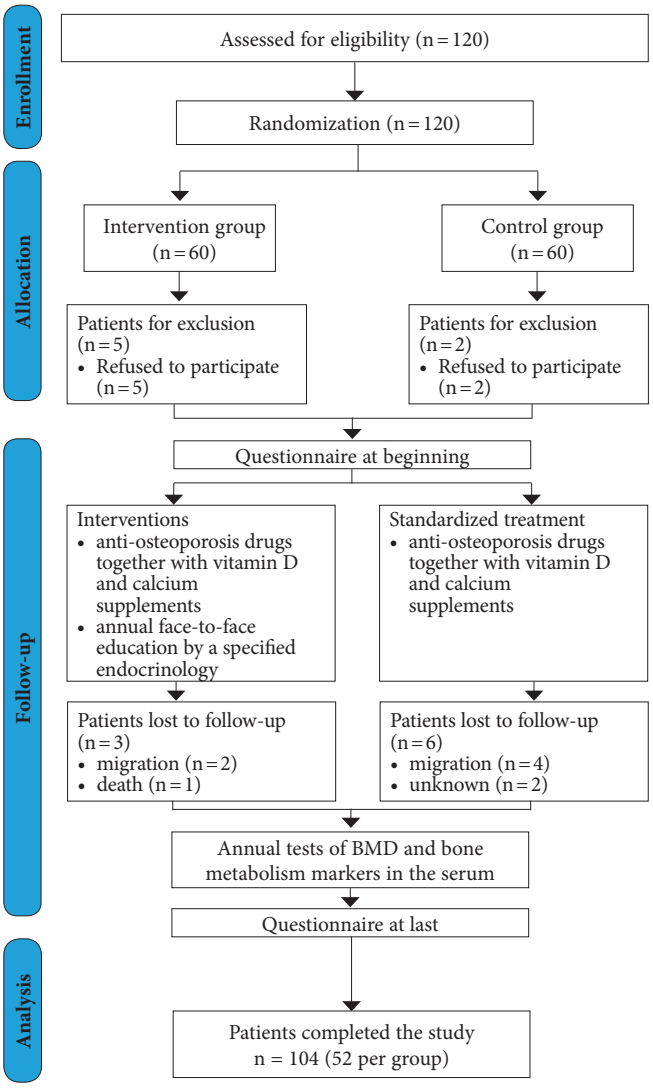
Inclusion criteria. Inclusion in the study was based on (a) the diagnosis of primary osteoporosis according to the Chinese guidelines for diagnosis and treatment of primary osteoporosis published in 2011 (available at www.csobmr.org.cn/UploadFile/Ueditor/file/20160513/635987469170103750812999.pdf; Accessed December 28th, 2020; only available in Chinese), and osteoporosis was diagnosed in the presence of brittle fractures of the vertebral body or hip (regardless of bone mineral density *t* score), defined by pathological fracture that results from minimal trauma; *t* score ≤-2.5;[9] or bone loss ($-2.5 < t < -1$) combined with fragility fracture of the proximal humerus, pelvis or distal forearm; and (b) postmenopausal women age >45 years.

Exclusion criteria included patients with (a) confirmed secondary osteoporosis; (b) endocrine diseases such as diabetes and thyroid disease; (c) severe disease of the liver, kidney, cardiovascular, cerebrovascular, or blood systems; (d) cognitive dysfunction or unable to live independently; (e) long-term users of certain drugs that may influence bone metabolism; (f) any diseases that may cause ataxia.

Data Collection at Inclusion

All patients were asked to complete a questionnaire that included data regarding their gender, age, childbearing history, education level (≥9 years or <9 years), menopausal age, family history of hip fracture, smoking habits (ever-smoker or never-smoker), heavy alcohol consumption (yes or no), regular coffee or tea consumption (more than 3 times/week or not), intake of dairy products (ml/day), outdoor activities (>2.5 hours/week or not), history of fragility fractures after age 45 years (yes or no), height decrease within 5 years (3 cm shorter than their maximum recorded height or not), visual analog scale (VAS) pain score, diagnosis of rheumatism or rheumatoid arthritis (yes or no), regular use of corticosteroids (yes or no) and use of calcium and/or vitamin D supplements. In this study, BMD was measured by dual energy x-ray absorptiometry (DXA), GE LUNAR (Seattle, USA). In addition, the weight and height of all patients were measured and recorded by a trained research nurse at in order to calculate body mass index (BMI).

Figure 1. Flow chart of the study protocol and enrolment.



Randomization and education Intervention

A total of 120 patients were randomly assigned to either the education intervention or the control group by a block random method (block size 10). Of the initial 120 patients, 113 signed a written informed consent form; 5 patients in the intervention group and 2 in the control group quit due to personal reasons at the beginning of the study (see Figure 1).

The control group received standard treatment and patients were followed up according to Chinese guidelines. More specifically, the patients were prescribed anti-osteoporosis drugs together with vitamin D and calcium supplements and followed up once a year with repeated tests of BMD and bone metabolism markers in the serum. In addition to standard treatment and follow-up, each patient in the intervention group was assigned to an endocrinologist. Upon inclusion in the study, this specialist provided face-to-face education to the patient and one of their primary caregivers for at least 30 minutes. The education included basic knowledge about osteoporosis, interpretation of the BMD test results, personalized recommendations for diet, exercise and other lifestyles choices and knowledge about how to prevent falls, including suggestions for room layouts, anti-slip measures, eyesight improvement, minimized use of psychotropic drugs and the use of walking aids. Moreover, the importance and necessity of taking supplements such as calcium and vitamin D and compliance with anti-osteoporosis treatment including medications and follow-up were emphasized during the education. During the follow-up period, this education was repeated annually by the same specialist for no less than 30 minutes each time, and further suggestions were provided to improve the patients' lifestyle, prevent falls and increase compliance with the use of supplements and anti-osteoporosis drugs, in accordance with the patients' current physical condition and updated risk for fragility fracture.

Table 1. Demographic and Clinical Characteristics (Mean ± SD)

Items	Intervention group n = 52	Control group n = 52	*P* value
Age (years)	70.040 ± 7.483	68.02 ± 9.775	.240
Education level (≥9 years or not)	15/37	21/31	.216
Number of children	2.440 ± 1.378	2.23 ± 1.450	.447
Age at menopause (years)	46.790 ± 4.573	46.13 ± 4.606	.469
History of fracture (yes/no)	19/33	32/20	.011[a]
PHF	4.817 ± 4.154	4.288 ± 3.821	.501
PMOF	9.738 ± 4.870	9.192 ± 5.362	.588
Smoking (Ever/Never)	49/3	50/2	.647
Alcohol consumption (Yes/No)	50/2	49/3	.647
Coffee/tea consumption (Yes/No)	47/5	48/4	.727

[a]Statistically significant

Abbreviations: PHF, probability of a hip fracture; PMOF, probability of a major osteoporotic fracture; SD, standard deviation.

Table 2. Assessment of the Education Intervention (Mean ± SD)

	Difference		
	Intervention group (n = 52)	Control group (n = 52)	*P* value
Dairy products (ml/day)	73.462 ± 172.276	74.80 ± 117.473	.963
Calcium supplements (increase/decrease and unchanged) (%)	15/37	13/39	.658
Vitamin D supplements (increase/decrease and unchanged) %)	18/34	8/44	.024[a]
MPR anti-osteoporosis drugs	0.752 ± 0.535	0.356 ± 0.373	.000[a]
BMI	1.439 ± 6.210	1.163 ± 3.311	.778
Outdoor activities (increase/decrease and unchanged) (%)	5/47	5/47	1.000
Use of walking aids (yes/no)	9/43	10/42	.800

[a]Statistically significant

Abbreviations: BMI, body mass index; MPR, medication possession rate.

Follow-up and Outcomes

During the follow-up period, 2 patients in the intervention group and 4 in the control group moved away, 2 in the control group were lost to follow-up due to unknown reasons, and 1 in the intervention group died due to cancer. Finally, 104 patients were followed up once a year for 5 years (see Figure 1) according to a schedule monitored by a research assistant who contacted patients via telephone and sent a reminder 3 days before each follow-up date. Any patient who did not come to their follow-up appointment were contacted again and rescheduled for another follow-up in the next month.

At the final follow-up, the patients' height was measured again to obtain their current BMI, and another questionnaire was given to the patients to collect data on their smoking habits, alcohol consumption, regular coffee or tea consumption, intake of dairy products, outdoor activities, use of walking aids and pain level as measured by VAS. Data regarding the type and duration of supplement and anti-osteoporosis drug regimens were also collected and the medication possession rate (MPR) was calculated by dividing the actual amount of medication taken in a year by the amount prescribed. The number of incident fragility fractures during follow-up was also recorded and BMD tests were performed. The Fracture Risk Assessment Tool (FRAX®) recommended by the World Health Organization was used to estimate the patients' 10-year probability of a hip fracture (PHF) and of a major osteoporotic fracture (PMOF).

Statistical Analyses

Follow-up analyses were conducted in the 104 patients who completed the 5-year follow-up, with 52 patients in each group. The primary outcome of the study was the incidence of fragility fracture. The secondary outcomes included BMD; intake of dairy products, calcium supplements and vitamin D supplements; BMI; outdoor activities; VAS score; use of walking aids and MPR of the anti-osteoporosis drugs.

All continuous variables were presented as mean ± standard deviation (SD). The difference in continuous variables between the 2 groups were compared by independent *t* test, and the difference in categorical variables between the groups was tested by chi-square and Mann–Whitney U tests.

Multivariable linear regression was used to evaluate the association between the education intervention and the change in BMD and VAS score, and to perform an adjusted analysis of the association with estimated *P* value. In addition, logistic regression was used to test the association between the education intervention and fragility fractures and to perform an adjusted analysis to estimate *P* values and 95% CI. Taking into consideration potential confounding factors that were not fully balanced by randomization, $P < .05$ was established for baseline comparisons between the groups. These confounders were history of fracture, age, BMI and calcium supplements. A subgroup analysis by history of fracture was also conducted in the 2 study groups to evaluate whether past fractures had an effect on new fractures. The analyses were conducted with Stata 16 (StataCorp, College Station, Texas, USA). All statistical tests were two-sided with $P < .05$ considered statistically significant.

Table 3.1. Comparison of New Fragility Fractures and Subgroup Analysis After Education Intervention

	New fractures		
	Yes (Intervention/Control)	No (Intervention /Control)	*P* value
Total (n = 104)	4/16 patients	48/36 patients	.005[a]
Past fractures			
Yes (n = 53)	2/8 patients	31/12 patients	.002[a]
No (n = 51)	2/8 patients	17/25 patients	.227

[a]Statistically significant

Table 3.2. Site and Number of New Fragility Fractures After Education Intervention

Site	Intervention group	Control group
Anklebone	1	3
Thighbone	1	2
Fibula	0	1
Shoulder joint	0	1
Foot bone	0	1
Collarbone	0	2
Humerus	0	3
Wrist	0	1
Lumbar vertebrae	0	2
Ribs	0	1
Ulna	0	1
Shin	0	1
Tail vertebrae	1	0
Radius	1	0
All	4	19

Table 3.3. The Association of New Fragility Fractures and Intake of Vitamin D Supplements or MPR of Anti-Osteoporosis Drugs Before and After Adjustment

	New fragility fractures			
Education interventions	***P* value**	**95% CI**	**Adjusted[a]**	**Adjusted 95% CI[a]**
Vitamin D supplements (increase/decrease and unchanged) (%)	.113	0.061-1.342	.151	0.051-1.582
MPR of anti-osteoporosis drugs	.230	0.155-1.563	.254	0.150-1.649

[a]Adjusted *P* means *P* value adjusted for history of fracture, calcium consumption, age and BMI; dose adjusted 95% CI.

Abbreviations: MPR, medication possession rate.

RESULTS

Of the initial 113 patients, 104 (52 in each group) completed the follow-up for 5 years, with a valid 92.04% follow-up rate in our study (9-11). Baseline demographic and clinical characteristics were similar across the 2 study groups (as shown in Table 1), except for the history of fracture ($P < .05$).

After 5 years of education follow-up, intake of vitamin D supplements and MPR of anti-osteoporosis drugs were significantly different (both $P < .05$). The MPR of the anti-osteoporosis drug was significantly higher in the intervention group than in the control group ($P < .001$). Compared with the control group, vitamin D supplements in the intervention group increased ($P = .024$). The changes in intake of dairy products and calcium supplements, BMI, outdoor activities and use of walking aids were not significantly different (see Table 2).

Fragility Fractures Outcome

Of the 52 patients in the intervention group, 4 (7.7%) had **4 fragility fracture**s, and 16 of the 52 patients in the control group (30.8%) had **19 fragility fractures** (see Table 3.1 and Table 3.2); the incidence of fragility fracture was significantly different across the 2 study groups ($P < .05$). In subgroup analyses, the incidence of new fragility fracture was 6.06% in the intervention group compared with 40.00% in the control group ($P < .05$) in patients who had experienced a fragility fracture (see Table 3.1). There was no difference in the incidence of new fragility fracture ($P = .227$) between the intervention group and the control group in patients who had not experienced a fragility fracture (see Table 3.1). The sites and times of the new fragility fractures in both groups are presented in Table 3.2. The association between new fragility fractures and the intake of vitamin D supplements or anti-osteoporosis drugs MPR were not significantly different (both $P > .05$) when adjusted for history of fracture, age, BMI and whether or not calcium supplements were taken (as shown in Table 3.3).

Table 4.1. Comparison of Bone Mineral Density Before/After Education Intervention

Sites	Difference		
	Intervention Group (n = 52)	Control Group (n = 52)	*P* value
Femoral neck	0.042 ± 0.280	0.019 ± 0.349	.710
Greater trochanter of femur	-0.015 ± 0.447	-0.190 ± 0.441	.047[a]
Total hip	0.577 ± 0.244	-0.088 ± 0.372	.020[a]
First lumbar vertebra	0.313 ± 0.529	0.104 ± 0.364	.020[a]
Second lumbar vertebra	0.008 ± 0.937	0.179 ± 0.631	.277
Third lumbar vertebra	-0.142 ± 1.202	0.098 ± 1.158	.301
Fourth lumbar vertebra	0.357 ± 0.486	0.342 ± 0.571	.883
First to fourth lumbar vertebrae	0.302 ± 0.403	0.210 ± 0.419	.255

[a]Statistically significant.

Table 4.2. The Association Between Change in BMD and Vitamin D Supplement Intake or MPR of Anti-Osteoporosis Drugs Before and After Adjustment

Education interventions	Greater trochanter of femur		Total hip		The first lumbar vertebra	
	P value	Adjusted *P*[a]	*P* value	Adjusted *P*[a]	*P* value	Adjusted *P*[a]
Vitamin D supplements (increase/decrease and unchanged) (%)	.255	.536	.078	.062	.578	.733
MPR of anti-osteoporosis drugs	.023*	.040[b]	.200	.278	.066	.070

[a]Adjusted *P* means *P* adjusted for history of fracture, calcium consumption, age and BMI.
[b]Statistically significant.

Abbreviations: MPR, medication possession rate.

Bone Mineral Density Outcome

As for BMD, there was a significant difference in change in BMD values at the greater trochanter of the femur, total hip and the first lumbar vertebra after the education intervention ($P < .05$) (see Table 4.1). The BMD values at the greater trochanter of the femur, total hip and the first lumbar vertebra in the intervention group were higher than in the control group. The association between change in BMD and MPR of anti-osteoporosis drugs were both significantly different (both $P < .05$) before and after adjusting for history of fracture, age, BMI and calcium supplements (see Table 4.2).

Following the 5-year intervention, VAS scores were significantly lower in the intervention group compared with the control group ($P < .001$) (see Table 5.1). The association between the change in VAS scores and the MPRs of anti-osteoporosis drugs were both significantly different (both $P < .05$) before and after adjusting for history of fracture, age, BMI and calcium supplements (see Table 5.2).

DISCUSSION

This is a prospective randomized controlled study aiming to evaluate the effect of education intervention on the occurrence of osteoporotic fractures in elderly women with primary osteoporosis. After the 5-year intervention, the women who were received the annual education had a lower risk for fragility fractures and lower pain scores, as well as a higher compliance with anti-osteoporosis drug regimens, and a higher intake of vitamin D supplements compared with the women in the control group.

Previous studies evaluating the effect of education intervention on reducing osteoporotic fractures were mostly based on community-dwelling populations. A Finnish study[13] and a Swedish study[14] showed that education on osteoporosis and the prevention of falls could decrease the incidence of fracture in community-dwelling women after 10 years. The present study was based on outpatients seeking specialist care or inpatients hospitalized for osteoporosis whose osteoporotic symptoms and bone loss may have been more severe compared with their community counterparts. Of more importance, their risk for fragility fracture may be even higher than in community-dwelling women. Thus, it is important to evaluate the effect of education intervention in these women.

After the education intervention, the risk for refracture decreased in the intervention group compared with the control group. Another study from Australia[15] found that active identification and management of osteoporosis reduced the risk for refracture by more than 80% in patients with recent fragility fracture, which is similar to our results. However, at study inclusion, there were more prevalent

Table 5.1. Comparison of Pain Scores After Education Intervention

Pain score	Difference		*P* value
	Intervention group (n = 52)	Control group (n = 52)	
Visual analog scale score	-0.808 ± 1.401	0.346 ± 1.792	<.001[a]

[a]Statistically significant.

Table 5.2. The Association Between Change in Pain Scores and Vitamin D Supplement Intake or MPR of Anti-Osteoporosis Drugs Before or After Adjustment

Education interventions	Pain score	
	P value	Adjusted *P*[a]
Vitamin D supplements (increase/decrease and unchanged) (%)	.100	.264
MPR of anti-osteoporosis drugs	<.001[b]	<.001[b]

[a]Adjusted *P* means *P* adjusted for history of fracture, calcium consumption, age and BMI.
[b]Statistically significant.

Abbreviations: MPR, medication possession rate.

osteoporotic fractures in the intervention group, so this group could be considered more fragile and perhaps more concerned and receptive to an intervention with the final objective of decreasing the number of fractures.

Multiple medications were proven to have a definitive effect on treating osteoporosis, including bisphosphonates, calcitonin, selective estrogen receptor modulators, teriparatide and denosumab.[16] However, the clinical effects of these medications are largely influenced by the accuracy of the diagnosis, the timing of treatment initiation and patients' treatment compliance. It was estimated that less than 40% of patients continued taking oral bisphosphonates treatment 1 year after treatment initiation, and discontinuation of treatment was associated with an increased risk for fracture.[17] In the present study, the MPR of anti-osteoporosis medications was approximately 75% in the intervention group, in contrast to >40% in the control group. Further analysis of the association between fragility fractures and taking vitamin D supplements and MPR of anti-osteoporosis drugs, showed that the associations were not significantly related even after adjusting for a history of fracture, age, BMI and calcium supplements. Although these results do not support the theory that compliance with anti-osteoporosis medication regimens was the main cause of reduced risk of refracture in the intervention group, the high MPR may be indirectly associated with other risk factors for fragility fracture that could be improved by education. Further studies are needed to explore the underlying reasons.

A previous meta-analysis showed that education intervention may not be effective in improving BMD in patients with osteoporosis,[18] which is inconsistent with the results from our study, in which increased BMD at the greater trochanter of femur, total hip and the first lumbar vertebra were observed in the intervention group compared with the control group. In addition, the education intervention concerning anti-osteoporosis drugs was also associated with a significant increase in the BMD of the greater trochanter of the femur after 5 years, suggesting that persistent intake of anti-osteoporosis drugs is beneficial for BMD improvement. Change in BMD is a slow process, and it may take a long time before any effect of the education intervention on BMD occurs. Of the studies included in that meta-analyses, follow-up shorter than 5 years may lead to missed late effects. The effect of the education intervention may vary significantly in different study populations, different methods of addressing the education and the frequency and intensity of the education.

Another systematic review and meta-analysis found that intensive secondary prevention for fracture is more effective than education only.[19] However, given the huge number of patients, a more intensive education program may not be feasible in Chinese general hospitals or specialist care centers. Also, different methods for addressing the education have also been applied in different studies, ranging from group education,[5] educational brochures, and telephone consultations[20] to educational videos.[8] In recent decades, the establishment of primary care systems and community healthcare centers has been accelerated in China, which may provide an opportunity for future studies to further investigate the effects of different methods for addressing the intervention and the cost-effectiveness of different levels of intervention.

CONCLUSION

This study showed that personalized education interventions by endocrinologists can significantly increase BMD at the greater trochanter of the femur and reduce pain scores in elderly women with osteoporosis, suggesting that education intervention may serve as an important addition to standard anti-osteoporosis treatment.

Study Strenghths and Limitations

The strengths of this study include a well-defined study population of postmenopausal women and the fact that any potential cause for secondary osteoporosis was ruled out at study inclusion. All patients in both groups were recruited within a short period and underwent measurement of BMD at study inclusion and at the last follow-up. Any factors that might influence bone metabolism were also determined by questionnaires at these 2 time points.

Study limitations include that the sample size is only moderate. Another weakness is that only endocrinologists were involved in the education intervention, and no detailed plan for physical exercise was provided to the patients, restricting the possibility of investigating the effect of education on the prevention of falls and the promotion of proper exercise. The specific muscle strength and balance exercises and indicators of them (such as the Short Physical

Performance Battery Protocol [SPPB]) was not considered in the context of health education at the design phase, which is also a study limitation.

Further study is needed to assess the effect of specific muscle strength and balance exercises in the care of patients with osteoporosis.

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CONFLICTS OF INTEREST

None.

DATA SHARING

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

ETHICS APPROVAL AND INFORMED CONSENT

This study was approved by the Ethics Committee of Sichuan Academy of Medical Sciences and Sichuan Provincial People's Hospital (No. 080363) and informed consent was obtained from all patients included in the study.

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